THE CULTURE AND DISEASES OF THE SWEET PEA

J. J. TAUBENHAUS

OTHER WORKS
BY THE SAME AUTHOR

DISEASES OF TRUCK CROPS AND THEIR CONTROL
[In Preparation]

DISEASES OF GREENHOUSE PLANTS
[In Preparation]

DISEASES OF THE SWEET POTATO
[In Preparation]

E. P. DUTTON & CO
NEW YORK

A Fine House of Sweet Peas.

THE CULTURE AND DISEASES OF THE SWEET PEA

BY

J. J. TAUBENHAUS, Ph.D.

Plant Pathologist and Physiologist in Charge. Experiment Station, Agricultural and Mechanical College of Texas

NEW YORK

E. P. DUTTON & COMPANY

681 FIFTH AVENUE

PRINTED IN THE UNITED STATES OF AMERICA

TO

THE REVEREND CHAIM HIRCHENSOHN

WITH LOVE AND DEEP AFFECTION

PREFATORY NOTE

The keen appreciation of the public of the beauties of nature as expressed in the building of parks and public gardens, in the planting of street trees, and in the adornment of private grounds and homes by means of ornamental plants is one of the most distinctive marks of an advanced civilization. The success of these undertakings means the overcoming of many difficulties which the casual observer fails to appreciate. It means not only the selection and arrangement of varieties in such manner as to meet with the most æsthetical tastes of the public, but it frequently means growing the plants under new environmental conditions, the study of soil and climate, the contest against insects and diseases which continually threaten the existence of these plantings.

It has long been known that unfavorable soil and climatic conditions and destructive insects were very important factors in plant culture, but it is only within recent years that the public has begun to appreciate that many of the difficulties in growing plants, in fact, many of the failures are due to diseases. Most of these diseases are due to fungus or to bacterial organisms. Since most of these organisms are so small that they cannot be seen except with the aid of a microscope, the grower has usually attributed the disease to other causes. The appreciation of these facts makes a work on the growing of any group of ornamental plants in which the importance of the control of the diseases is given a prominent place very desirable. Therefore, this work on the Growing of Sweet Peas, by a worker who has made a special study of the diseases is very timely.

The sweet pea is a favorite flower with the great majority of people. It is enjoyed by both the high and the lowly, and is within the reach of all. It is a profuse bloomer and presents an untiring variety of sizes and delicate colors. It is well adapted to various conditions and can be grown over a very large part of the world.

The author's training in plant pathology and his large experience with diseases of ornamentals is a guarantee of meritorious character of the work. The work is both practical and scientific; it is equally useful to the layman, the commercial grower and to the scientist; it deals not only with the diseases of sweet peas, but with the cultivation and other important questions connected therewith.

MEL. T. COOK.

Rutgers College,
New Brunswick, N. J.
January, 1917.

PREFACE

The sweet pea is unfortunately one of those crops which has received scant consideration in horticultural text books. The field to be covered by the latter is so large that their treatment of many a crop is necessarily meager. Good articles on the culture of the sweet pea are to be found in various journals, but are not accessible to the practical grower. The cultural directions which seed concerns publish for the benefit of their patrons are brief; and Mr. Harrison Dick's "Sweet Peas for Profit" covers only one phase of the subject, namely, the greenhouse culture. As no complete study of the sweet pea has been published in America, it is felt that this book may be very timely, especially since this delicate flower is gaining so rapidly in popularity.

The chief difficulty encountered by the growers of the sweet pea is the combating of diseases, in which they have had very little help. Massee and Chittenden in England have devoted some time to the "Streak disease," but these workers have been misled in their observations by attributing this disease to the fungus Thielavia. In the United States, floral pathology is still in its embryonic stage, and the sweet pea was not the first to claim the attention of Pathologists. The author of this book in the last three years has published several papers on his own investigations, taken up largely because of numerous complaints from growers who met with failure in their attempts to grow this beautiful flower. Florists and gardeners have often been hopelessly discouraged the first time they tried to grow sweet peas because of total loss from disease. Others who have grown them for years have been meeting with difficulties that are considerably reducing their profits. The layman, particularly the housewife so proud of her row of sweet peas by the house, has seen many of them carried off by blights and the remainder dry up and wither away.

Naturally the blame fell at once on the seedsman, who was accused of supplying a poor grade of seed. In seeking justification, seedsmen attributed the growers' failures to bad weather, to drought, or to the green aphids. A few seed catalogues and some popular articles on the culture of the sweet pea asserted that the plant is unusually free from disease, and that all failures are due to overfeeding. Many practical men do not realize that plants have diseases just as do animals and human beings. We shall here endeavor to show that although bad weather, over-feeding, etc., may be important factors, they are not the fundamental reasons for failure. We shall study the specific causes that lead to the diseases of the sweet pea; the definite parasitic forms of life such as insects, fungi, and bacteria that live upon this plant and bring about its destruction. The nature of the attacking insects is still incompletely known and there is urgent need of further investigation of them. Of the fungi, nine produce serious diseases in either roots, stems, foliage, or blossoms of sweet peas. Only one bacterial trouble, however, is so far known to affect sweet peas, and that is the dreaded "Streak." To these troubles may be added eel worm, red spider, and mites, all of which add considerably to the losses.

In the discussion which is to follow,

technical terms as far as possible will be avoided, with the exception, however, of the scientific names of the parasites. Popular terminology does not always distinguish between diseases of different nature that are apparently alike. For example, the term "blight" is applied to diseases of similar symptoms but of quite different causes. Methods of controlling a disease are directly dependent on a knowledge of the nature and cause of the particular trouble. Taking insect pests as an example, it is essential to know whether they are biting or sucking, each class requiring different treatments.

The writer feels that no apology is needed for allowing space in this book to a discussion of the culture of the sweet pea. No matter from what angle we look at it, we cannot deny the fact that plant diseases are directly dependent on the cultural conditions of the host. In other words, the attack of most plant diseases depends on some weak point in the cultural methods which has weakened the host at some phase in its life history. If we accept the definition of disease as any serious deviation from the normal; and admitting as we do that proper cultural conditions are necessary to maintain the proper balance of health of a plant, it becomes self evident that a discussion of culture requirements goes hand in hand with any discussion on plant diseases. To be more specific, it is very apparent that the man who understands plant life in all its aspects will be in a much better position to also cope intelligently with any problem of disease which may confront him at any time. Since growers as a rule must be their own plant doctors they cannot be provided with too much information on cultural requirements of the particular crop with which they are concerned.

Although the writer had considerable experience in growing sweet peas in the open and in the greenhouse, he felt that this ground could be so much better covered by eminent specialists such as Professor Beal of Cornell University; Mr. Cuthbertson, Messrs. Morse and Co., and all the others who are here quoted.

It may perhaps be the opinion of a few that a book on plant pathology should not include a discussion on insect pests. The writer, however, believes that in a specific work of this nature such a discussion is invaluable. Insects are known to be carriers of numerous plant diseases. In this work it would be rather difficult to give a complete discussion of Mosaic, or in fact of any of the other sweet pea diseases if we were to leave out of consideration the damage caused by the Pea Aphis, or any other of the insect pests here described. The writer did not trust to his own knowledge of Entomology. Insect specimens in each case were submitted to the Department of Entomology, United States Department of Agriculture for identification, and there due credit belongs.

This book is primarily intended to be a practical treatise. The aim cannot be attained if our study is to be deprived of its scientific basis and its scientific value. It is hoped this double character of the work will make it a means of ready reference for both growers and investigators.

During the past four years numerous letters of inquiry have been received by the writer from sweet pea growers relative to various difficulties, especially those of a pathological nature. Although hesitating to make hasty suggestions, we could not turn a deaf ear to the numerous requests from sweet pea growers as well as from technical men who urged the preparation of a book of this nature. The writer seriously solicits suggestions or criticism of this work.

Acknowledgments are due to Professor A. C. Beal, Mr. F. G. Cuthbertson, and C. C. Morse and Co. for valuable contributions on the culture of the sweet pea. To Mrs. D. de Sola Pool (née Miss Tamar Hirchensohn), previously of the Faculty of Hunter College, N. Y.; to Dr. Owen Sypherd of Delaware College, to Dr. C. H. Farr of the A. and M. College of Texas, to Dr. M. T. Cook of Rutgers College for suggestions in reading the manuscript. To the Delaware Experiment Station for figs. 7 to 21, 25 to 31, 38, 42, 43, and 45, all of which were originally taken by the author. All the other

figures have been accredited in their proper places.

Last but not least, acknowledgment is due my wife, Esther Michla Taubenhaus, by whose inspiration this work was made possible.

J. J. Taubenhaus.

College Station, Texas.

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS

CULTURE OF THE SWEET PEA

INTRODUCTION

The ancients believed that diseases in plants were induced by evil spirits. For instance, the rust of wheat was thought by the Romans to be caused by the evil spirit Rubigo. The remedy then employed was to frighten away the spirit by beating with drums of various kinds. To-day, some insist that all plant diseases are brought about by conditions of environment such as excessive sunshine, drought, rain or dew. We may perhaps justify these views when we consider that plants in their mute way are unable to tell of their ailments. The keen eye and the close observer, however, have singled out on plants parasitic organisms whose work brings about deviations from the normal. To-day Plant Pathology has become recognized as a definite science. There is hence no reason why we should tolerate certain plant diseases when we realize the vast store of scientific knowledge available. Indeed it is highly imperative that any man who is engaged in the growing of crops should be able to recognize a diseased condition in plants.

Like every science, Plant Pathology has made slow progress in its beginning. Scholars who considered it from a purely speculative or philosophical point of view only were interested in it at first. It was really during the first half of the nineteenth century that Plant Pathology built for itself a solid foundation, and gained a place among the leading sciences. It seems that it was very difficult for scholars previous to the nineteenth century to believe otherwise but that parasitic fungi were emanations or waste products of the higher plants. It was DeBary who first established definitely that healthy plants may be attacked and penetrated by fungi. This important discovery has forever dispelled doubt as to the parasitic nature of most plant diseases. Nevertheless, the economic aspect of Plant Pathology could not gain much impetus as long as growers were content to lose annually from five to forty per cent. of their crops. It required severe epidemics to arouse the attention of farmers in which cases they turned to the scientist for help. An instance of this is the epidemic of late blight of potatoes in Ireland, in 1845, which practically resulted in famine and great hardship to the people. Unfortunately, there were no trained Pathologists at that time to cope with the situation. A similar epidemic was that of downy mildew of grapes in France, in 1882. France, however, met the crisis through one of her noble sons, Professor M. Millardet, then of the Academy of Science at Bordeaux. His keen observations and studies have evolved a remedy for the grape mildew. Millardet was in fact the first to show the value of copper as a fungicide; and incidentally also laid the foundation to modern methods of spraying and of disease prevention in general. To-day Plant Pathologists are everywhere investigating plant diseases which cause serious epidemics. And they are going farther, for the diseases of every weed is important and will aid in the solution of many problems regarding disease in vegetables, fruits and crops.

Although nearly every Agricultural College or University in the United States offers courses in Plant Pathology, the supply of trained investigators is nevertheless limited. Since every Experiment Station is directly supported by state and federal funds, it is natural that every worker is more or less impelled to investigate diseases of plants which are of greatest economic importance. For this reason nearly all the research was directed to fruit, cereal and forage crops. Flower pathology is as yet in its embryonic stage. To-day there are but few institutions of learning which have established definite divisions in the investigation of diseases of ornamental plants. As stated in the preface, the sweet pea diseases have received scant attention, except those worked by the writer. Even in this case for lack of funds the investigations were brought to an untimely end. The little that the writer was able to contribute was made possible through the moral support of the American Sweet Pea Society; and especially by money donations from the various seedsmen and other lovers of the sweet pea in the United States.

It is believed that the present work is fulfilling an urgent need. There never was a time when ornamental plants were grown commercially on a larger scale than to-day. In fact the sweet pea itself forms an industry, the economic importance of which cannot be overlooked. It is within recent memory of all when the hollyhock occupied the place of honor in every garden. In every flower exhibit in this country or abroad it was king. To-day the hollyhock is only mentioned as ancient history. Diseases have so crippled that beautiful plant, that growers out of sheer discouragement have ceased raising it. Now it is found occasionally near abandoned houses or in neglected back yards. The sweet pea is undergoing similar critical periods. In England, for instance, the "Streak" already constitutes a serious menace to profitable sweet pea culture. The same conditions are beginning to prevail in the United States, and several perplexing diseases now threaten the economic existence of one of the most delicate of flowers.

CHAPTER I

HISTORY, EVOLUTION, CLASSIFICATION AND CULTURE[1]

Among the annual flowers none excel the sweet pea in beauty, usefulness, fragrance, and range of color. No annual flower is more popular. If the rose is the Queen of Flowers, the sweet pea is a truly royal princess worthy of her train. This flower has long been grown in England and America; of late years it has been gaining in favor in continental Europe; and it is also extensively grown in far-off Australia and Tasmania.

The sweet pea is a native of the island of Sicily. It was first mentioned in 1695

[1] By Professor A. C. Beal of Cornell University.

by an Italian monk who sent seeds to England and Holland. In England sweet peas were cultivated in many gardens. The plant is one of the species of Lathyrus, which is a genus of Leguminosæ. Unlike other species of this genus, the sweet pea has fragrance, and Linnæus gave it the name of odoratus. Its scientific name, therefore, is *Lathyrus odoratus*. The color of the original sweet pea was purple in the standard, and sky-blue in the wings.

During the first one hundred years of its history there was little improvement in the sweet pea. A variety with white flowers and another with pink and white flowers were developed. The first half of its second century of cultivation was signalized by the development of several varieties, so that in 1860 there were nine known varieties. About this time seedsmen began to take greater interest in sweet peas; but more varieties came in slowly. Every flower, however, that has won popular favor has had at least one great genius to develop it. The greatest genius in sweet peas was Henry Eckford, who commenced crossing the best obtainable varieties about 1878, and began to sell new varieties in 1883. Steadily he kept at work until, at his death in 1905, although the number had increased to more than three hundred, he was to be credited with originating most of the leading varieties. About 1890, the American sweet pea growers began to appreciate the beautiful varieties Mr. Eckford was sending out and there was a wave of popularity for the flower. The discovery that California had a favorable climate for the production of sweet pea seed enabled the seedsmen to supply the greatly increased demand. This development has continued until the larger part of the world's supply now comes from California.

Meanwhile the variety Blanche Ferry was discovered growing in a garden in New York State and was put on the market in 1889. From this was developed the varieties Early Blanche Ferry, Earliest of All, Earliest White, and the whole race of winter-flowering sweet peas. The American originators have given us many good striped varieties, such as America, Aurora, etc., and also such blues as Navy Blue and Flora Norton. Other notable varieties are Helen Pierce, Dainty, Janet Scott, Emily Henderson, Phenomenal, Stella Morse, Admiration, Shasta, and White Wonder. The dwarf or Cupid sweet peas originated in California and were offered in 1896.

During the closing years of Mr. Eckford's busy life, at a time when some growers thought that the limit of development in sweet peas had almost been reached, a new type of sweet peas appeared. This was the waved or Spencer type. The first variety, Countess Spencer, sent out by Mr. Cole (the originator) in 1904, was at once very popular, and since that time there has been an extraordinary interest in sweet peas on both sides of the Atlantic. However, the greatest interest has been in England, where a great many persons are interested in originating new varieties and a large number are placed on the market each year. Numerous exhibitions are held, and the National Sweet Pea Society has over one thousand members.

Although the interest in sweet peas in America is not so intense, yet this flower is seen in almost every home garden, where it is cherished for its special beauty.

The sweet pea may be classified according to the habit of the plant into

Climbing: { Garden varieties
Winter-flowering

Dwarf: { Cupids
Bush varieties (now obsolete)

It is important to remember that the winter-flowering varieties are absolutely distinct from the garden varieties in their habit of growth. The Cupids are occasionally grown because of their novelty.

Sweet peas are usually classified according to the form of the flower. The earliest known varieties of the sweet pea had flowers in which the standards were reflexed and deeply notched at the apex. The effort of Mr. Eckford and others was to eliminate the notch and give the standard greater substance so that it could hold itself erect. This brought about the open form which often retained something of the apical notch. Then came the hooded form, in which the edges of the standards are rolled forward. There are various degrees of hooding in different varieties. Extreme hoodings were at one time recognized under the name of snapdragon varieties, which were never more than a passing novelty. Finally, there is the waved form in which the edges of the standards and often the wings are beautifully waved. This is the most handsome form of sweet pea flower (the flowers are larger and have longer stems), and it is probable that the other forms will pass away. The older types, however, seed more freely, and therefore it has been possible to produce seed more cheaply. However, any one who has grown the waved or Spencer varieties will not again take up the culture of the old varieties, and therefore in the course of time the latter are doomed.

The following is a classification of sweet peas according to form:

Garden type	*Winter-flowering type*	*Dwarf Type* (Cupid)
Open form	Open form	Open form
Hooded form	Hooded form	Hooded form
Waved form	Waved form	

Sweet peas are classified also according to color. The English Sweet Pea Society recognizes thirty-two color classes as follows: Bicolor; Blue; Blush; Carmine; Cerise; Cream, Buff, and Ivory; Cream-pink (Pale); Cream-pink (Deep); Crimson; Fancy; Lavender; Lilac; Magenta; Marbled and Watered; Maroon; Maroon Purple; Maroon Red; Mauve (Dark); Mauve (Pale); Orange-pink; Orange Scarlet; Picotee Edged (Cream Ground); Picotee Edged (White Ground); Pink (Deep); Pink (Pale); Rose; Salmon Shades; Scarlet; Striped and Flaked

(Purple and Blue); Striped and Flaked (Chocolate on Gray Ground); Striped and Flaked (Red and Rose); White.

When one compares this with the following classification used in a prominent seedsman's catalogue only fifteen years ago, one can appreciate the marvelous development in the sweet pea. This catalogue grouped all varieties under White, Cream, Light Yellow, Light Blush, Light Pink, Deep Pink, Rose, Red and Scarlet, Shades of Orange and Salmon, Pink and White, Blue and White, Claret and Maroon, Striped and Variegated, Lavender and Light Blue, and Blue and Purple.

Varieties

Catalogues usually classify sweet peas according to color with a separate list of the winter-flowering varieties.

More than twelve hundred varieties

of sweet peas have been introduced. Many varieties have passed into oblivion, but there are large numbers in the trade and every season witnesses a considerable number of aspirants for public favor. The following list is the result of testing hundreds of varieties during the last few years. It is a matter of personal taste whether some of the colors, as represented by the color sections, are desirable for any particular garden. The classification will enable any one to select those colors and varieties suited to individual tastes.

WAVED VARIETIES

Bicolor—Mrs. Cuthbertson, Colleen

Blue—Margaret Madison, Flora Norton Spencer, Blue Jacket

Blush—Lady Evelyn Eyre, Princess Victoria, Florence Morse Spencer

Carmine—John Ingman

Cerise—Chrissie Unwin

Cream, Buff, and Ivory—Primrose Spencer, Isabel Malcolm, Primrose Beauty, Lady Knox, Queen Victoria Spencer.

Cream-pink (Deep)—Mrs. Gibbs Box, Constance Oliver

Cream-pink (Pale)—Mrs. Routzahn, Lady Miller, Mrs. Hugh Dickson

Crimson—King Edward Spencer

Fancy—Afterglow

Lavender—Florence Nightingale

Magenta—Menie Christie

Marbled—May Campbell

Maroon—Nubian, King Manuel

Maroon-purple—Arthur Green

Maroon-red—Brunette, Red Chief

Mauve (Dark)—Tennant Spencer

Mauve (Pale)—Mrs. Heslington, Mauve Queen

Orange-pink—Edrom Beauty, Carene, Helen Lewis

Orange-scarlet—Thomas Stevenson

Picotee edged (Cream ground)—Evelyn Hemus, Mrs. C. W. Breadmore

Picotee edged (White ground)—Dainty Spencer, Elsie Herbert, Martha Washington

Pink (Deep)—Hercules, Countess Spencer

Pink (Pale)—Elfrida Pearson

Rose—Marie Corelli, Rosabelle

Salmon Shades—Stirling Stent, Melba, Barbara

Scarlet—Dobbie's Scarlet, Scarlet Emperor, Red Star

Striped and Flaked (Chocolate on gray ground) —Senator Spencer

Striped and Flaked (Purple and blue)—Loyalty

Striped and Flaked (Red and rose)—America Spencer, Aurora Spencer, Mrs. W. J. Unwin

White—White Spencer, Nora Unwin

VARIETIES OF OPEN AND HOODED FORMS

Bicolor—Blanche Ferry, Jeannie Gordon

Blue—Brilliant Blue, Navy Blue

Blue (Light)—Flora Norton

Blush—Modesty

Cerise—Coccinea

Cream, Buff and Ivory—Zarina, The Honorable Mrs. E. Kenyon, Queen Victoria

Crimson—King Edward VII

Lavender—Lady Grizel Hamilton

Marbled—Helen Pierce

Maroon—Black Knight, Othello

Mauve—Admiration, Mrs. Walter Wright, Dorothy Tennant

Orange Shades—Henry Eckford, Miss Wilmott

Picotee edged—Dainty, Lottie Eckford, Phenomenal

Pink—Prima Donna, Lovely, Katherine Tracy, Janet Scott

Rose and Carmine—Lord Roseberry

Scarlet—Queen Alexandra

Striped and Flaked (Chocolate on gray ground) —Senator

Striped and Flaked (Purple and blue)—Princess of Wales, Hester

Striped and Flaked (Red and rose)—America, Aurora, Romona

White—Dorothy Eckford, Shasta, Emily Henderson, White Wonder

EARLY-FLOWERING VARIETIES

Bicolor—Earliest of All

Blue—Le Marquis

Lavender—Mrs. Alexander Wallace

Primrose—Earliest Sunbeams

Salmon-pink—Mrs. William Sim

MARKET VARIETIES

Open and hooded varieties—Dorothy Eckford, King Edward VII, Brilliant Blue, Lady Grizel Hamilton, Prima Donna, Blanche Ferry

Waved varieties—Countess Spencer, Nora Unwin, Asta Ohn, King Edward Spencer

Cultural Requirements

Site. Sweet peas should be planted where they can get the maximum amount of sunlight, and the rows should run north and south. A free circulation of air is beneficial, but the best site is one which is not swept by strong winds, which break the plants from their supports and injure the stems of the plants. Any injury to the stem of the plant invariably results in smaller flowers and shorter flower stems.

Soil. Any garden soil is suitable for sweet peas, provided it is sufficiently drained so that in periods of excessive rains the water will not lie upon the surface about plants, and thus cause them to become yellow or to decay at the roots. Soil suitable for growing vegetables usually gives good results, but extra care in the selection and preparation of the soil will be repaid in larger flowers, longer stems, better colors, and a longer blooming period.

Preparation. The sweet pea is a deep-rooting plant, and in order to provide suitable conditions so that the effects of drought will be overcome, the preparation of the soil must be deep and thorough. Whatever the nature of the soil, unquestionably the best preparation can be made by trenching the soil in the autumn. This means turning the soil to a depth ranging from 18 inches to as much as three feet. In America this method is usually found too expensive, and instead a trench 15 to 18 inches wide along the line of the rows is used. The soil is removed and replaced with prepared soil made by composting sod from an old pasture with manure. If this method cannot be followed, the top soil, to the depth of one foot, can be thrown out on one side of the trench and the lower soil broken up as deep as possible with a pick. If a good application of stable manure can be mixed with the subsoil the results are better. Often a layer of leaves or coarse manure placed in the bottom of the deep trench serves to promote drainage. In all cases the trenches should be from 18 inches to two feet deep, and it is a good plan to work in all the manure possible. It does not matter in the fall-preparation of the soil if the manure is fresh, but of course strawy manure will not do except in the bottom of the trench. A good application of lime should be made while preparing the soil in the autumn.

Many soils that have been cultivated for a long time are acid, and therefore not adapted for growing leguminous plants such as clover or sweet peas even though the soil may be fertile. The lime corrects this condition, and also releases plant food which otherwise would not soon become available. Clay soils are made more open and porous by the action of lime.

Planting

The Seed. Some primrose and white-flowered varieties have white or light-colored seeds, and some have black seeds. The white seeds often rot in the soil, especially if they are planted early when the soil is cold, or because their germinating power has been impaired; also they frequently split in the pod before harvesting and in this condition are likely soon to lose their vitality. For the foregoing reasons it is advisable to sow seeds of this color close together and not so deep as the black-seeded varieties.

In some seasons, sweet pea seeds are slow in germinating. It is well to examine such seeds in order to ascertain their condition. If the seeds are found dormant but still fresh and plump, the seed-coats should be cut with a sharp knife and replanted; they will then germinate well. This difficulty is not confined to the sweet pea; some of the other species of Lathyrus behave similarly. The trouble usually follows a very hot dry season, when the seed becomes so excessively ripened as to render the seed-coat impervious to water. Sometimes, in order to expedite germination, the seeds are soaked; a better method for the amateur is that recommended by Mr. Hutchins. He places the seed packets in moist earth for seven or eight days.

He then takes them out and examines them; the swollen seeds are planted, and the others cut with a knife.

Fall Planting. Often the finest as well as the earlier flowers are secured from plants the seed of which was sown in the fall. South of the latitude of New York City this time of sowing can be recommended. North of this line this method cannot always be depended upon unless a sandy, well-drained soil is chosen. If the water does not lie upon the ground in winter, and particularly if there is little or no freezing and thawing, it is advisable to give this method of planting a trial. The same preparation of the soil is made as described above, but care must be taken to firm the soil so that it does not settle. The trench or furrow should be filled so as to allow for a slight settling of the soil, thus producing a slightly crowning ridge. In this ridge a little furrow, two inches deep, should be made; or, if preferred, two small furrows of equal depth six inches apart may be made. The seeds should be sown one or two inches apart in these furrows and covered so that the surface is slightly ridged for drainage. The most important point in fall planting of sweet peas is to plant so late that the plants do not appear above the surface before freezing. In the Northern states, if the plants appear above the surface of the ground, they will be killed by the winter. Seed that have only "sprouted," however, will not be harmed. In central New York it has been found that after November 10 is the best time to sow, but, of course, this varies with the season.

After the ground freezes, a mulch of manure should be placed over the row, and if the snow remains upon the ground all the winter the conditions are most favorable. The approach of bright weather in spring is the time to examine your sweet peas to see whether they are growing. Often the manure mulch keeps the soil soggy and cold when the bare soil is becoming dry and warm. In such cases remove a portion or all of the mulch, leaving it between the rows or near at hand, so that if there should be a cold wave it can be used to cover the plants. The plants from fall-sown seed get an earlier start than it is possible to secure by sowing in the spring. The seed of standard varieties of sweet peas is so cheap that the fall-planting of sweet peas is an effort well worth while.

Spring Planting. As soon as the frost is out of the ground and the soil is in workable condition in the spring, a heavy application of superphosphate of lime should be made and raked in. Care should be exercised not to get the soil too loose, and for this reason it is best to confine all stirring of the soil to smoothing the surface. Especially is this true with light soils, which, if stirred deeply in the spring, must be well firmed. Heavy soils that are likely to bake may be improved by working in a light dressing of old, thoroughly rotted manure.

Sweet peas should be sown as early in the spring as the soil is dry enough to work, even though it is probable that heavy frosts will follow. The writer thinks that one reason why even the most inexperienced amateur usually has such good average results with sweet peas, is that he gets his annual "violent attack of gardening fever" in early spring, and he begins his operations at just the right time for sweet peas to go into the ground.

An essential requirement in growing sweet peas is to plant early, while the atmospheric conditions are such as to prevent top growth before the plant has started a vigorous root development. The result is that, when warmer weather comes, the top grows strong and heavy, the plant branches out, and throughout the season this increased vigor is evident. Experiments made by sowing seeds every ten days from the earliest practicable date until the end of May indicate that early planting is desirable.

DEPTH. If the preparation of the soil has been made in the fall, it is advisable to smooth the surface of the trench and plant in this. When the preparation has been made in the spring the soil must not be left too loose—a condition that may easily occur if a deep trench is made and only loosely filled with soil and manure.

One method recommended is to hollow out a broad trench, twenty-four to thirty inches wide and two inches deep, and then sow the seed one inch deep in single or double rows. The trench should be kept open for six weeks in order to retain the water. This system is very good in a garden where all cultivation is given by hand; but where many rows are grown and cultivation is done with a horse and cultivator, it is manifestly impossible to make or to maintain such a trench. Furthermore, when horse cultivation is used there is difficulty in keeping the young plants, if planted below the surface, from being covered during the early cultivations. Therefore, planting on the level is necessary in field culture. It is advisable, however, in garden culture, to plant so that when covered the row will be two inches below the ordinary level.

The seed may be sown in single or double drills as described under fall-planting. It is advisable to sow the seeds one or two inches apart; if it is suspected that a good germination will not result, more seed should be sown.

THINNING. Many persons do not thin their plants, and in many cases the reason that poor flowers are obtained is because of overcrowding. On the other hand, the practice of English growers of thinning the plants so that they stand several inches apart, will not bring successful results in our climate. It is difficult to give instructions that will apply everywhere; but under conditions in New York state thinning the plants so that they are from four to six inches apart has given the best results.

American sweet-pea growers almost invariably plant sweet peas in rows, but garden lovers are advised to try the method of planting sweet peas in small circles or even in clumps. Grown in this manner, sweet peas may be effectively used in the flower garden and in borders. The preparation of the soil is similar to that for the other method of planting.

Sowing in Pots for Outdoor Bloom. Many English growers practice sowing in pots under glass, hardening the plants in frames, and planting out. From his own experience, the writer is inclined to look on this method with favor, especially in growing high-priced novelties or varieties for exhibition.

In the greenhouse the seed may be sown in February or March. Usually it is best to sow about six weeks before one expects to plant in the open ground. The seeds are sown in three and one-half or four-inch pots, using a good compost of rotted sod, well-decayed manure or leaf mold, and sand. A little of the rougher portion of the turf should be placed in the bottom of the pot to insure drainage. Fill the pots firmly to within one and one-half inches of the top and sow four seeds at equal distances apart, and cover them with an inch of soil. Label each variety carefully as the seed is sown. The pots are then placed in a cool greenhouse; and after germination, if the weather is favorable, transferred to cold-frames to harden the plants. The pots may be placed in cold-frames immediately after sowing, but they cannot be sown as early as in the greenhouse. The seeds of some of the new varieties appear to have thick seed-coats, and therefore do not germinate readily. Such seeds should be clipped with a knife so that the moisture can penetrate the seed-coats. After the plants appear the pots should be kept near the glass so that the plants will be dwarf and sturdy. Care must be employed in watering so that the soil does not become sour; and watering the pots in frames should be done in clear weather so that the plants will dry off before night, for if the night is frosty the plants may suffer. In severe weather the frames must be protected by mats and banked up with manure. The frames must be kept well ventilated, and as warm weather advances the sash should be entirely removed during the day. Proper handling during planting out will insure success.

If the plants begin to form tendrils, a few twigs should be inserted to support the plants. Results of the neglect of this important requirement will be apparent later in the season. Except when grown for market purposes, for which earliness is an important consideration, it is advisable for the amateur to delay the sowing so that the plants in pots do not become tall enough to require much support. The usual practice is to plant these pot-clumps twelve to eighteen inches apart in the row. The entire potful is planted without disturbing the twigs supporting the plants. It is better to pick out the crock from the ball since it loosens the tips of the roots which, when planted, are encouraged to strike down into the soil. Sometimes, the roots are long, and therefore are wound around the ball of earth in the pot; if they are not loosened, they may continue to grow in the same manner, thus not establishing connection with the soil prepared for the plants. It is essential to keep the roots growing down into the cooler, moister soil. No difficulty will be experienced in planting sweet peas from pots, provided they have been given a good watering the day before planting, which will aid in keeping the ball of earth entire when the plants are knocked out of the pots. If the soil is dry when the planting is done, it will often be advisable to water the plants when they are set. Under normal conditions, however, this practice is not advised.

THE CORDON SYSTEM.[1] After transplanting, pinch off the tip or growing point of the plant and allow only two laterals to develop. Pinch off all others and thereafter allow only two shoots on each plant. If the ground has previously been well firmed down, the plants will be sturdy and short jointed, producing an abundance of blossoms. For the cordon system the plants should be trained up on tall sticks about ten feet high, which have been securely fastened at their upper end to a stretched wire. A good practice is to have

[1] By Frank G. Cuthbertson, Sweet Pea Specialist.

Fig. 1.—Method of growing Sweet Peas for seed in England. The vines are trained on tree boughs, and the pods gathered by hand.

View at Dobbie and Co.'s seed farm, England.

a double row of plants about ten inches apart and a double row of stakes or supports. If stakes cannot be had, strings may be stretched from a line of wire ten feet high down to the plants and pegged down. The shoots will have to be tied to the stakes or strings as fast as they grow, thus preventing the breaking of stems and blossoms. The tendrils should also be cut off, as well as all laterals as they appear.

By following the cordon system the leaves will be very large and the flowers will have standards of one and one-half or two inches across.

SUPPORTS. Among English sweet pea growers there is considerable unanimity of opinion that sticks form the best support for sweet peas (fig. 1). The replies of fifty-two leading experts, published in the *Sweet Pea Annual* for 1907, show that forty-three growers favor sticks (generally hazel sticks), five favor wire netting, two favor either sticks or wire netting (the netting if new to be painted), one prefers sticks and string, and the remaining one, a correspondent from British Columbia, uses telephone wire and string.

In this country, where good twiggy boughs can be obtained such boughs unquestionably form the best support to use since they are the most natural. In many places birch boughs can be obtained in lengths of twelve to fourteen feet. These may be prepared in the lengths desired.

The height of the support must be determined by the grower. If the soil has been prepared properly and the plants look strong, and if the grower waters the plants properly and gives them every care, then the support should be six feet high. If the soil is only moderately fertile or has not been properly prepared, or if the grower does not intend to keep all seed-pods picked off or cannot water the plants in order to overcome drought, the support should be kept down to four feet. The variety has something to do with the height of the support, whatever the care bestowed, some varieties being naturally dwarfs.

The sticks should be cut in late winter or very early spring so that they are rather green and tough enough to bear the load until the end of the season. They should be inserted in the soil at least a foot, because when they are clothed with vines to a height of six feet a strong windstorm exerts a tremendous leverage on them. If the sticks have not been inserted deeply, or if they have become dead and brittle, the row will go down under the force of the wind and the great weight of the wet vines. In order to guard against disaster, strong stakes are sometimes placed every ten feet and wire is run lengthwise through the sticks and fastened to the stakes. It is desirable to have the sticks more bushy at the top than at the base, so that they spread out more than at the base; if not naturally so, leaning the sticks alternately outward will produce this result. This method gives greater freedom for the vines when they are in flower.

After the sticks are inserted, a better effect is produced if the tops are clipped to a level and straggling ends are cut back. If the sticks are not "feathered" sufficiently at the base for the plants to start up on them, the clippings from the tops may be inserted between the tall sticks. Some growers make a practice—and it is a good one—of providing a light support when the plants are one to three inches high, and later placing the tall sticks. For the light support they often use old raspberry canes, in fact, anything of a light, much-branched character. This affords protection from high winds when the plants are small.

NETTING. When other systems of supporting are to be employed, it is quite imperative to provide a support of small, short twigs as soon as the seedlings begin to produce tendrils. This method prevents the rain from beating the small plants down, and enables them to get up to the other support. In city gardens, owing to the difficulty in procuring suitable sticks, wire netting makes a very satisfactory support. The peas do not cling to it so well, but it is cleaner and neater in appearance, and thus offers a compensating advantage. The large mesh (four-inch) is preferable; but in many places this is not procurable and the ordinary chicken netting, or fence, is used instead. Strong stakes at intervals not to exceed ten feet are used to support the netting. One advantage of wire netting is that if stakes six feet high are used, a forty-two or forty-eight-inch strip of netting may be placed in position; and, if the season or soil is favorable and the peas grow above this, a narrow strip of netting may be added or a string or wire stretched from stake to stake over the row. A well-galvanized netting can be used repeatedly for several years, and will last longer if taken off in the fall and stored.

String. Another method is to construct a support of wire and string, or of string alone. The ingenious grower can construct all sorts of fanciful designs with wire and string on posts set not over ten feet apart. Sometimes a wooden strip is nailed horizontally at the top and bottom, but often a wire is used instead. From bottom to top, between these horizontal strips or wires, a homemade network can be constructed. When the peas are grown in double drills, the construction described above is made on each side in box-like form.

When sweet peas are grown in single drills, especially on a considerable scale, the best and cheapest support is one made by placing stakes at intervals of less than ten feet and winding strong cord around the row from stake to stake. The strings are placed six to eight inches apart, or closer if necessary. If the stakes are too far apart—ten feet or more—the string will stretch after becoming wet or even damp, and the plants will fall over. If appearance is not an object, anything will serve for stakes, e.g., tailings from the mills, poles, and the like. If neat stakes are used, the string method is very good for the garden as the vines cling to it better than to wire netting, which furthermore becomes hot in the summer. At the end of the season, if the stakes are worthless, the whole support as well as the vines may be burned.

The foregoing method applies to sweet peas grown in rows. Sweet peas are sometimes grown in clumps and must be supported. Here again sticks are often favored, especially where the plants occupy a circle six feet or more in circumference. Wire netting cut in suitable lengths may be made into cylinders for clumps of any size.

Henry Eckford recommends a sweet pea support consisting of four stakes, each in two pieces three feet long. These are placed ninety degrees apart around a circle and three-foot netting is stretched around them. When the peas reach the top, if greater height is needed, the upper half of each stake is fitted by means of a mortise into the top of the one already driven and another strip of netting is put on.

An English seedsman advertises sweet pea ladders for use in training the vines in garden decoration. The ladders are made six feet long and six inches wide. They are used perpendicularly, the tops being fastened to a horizontal wire. Two rows are supported by leaning the tops together and fastening them to an overhead horizontal wire. Plants grown in circles may be brought together in the center at the top where the ladders are fastened to a center stake. Sweet pea arches about six feet high are sometimes made.

The ladders can be easily made with two No. 10 galvanized wire rose stakes of the proper length, and some smaller wire for the rungs or cross wires. These, of course, should never be over six feet high or they would seldom be covered. The arches can also be made complete, if desired, by merely making the ladder long enough and bending it into the form of an arch.

Cultivation

Tillage. Sweet peas need frequent cultivation. A loose dust mulch upon the surface must be constantly maintained in order to retain the moisture for the plants. Amateurs often fail because they do not cultivate their sweet peas, but depend upon artificial watering, which will not bring the same results as stirring the soil. The surface should be kept loose with a rake, and if this condition is maintained there is usually little need of artificial watering.

WATERING. This practice often results in more harm than good. During periods of drought it may be advisable to apply water. If so, apply liberally so that the soil is thoroughly soaked. It is also important to remember that having begun to water, it is necessary to keep it up until the rains come. Two or three applications a week will probably be required.

MULCHING. A mulch of thoroughly rotted manure around the plants will assist in lessening the effects of a drought; or if water is also applied, the mulch will enable the plants to get the benefit of it by preventing rapid evaporation.

DISPODDING. A long period of bloom cannot be had unless the seed-pods are consistently picked off. Even the best cultural methods go for naught unless this operation is given careful attention. The importance of watering has been over emphasized, whereas the true explanation of success lies in the removal of all pods as soon as the flowers wither. If delayed until the seed-pods are well developed, their removal is of little benefit to the plant. If one desires to save seed, it is best to mark vigorous plants and save seed from them. As the plants usually flower freely, few plants are necessary to supply all the seeds required by the amateur. All plants not required for seed production should be kept free of seed-pods so that they will continue to produce flowers. Cutting all of the best flower spikes does not produce the desired results, unless the plants are gone over frequently, many short-stemmed or inferior flowers will form pods and in a very short time the strength of the plant will be utilized in developing these in the effort to reproduce itself. To obtain good flowers for the longest period of time the grower must destroy promptly and thoroughly the withered flowers.

An English sweet pea expert has concisely summarized sweet pea culture as follows:

"Sweet Pea Culture, condensed in these words. Trench deeply; manure liberally; plant thinly; stake quickly; water freely; dispod promptly."

Marketing

Picking. The ideal time to pick sweet peas is two or three hours before they are needed or are to be placed on the market. This length of time is the period the blooms should remain in water. During this period many varieties will improve in size and color, and of course it is desirable to have flowers at their best when they are to be sold.

If the flowers are to be shipped to market, the time in transit must be added. These factors will govern the time of picking. It is best, however, to pick in the morning or late afternoon.

The stage at which the flower spikes are picked will depend upon the foregoing factors, and also upon the weather and temperature conditions. The spikes ought to be picked when the upper flower is about one-half open.

In picking, a knife or scissors should not be used, but the spikes should be pulled. A quick side pull, while holding the stem near the base, will usually accomplish the result without damage to the plant. As soon as picked, the flowers should be placed in water. Vases about eight inches in diameter, and the same in depth, are about right, since the stems can be plunged six or seven inches. Sometimes eight-inch pots are taken and the bottom opening plugged up so as to make sweet-pea vases. These are excellent because they have the best form to keep the flowers in the proper position.

Packing

Sweet peas are bunched before packing, twenty-five flowers usually being put in each bunch. If the bunches are made flat instead of round, they will pack much better. Tie the stems near the base and never near the flowers. A flat box for one or two layers of bunches is the best package. The corrugated and folding paper boxes will probably be found to give the best results. It is essential that the bunches be packed tight enough to prevent bruising. Some make a practice of wrapping each bunch in wax paper. The boxes should be properly lined with paper before the bunches are put in.

Exhibiting Sweet Peas

The foundation for success in raising sweet peas for exhibition is laid the previous autumn in the thorough preparation of the soil, followed by a careful selection of varieties, thin planting, and liberal culture. In order that good flowers may be obtained for exhibition, it is best to remove all flowers about a week before the date of the exhibition, and to allow only the spikes with the longest stems to develop. The size of the flowers may be increased at this time by the use of ammonia or nitrate of soda applied to the soil.

All varieties subject to scorch or scald should be shaded with cheesecloth or tiffany. If such varieties are planted together, the shading may be more easily accomplished. The varieties which have orange in their coloration—that is, Henry

Eckford, St. George, and Helen Lewis—the salmon varieties, and possibly some of the scarlets and blues, should be shaded for four to six days previous to the time the flowers will be needed. The shade should be so arranged that it can be removed at night.

The sweet peas having been well grown, with stems twelve to fifteen inches long, the next consideration is the cutting of the flowers; for it is one thing to grow good flowers, and quite another, but equally difficult, to exhibit successfully.

Sweet pea flowers, especially for exhibition, should be cut while dry, preferably in the morning or evening. The proper stage of development will depend on the number of hours that must elapse before the judge can pass upon the exhibit. Flowers cut the day before exhibiting should be taken with the lower flowers open and the top ones in bud. Those with four flowers on a spike may be taken with the two lower flowers open, the third flower opening, and the topmost one in bud. The flowers should be placed immediately in cool water and removed to a cool, dark room or cellar until they are packed. Here they are left until the latest moment consistent with their timely arrival at the exhibition hall, not more than six or seven hours if possible.

When packing, the stems should be squeezed in order to remove surplus water and then wrapped in a strip of oiled paper. Great care should be exercised not to get water on the flowers. Each bunch should be wrapped in tissue paper and the bunches packed not too tightly as to crush the flowers.

Everything is necessary to insure the prompt arrival of the flowers at the exhibition hall, where they are unpacked and loosely arranged so that they may resume their natural form after the journey.

The flowers having been put in water, the work of arranging the exhibition vases should begin. George W. Kerr, an experienced exhibitor, gives the following directions for the arrangement of flowers:

"In staging the flowers never crowd them. Let every flower 'speak for itself.' Twenty sprays make a nice vase, and the best method of arranging them is to start by putting some grass (cut two inches long) in the mouth of the vase, as this helps to keep the stems in position. Each stem must be put in separately. Let every flower be seen as far as possible and all face one way, with the exception of such varieties as have the back of the standards tinted in coloring other than the ground color of the flower, when the position of such might be judiciously varied. One or two pieces of foliage—a little Gysophila —or light grass, such as Agrostis neublosa, might with advantage be used. But this should not be overdone, and only if the rules allow of it.

"In staging a collection of twelve varieties, they should be placed in three rows, the back rows being tiered eight or nine inches above the other, and arrange the colors so that they do not clash. Even if the show schedule does not ask for it, name each variety with a neat card placed at the base of each vase."

Two very important points for the exhibitor to observe are: (1) follow the rules as to the number of stems per vase and foliage allowed; (2) see to it that the flowers are true to name. Varieties of distinct colors should be used and those that are very nearly like others in the exhibit excluded. Finally, in placing the vases, it is important not to lose sight of the fact that a good color scheme is a great aid to success.

CHAPTER II

CULTURE OF SWEET PEAS FOR SEEDS[1]

LAYMEN who visit a large seed farm in California marvel at the acreage of sweet peas in that state and wonder how the enormous output will be disposed of. But it must be borne in mind that California grows fully 75 per cent of the sweet peas used all over the world. About 50 per cent of the sweet peas grown in California are exported. Of these much is sent to Great Britain, the remaining 50 per cent to Holland, France, Germany, New Zealand, and Australia. The gardening public of Great Britain, aided by the seedsmen, quickly realized the possibilities of the sweet pea as an exhibition and decora-

[1] By C. C. Morse and Co. of California.

tive flower. Other countries are now gradually taking more sweet peas and the future may bring a larger export business. In the United States only a small proportion of sweet peas is grown. However, the public is beginning to grow more of that flower every year, and especially the newer Spencer types. On an everage the acreage of sweet peas in California is about 2000 acres with about 50 per cent Grandifloras, and 50 per cent Spencers. The value of this crop to the growers is about $250,000. The crop obtained from an acre of sweet peas varies very largely according to season, but an average yield of Grandifloras would be about 800 lb. per acre; that of a good strain of Spencers about 250 lb. per acre. Owing to the peculiar formation of the floral parts, the Spencers are not so prolific as the Grandifloras. In the latter the keel of the flower is clamped, enclosing the stigma and the anthers; whereas in the Spencers, the keel is full or open and the stigma protrudes farther out than the anthers, thus interfering with complete pollination. It would be hard to estimate the value of the sweet pea seed to the wholesalers and retailers of the United States, but it is safe to put it down to about $600,000. There is no acreage of sweet peas worth mentioning grown in the United States outside of California. A few acres of high class varieties are grown in England and in the other countries above mentioned. Except in cases of stock seed of new varieties, no sweet pea seed is imported in California.

When most people think of California as a seed growing state, they have the idea that it is a land where the only thing the grower has to do is to plant and to harvest, and that California does the rest. The seedman in California, however, has his trials and troubles like all others and he has all the scope he wants for his practical ingenuity; probably there is more need of it there than in any other state or country. It may surprise many to learn that there are comparatively few valleys or parts of valleys suitable for sweet peas in California. This in itself already offers the grower a chance to use the best of his skill and ingenuity. In California, the sweet pea does best in a rich heavy loam or a rich sediment soil. Too heavy and too sandy soils are unfit for that plant.

The best climate is one which never gets too hot during flowering season, and the best results have been obtained in valleys where the fog rolls in from the ocean in the evening, keeping the air moist and cool. A hot spell during blossoming is often fatal to the crop, especially if it is grown on light land; and if the rainfall has been slight even on the heavier lands, the vines burn up completely. When the soil is of a loamy character and the climate foggy, fifteen inches of rain are sufficient to carry the crop.

The land is best when dry plowed, just as soon as the previous crop is off in the fall. Thus when the rain works through the clods the particles of soil crumble and become pulverized, leaving the soil in good shape for early planting. In California it has not been found necessary as yet to apply any fertilizer to sweet peas. They can be grown year after year on the same land, often producing better crops each year, provided, of course, that diseases are kept out. To get the best results in California, sow the seeds in November or December if possible. As soon as the clods can be broken down by a disk plow or harrow, the work should be started. The peas are drilled in rows about three feet apart by a two-horse drill, sowing two drills at a time and from eight to fifteen pounds per acre. The acreage which can be sown per day depends upon many things such as the condition of the land and the size of the plot to be planted, but an average of ten acres per day would be about right. The planter is set to place the seeds about one inch deep, this being deep enough for California conditions.

When the plants are high enough so that the rows may be easily seen, the field is cultivated by a two-horse "riding" cultivator; and if the weeds have started, the plants are given their first hoeing. During the months of February, March, and April, the cultivators are kept going over the field until the meeting of the vines between the rows prevents further cultivation. It is generally necessary to hoe the crop three times.

Sweet peas are never given supports or stakes in California. The vines meet in the rows and by supporting one another soon grow to quite a height. In a good season they may grow five or more feet high. In California each plant sends out a very large number of shoots immediately above ground so that the fields are very thick and in flowering season are just one mass of blossom.

The most important problem is that of "rogueing" and of selection. This is especially the case with Spencer sweet peas. The stock seed should be right; otherwise enormous expense and labor are entailed in rogueing the great mass of plants in flower, and great damage is done. Should some rogues be allowed to seed, the stock is not only reduced in value, but the land that the variety is grown on is fouled for all time. Sweet peas will volunteer for five or six years, often longer. It may thus readily be seen that it pays the grower to be careful of his stock when sweet pea land is scarce. Rogueing sweet peas consists in taking out all wrong colors and wrong types. The color rogues are fairly easy to see, but it takes a trained eye to pick out the type rogues; and this work has to be most carefully done. Should a Grandiflora plant be allowed to remain in a crop of Spencers, it would spoil the latter in a short time. The rogues are cut out with a knife below the level of the ground so that the plant will not sprout again and give further trouble.

The careful grower has his stock seed grown and selected carefully before he plants his acreage. He knows the pedigree of his stock and if he has done his work thoroughly he can depend on a crop true to type.

The season of harvest varies. Cutting, which is done with the mower, usually commences in July. Judgment must be exercised as to the proper time for harvest. The vines are ordinarily cut when it is considered that most of the pods are ripe. Immediately after cutting, the vines are piled on large pieces of canvas which are placed on the ground where the crop has been growing. These sheets are generally forty feet square. When the vines are thoroughly dry the thrasher and separator are hauled to the patch and a portable gasoline engine supplies the driving power. The fields of sweet peas are so planned that the thresher will not by any chance let any seed drop elsewhere than on the area occupied by the variety. After each variety is finished the separator is thoroughly cleaned out and run empty for a while so that no seed will be left in to mix with the next variety to be threshed. Stock seed is generally threshed by flail in order to avoid all possible chance of mixture. After this the seed is taken to the cleaning house and put through a series of fans and screens to take out all chaff and small and broken seeds.

The raising of new varieties is very interesting. All careful breeders work on the Mendelian principle, and since the realization of the importance of these laws, there has been less unfixed stock put on the market. The following is a brief statement of the procedure for raising new varieties. The flower to be pollinated must be in a very young stage, generally a bud before the color even begins to show. As the sweet pea blossom sheds its pollen in the bud stage, the selection has to be made carefully. The buds being selected, the keel is split open with a sharp knife and all the stamens are carefully removed. The stigma is carefully examined to see that no pollen has been deposited accidentally. Then pollen is carefully gathered from the other parent and deposited with a fine camel's hair brush on the stigma of the flower from which the stamens have been removed. The artificially pollinated blossom is now wrapped in a paper bag which is securely fastened to exclude all possibilities of further pollination. It is necessary to make a large number of such crosses to obtain results, as it often happens that a large per cent of the flowers thus crossed fail to set seed. The seeds from the successful crosses are carefully gathered and planted separately the second year (figs. 2 and 3). No particu-

Fig. 2.—Trial grounds of C. C. Morse and Co., San Juan, Cal.

Fig. 3.—Field of Morse's White Spencer on C. C. Morse and Co.'s Sweet Pea ranch at San Juan, Cal.

lar notice need be paid to the plants of the first year's cross; and all the seeds may be saved together. The second year, however, it will be found that there is a large variety of blossoms. Close inspection is then given to each plant to determine whether it has the merits desired. Some plants will no doubt be found to contain special merits; their seeds should be saved separately and grown another year or two to determine if they will come true to type.

Every careful seed grower must operate for his seed peas a trial ground in which are grown all varieties for comparison and test. A sample of each crop is taken before it is shipped to the customer and a sample of all selected stock is taken. The various samples of each variety are arranged together and any novelty of similar color is also arranged with the variety which it is said to supersede. The samples are planted alongside each other. Trial ground rows are generally about ten steps long, and a six-foot space is left between the rows. Each sample is given a number which is recorded. If rogues appear, their percentage is noted. Improvement in select stock seed is looked for and a value put on each novelty. The trial ground is an important part of the equipment of the seed farm, and too much study and time cannot be given to it. Points to be noted in judging a stock seed are the size of flower, length of stem, number of flowers on each stem, color, brightness and lasting quality, texture of flower, vigor of growth, length of blooming period, and the amount of seed produced.

The sweet pea is not an easy crop to irrigate and it can be done only with care and judgment. Generally one irrigation should be given and that before the pods are set on the vines.

CHAPTER III

CULTURE OF SWEET PEAS UNDER GLASS[1]

THE production of sweet peas under glass is being extended every year due to increase in prominence as a cut flower, and hence their economic value in winter. Greenhouse sweet peas as a cut flower rank third on the market, coming after the roses and carnations. They are thus grown in nearly every state in the Union, usually, however, in the vicinity of large cities. Philadelphia, New York, Buffalo, Boston, Chicago, Detroit, Milwaukee, Omaha, St. Louis, Kansas City, Denver, and a number of other large cities offer good market opportunities for winter flowering

[1] Abstract of Commercial Sweet Pea Culture by Ant. C. Zvolanek.

sweet peas. In the warmer states sweet peas are grown out of doors during the winter, requiring but very little shelter.

For sweet peas under glass it is necessary to have a suitable house (see Frontis.). The sides of the house should be at least eight feet high, the upper being of glass. If the houses are but seven feet high, the side rows strike the glass when the vines are about half grown, thereby giving half a crop. The ridge of the house should be from twelve to fifteen feet high. The higher the vines grow, the more and better flowers. For December and January cuttings, large houses are necessary so that the sun may penetrate every corner. Sweet peas sown in October as, for example, after chrysanthemums, will not bloom before February.

The ideal soil is sandy loam. Red shell soil is good if taken about six inches below the surface; very coarse gravelly soil if well fertilized answers the purpose. Soil taken from swampy places, provided it is not heavy clay, is good, but cannot be used the same year. It should be spread out about sixteen inches thick on high ground and left there to winter over. The rain will wash out any alkali which it may contain. In the following spring, about June, compost may be made of this soil. Some air slaked lime and coarse bone is added, together with the necessary manure.

Solid beds of good soil two, or two and a half, feet in depth are the best. If sweet peas follow a tomato crop, which is on the wane by the middle of August, the beds should be deeply trenched, bringing the bottom soil to the surface. In the bottom of the trench three inches of decomposed cow manure are worked in; one foot from the surface three inches more of the same material are added. The house is allowed to remain in this condition until nearly time for sowing the seed. The soil then is usually dry and needs to be moistened enough to cling together when it is worked next time with the spade. This time it is necessary to go down one foot and mix the top layer of manure with the surface soil; then make it as level as possible and thoroughly water it with a strong dose of liquid horse manure. In about three days, depending on the weather, the house will be ready for the planting.

Sweet peas may also be grown on a bench with a few inches of soil, but the result will be a weak growth and a crop of short stemmed flowers. These soon play out, as there is not enough soil or food for the vines to live on.

There are a great many varieties of the winter flowering type of sweet peas, the old grandiflora being the best known. According to Zvolanek the new Winter Orchid-flowering sweet peas are preferred to the old type. The principal thing is to select the best selling colors. In this respect the Pink and White Orchids seem to have no equal for mid-winter flowering. Of the white varieties there are the White Orchid, Bridal Veil, Venus, and Mrs. M. Spanolin. Of those of lavender shades the best are Lavender Orchid, Lavender Pink, and Lavender Nora, which is a clear lavender of the Winter Unwin type. The last named has large sized flowers, the average of which are as large as any of the Orchid-flowering type. In light pink, there are Mrs. A. A. Skach, Mrs. J. Manda, and Dolansky Orchid. In dark rose there are the Orchid Beauty and President Wilson. The best in orange pink is the Orange Orchid, and to this the Orange

Nora and Orange Bird are close seconds. Both of these are of the Winter Unwin type. The colors above mentioned are suitable to grow in large quantities. In the dark blue, the new orchid-flowering Mrs. M. Anderson is commendable, and second only to the Blue Jay or the Winter Unwin. In red, the Red Orchid is the best. All light pink varieties produce much brighter colors if grown so as to bloom after the middle of January, when the weather is sunnier than in December.

To obtain a good crop of flowers for the Christmas trade, seed should be sown anywhere north of Washington, D. C., between the tenth and twentieth of August; this time, too, will depend somewhat on the weather. Warm and bright days in the fall at the time of sowing will help the main crop in maturing early in November when the price of sweet peas is very low. On the other hand, if the weather is cool and cloudy at the time the seed is sown, the flowers will probably be too late for Christmas trade. It is much better to have the crop in January, as during that month and the following months the prices are usually as high as during the Christmas week.

When the beds have been well prepared the soil is pressed down and raked smooth. Rows are then opened at least five feet apart and the seed sown about three inches apart in the row, and covered to about one and a half inches deep. Seeds should not be sown in a soil which is too wet and sticky. It is better to wait a few days until conditions are right. White sweet pea seeds, if planted in dry soil and watered soon after being sown, will seldom germinate. After the seed is sown, rake the surface of the bed very fine to the depth of about one inch. This raking will make a fine soil mulch on the top, which conserves the moisture, besides keeping the soil cool, a condition necessary for successful germination. Under these conditions no watering will be necessary for at least ten days or as long as moisture may be found about four inches below the surface. Sometimes three weeks elapse before it becomes necessary to water the beds. This method encourages the seeds to send their roots deep into the soil in the direction of more water. Plants with deep roots can withstand the hottest days without damping off, a condition which often follows when the moisture is kept on the surface. If the soil becomes too dry after a while, water well down to the base, keeping the surface well worked. After sowing, the temperature should be kept as low as possible; and if the seed is sown in

August when the weather is extremely warm the glass should be kept white-washed as long as the hot weather continues. After the seedlings appear above ground they may be sprayed several times each day during hot spells.

To prevent slow germination the seed may be soaked in water for about fifteen hours just before sowing. This will cause the seed to soften and swell so that when sown they will germinate quickly. Those which still remain hard after the soaking should be rubbed against a fine flat file, taking one seed in each hand and striking once or twice over the file just enough to cut the hard skin. The seeds treated in this way should be dropped back into the water, and within another fifteen hours they will be soft, swollen, and ready to sow.

After the sowing, the greenhouse should be kept as cool as possible, admitting air day and night as long as the weather will permit. The cooler the temperature of the house when the plants are started the stronger and healthier they become. Late in the fall some heat is necessary. The temperature at night, however, should not be higher than 40 to 44 degrees Fahrenheit; otherwise the young plants will begin to bloom early before the roots have had a good start. The winter sweet peas, if sown in August or later, and properly cultivated, should be at least thirty inches high before the blooms appear. Sometimes during warm and bright days in the fall the plants show a tendency to bud very early. In this case, the buds should be picked off as soon as they appear. When the plants are between two and a half to four feet high, they should all begin to bud. At this time the temperature should be raised every night by one or two degrees. If the temperature averages 44 degrees F., make it 45 degrees the next day, and so on until 52 is reached. This is the highest and safest temperature for the older winter grandifloras at night. When in bloom, the temperature may be raised to 60 degrees F. during cloudy days and 68 during bright days. All the new Winter Orchid-flowering sweet peas in the first stage need the same treatment as that just described above. But as these begin to bud and flower the temperature should be raised to 55 degrees F. at night, 60 to 65 for cloudy days, and 70 to 72 during bright days. This higher temperature is necessary for the new strains, as the flowers are larger and the number to a single stem correspondingly more numerous; the additional warmth prevents the falling of the buds and encourages brighter colors.

After the plants have reached the height of about six inches they should be given something to climb on. The best and cheapest way is to run one wire on the bottom and another from eight to ten feet above each row, connecting these two wires with strings as is done in the growing of smilax. Strings should also be run lengthwise of the row, about every ten inches, as the plants advance in growth. At the same time it is well, occasionally, to help the vines to climb on the strings. The upper wire must be the strongest, for when the sweet peas are in full bloom they are usually ten feet high, and the vines of one row one hundred feet long will weigh over a ton. If at any time the upper wire should break, all the flowers become bruised, crooked, and of very little value.

In order to divide the weight, wooden or iron supports should be placed under the upper wire every eight feet.

After the sweet peas have been in bloom for some time and begin to produce short peduncles it is time to feed them a little. The best food is liquid or pulverized cow or sheep manure. It is doubtful if nitrate of soda is beneficial then. During blossoming the house should not be fumigated with hydrocyanic gas for although this will destroy many insects it will also destroy most of the buds which are forming.

It is preferable to pick the flowers in the afternoon, as at that time the greatest number of flowers are open. Where thousands of flowers are picked daily, the most experienced help should go over the rows first, picking only the best blossoms with the longest peduncles, ten selected flowers to a bunch. The second and less reliable help are put to pick the second grade of blooms, putting twenty-five sprays to a bunch; and finally the third hands should gather all the crooked and short stemmed blossoms. If the flowers are to be shipped a long distance to be sold the next day, pick all flowers having three or more blooms or buds to a stem. As soon as a certain number have been picked they should be placed in water, but not in deep vases or large pails as the blossoms may become wet and lose their fragrance. After the flowers have stood in water for about three hours they are ready to be shipped.

One of the most successful crops to grow after sweet peas is tomatoes. In small and moderately warm houses, or propagating beds, the tomato seed is sown in November and then transplanted in small pots and repotted several times afterwards until the plants are finally placed in five- or six-inch pots. After Easter the sweet peas which are then beginning to play out, are replaced by these tomato plants. They are planted 16 to 20 inches apart and trained to a single stem. By June or July, the tomato crop ought to be on the wane and the house is at once prepared again for sweet peas. Violets are also successfully grown in rotation with sweet peas. These should be planted the latter part of September. The beds should be five to six feet wide, with a space of twelve inches on the north side for one row of sweet peas, all the rest being planted in violets. Both of these flowers may be planted at the same time, since the violets, too, need a low temperature not over 40 degrees F. The sweet peas will grow slowly at first, probably not being over three feet in height by the last of February. By this

Fig. 4.—Sweet Peas and Carnations grown in the same house.

Courtesy of Lord and Burnham.

time the violets will have almost finished blooming, or at any rate their market price will be low. This is the time to discard the violets and to raise the temperature to suit the sweet peas; and which will presently produce a splendid crop. Chrysanthemums or carnations (fig. 4) may also be grown with sweet peas. In a house with early varieties such as "Golden Glow" and "Pacific," the chrysanthemums will be all done by October 20th. If sweet peas are sown in four-inch pots about September 10th, they will be large enough to be put in place by the time the chrysanthemums are gone. The soil should be prepared and the sweet peas planted in place at once, so that they may begin to bloom by the latter part of January. Other things may be grown between the sweet pea rows, namely, all kinds of bulbs and flats with small ferns.

CHAPTER IV

DISEASES OF GREENHOUSE SWEET PEAS

RECENT investigations have shown that failures with greenhouse sweet peas may be readily accounted for. Sickness and death, not considering accidental death, both in plants as in animals, are due either to insects or to certain definite forms of parasitic plant life, also known as germs or microbes. Sweet peas need plenty of air and sunshine and a cool climate. These conditions are far from being satisfied in the greenhouse. Plants, like animals, when placed in unnatural surroundings, become a ready prey to disease. Sweet peas under greenhouse conditions are forced to grow in an unnatural way.

The parasitic fungi which attack sweet

peas are minute microscopical forms of plant life, devoid of the green matter known as chlorophyll. Structurally, a fungus consists of one cell or of several cells, connected end to end, forming threads known as mycelium. The fungus gains access to the interior tissue of the plant, and deprives the latter of the food it needs for its welfare. This action results in slow death or in a sudden collapse of the affected host. In the case of powdery mildew, mentioned later, the fungus lives on the surface of the leaves, and sends delicate suckers into the epidermis to obtain its food from the tissue of the host.

Parasitic bacteria are smaller forms of life than are the fungi, but their mode of attack is not very different. With the exception of the large mushrooms, which are also fungi, most others are invisible to the naked eye and must be studied under a compound microscope. When grown in pure culture, however, they are plainly visible as colonies of aggregate individuals.

Insects are divided into two classes: one class derives its food by sucking the plant juices and is known as "suckers"; the other class chews and eats solid parts of roots, stems, foliage, or blossoms, and is known as "biting." All insects undergo certain changes (metamorphosis), beginning as larvæ and ending as adult beetles, bugs, or butterflies. Not all animals which are parasitic on plants are insects, as, for example, the eel worm. The latter belongs to the Arthropoda of the Animal Kingdom, its body being composed of many segments with no legs.

Red spiders and mites, likewise plant parasites, are not insects. These belong to the Arachnida or true spiders. Books of the same nature as the present work generally discuss fungi, bacteria, and insects under different headings. This precedent will not be closely followed here, but all three will be taken up from the point of view of their economic importance rather than in the light of their systematic relationship.

As a rule plant diseases do not spread so rapidly in the greenhouse as in the field. The restrictions of wind currents and the lack of easy access of insects are, no doubt, factors in keeping in check many diseases. There are, however, some indoor conditions such as moisture and temperature, which if not properly attended to, will result in great financial loss by favoring the spread of disease.

Upon proper watering depends much of the success of crops grown under glass. The amount of water and the way it is applied as well as the amount of moisture in the air of the greenhouse may determine the presence or absence of disease. A relatively high percentage of moisture in the soil or in the air favors damping off. The humidity of the atmosphere in a greenhouse is usually much higher than that out of doors. From this it follows that good ventilation should be provided. Overwatering of sweet peas gives rise to unhealthy conditions, especially in cloudy weather, when evaporation and transpiration are arrested. Thus the soil becomes flooded with water which interferes with the respiration of the roots and the plants become more susceptible to diseases which may be present in the soil in the greenhouse. An excess of moisture in the air also favors the development and spread of the powdery mildew. During bright sunny weather there is little danger from overwatering, since transpiration and evaporation are then very active. What is true of "damping off" and the mildews is also true for root knot. The minute eel worms cannot thrive unless there is sufficient moisture in the soil. Neither can they thrive in soils that are flooded, since they must have air to live. This is taken advantage of in open fields where root knot is controlled by flooding the land. Overwatering, or any form of injudicious watering, is no doubt an important factor in predisposing the sweet pea plants to the attacks of Thielavia, Rhizoctonia, Chætomium, and Fusarium root rots. It is therefore well to provide some means of drainage, especially where the beds are solid and in the ground. It is a good practice to lay at the bottom of the beds from one-half to one foot of ashes or a layer of broken bricks or crushed stones.

This will help to drain off the excess of water likely to be applied by unskilled or inexperienced help.

Water is not the only important factor in controlling or increasing fungous pests under glass. Temperature also plays an important rôle. Damping off of greenhouse sweet peas is best controlled by keeping the greenhouse at a temperature of 50 to 60 degrees F. A temperature of 80 to 90 degrees F. with a high moisture content of the air will cause all young seedlings to damp off, if the fungus is present in the soil. It is doubtful if temperature greatly influences the control of collar rot, although a temperature of 90 degrees will be more favorable to the fungus than a temperature of 50 degrees F. Nevertheless, a low temperature will not considerably check this disease when it once gets a start. In greenhouses where collar rot has become established, sterilization of the soil is the only remedy. Sweet peas grown in the greenhouse are subject to moisture conditions quite different from those grown outdoors. Natural light is less in winter, and in order to induce growth under adverse conditions heat is used as a stimulant. This produces plants readily susceptible to disease. As these difficulties cannot be avoided, it is essential to start with sterilized soil in the benches.

Most sweet pea growers do not change their greenhouse soil every year. As time goes by, and the crop is grown successively in the same place, the soil soon becomes sour. This condition naturally tends to encourage the development of a parasitic flora in the soil which is detrimental to sweet pea culture.

The following is a quick method to determine soil acidity, based on the use of litmus paper, devised by Mr. J. E. Harris,[1] who found that some kinds of litmus paper are not suitable. Experiments have shown that Kahlbaum's litmus paper is the best for the purpose. It is so sensitive that it is necessary to leave it in contact with the soil particles only for a moment or two. Soil only very slightly acid will change the litmus paper to a distinctly red color. Acid soils are easily corrected by the use of lime. The latter favors Thielavia rot but this is no consideration where sterilized soil is used.

RHIZOCTONIA ROOT ROT

Corticium vagum B. and C.

No mention is made in literature of a Rhizoctonia disease of sweet peas, al-

[1] Harris, J. E., Soil Acidity and Methods for its Detection. Science. N. S. XL: 491–493, 1914.

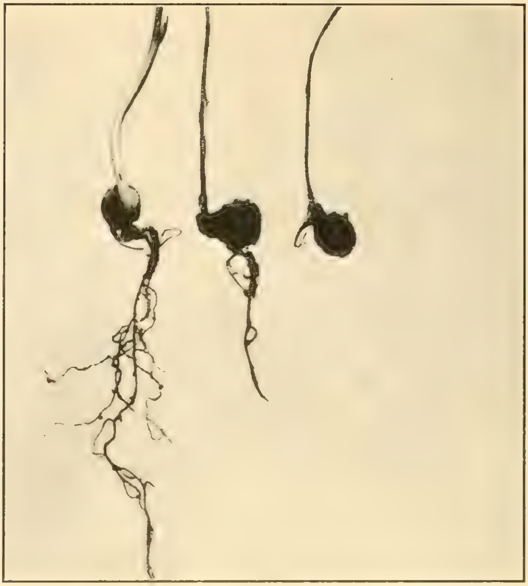


Fig. 5.—Root Rot caused by Rhizoctonia. Healthy and diseased plants.

Fig. 6.—Root Rot caused by Rhizoctonia. To the right the soil was inoculated with the fungus, resulting in no germination; to the left, check.

though the same fungus is recorded on other hosts. During the winters of 1911 and 1912, it was found by the author on greenhouse sweet peas from different localities. Through correspondence, Professor A. D. Selby reports its presence in Ohio; Dr. W. G. Sackett, in Colorado; and Professor E. C. Stackman, in Minnesota. There seems no doubt that the Rhizoctonia root rot of sweet peas is much more widespread than is reported. The nature of the trouble is unknown to the growers. Outdoors, Rhizoctonia also attacks the garden pea, bean, lettuce, carrot, celery, cow peas, and a number of other hosts.

Symptoms. Severely infected plants have practically no root system (fig. 5). In slightly infected plants, only one or two rootlets may be destroyed. The fungus produces a browning effect of the root before total destruction sets in. In very early stages of the disease infected seedlings are seen to have a wilted appearance; as the disease progresses they fall over and collapse. The fungus is not often confined to the roots alone. It frequently works its way up to the stem, producing a constricted area which marks it off from the healthy part above. The fungus being a soil organism is usually introduced with manure; infection may take place at any part of the roots, or at the lower end of the stem. When the latter is the case, reddish sunken spots are observed at the base of the stem. It seems that Rhizoctonia is primarily a seedling disease of the sweet pea, although older plants too are found to be affected with the same fungus, but are not killed outright since they linger for a considerable time without producing blossoms of commercial or ornamental value.

Pathogenicity. The pathogenicity or the disease producing power of the sweet pea Rhizoctonia may be readily proven by planting disinfected seeds in sterile soil and also in pots which were inoculated with a pure culture of the fungus (fig. 6). The best material is a culture which has an abundance of sclerotia.

The parasite has two stages—the Rhizoctonia, and the sclerotial stages. The Rhizoctonia stage consists of long and narrow mycelial branches varying in color from hyaline to reddish brown (fig. 7*a*). These threads are either imbedded in the substratum in which they grow, or they are aërial, depending on the media on which the fungus is grown. These mycelial threads are the most active and are more concerned in the parasitism of Rhizoctonia. The sclerotial stage consists of numerous sclerotia which are made up of closely interwoven short barrel-shaped hyphæ (fig. 7*b*).

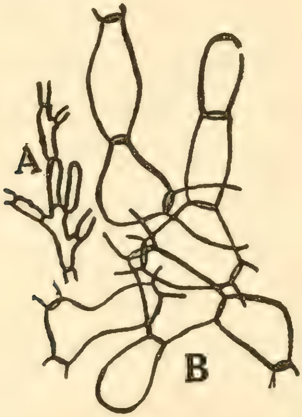


FIG. 7. *a* YOUNG *hyphæ* OF *Rhizoctonia* FROM SWEET PEA. *b* BARREL-SHAPED *hyphæ* FROM *sclerotia* OF THE SAME FUNGUS.

Rhizoctonia solani Kuhn produces only micro or small sclerotia, whereas *Corticium vagum B. and C.* produces macro or large sclerotia. After repeated attempts the Corticium or perfect stage of the sweet pea Rhizoctonia could not be obtained in pure culture. This accords with the findings of

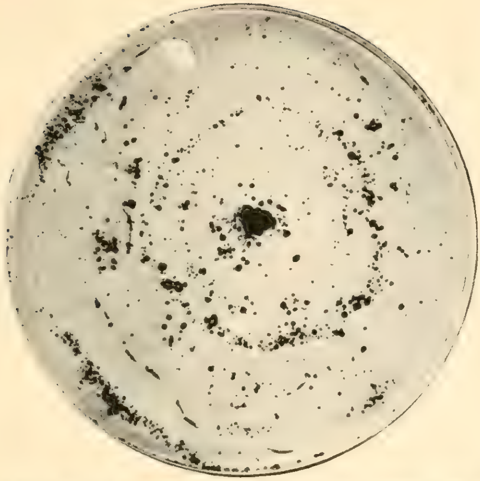


Fig. 8.—Pure culture of the Sweet Pea Rhizoctonia, showing large and smaller sclerotia of the fungus.

Fig. 9.—Pure culture of *Fusarium lathyri*, the cause of Sweet Pea Wilt.

Shaw [1] and Rolfs,[2] who could not obtain the perfect stage on culture media but found it several times on the host. However, as the sweet pea Rhizoctonia produces macro-sclerotia (fig. 8), and as already pointed out by Shaw, the macro-sclerotia produce the Corticium stage, the sweet pea organism is therefore referred to as *Corticium vagum B. and C.*

PATHOLOGICAL CONDITIONS OF THE HOST. Practical men, no doubt, like to know what happens to the host plant when it is attacked by the fungus. Rhizoctonia when attacking hosts other than the sweet pea, is found to parasitize the cambium layer or growing part of the plant. With the sweet pea, conditions are somewhat

[1] Shaw, F. J. F., The morphology and parasitism of Rhizoctonia. Mem. Dept. Agr. India, Bot. ser. IV: 115–153, 1912.

[2] Rolfs, F. M., Potato failures, a second report. Colo. Agr. Expt. Station Bul. 91, 1904.

similar. The fungus attacks the phlœm or food tracts and makes its way into the parenchyma cells as well as to the epidermal cells. The effect produced is loss of turgidity, wilting, and early collapse of the host.

Growers should not fail to recognize Rhizoctonia root rot in its initial stage. To allow this fungus to get a foothold would mean the ruin of an otherwise promising crop.

CHÆTOMIUM ROOT ROT

Chætomium spirochæte Patt.

In the autumn of 1912, Professor A. C. Beal of Cornell University sent me for diagnosis diseased specimens of greenhouse sweet peas. The trouble was readily located in the roots. A fungus was found invading the interior tissues of the roots, but no fruiting stage of any kind to help identify the fungus could be discovered. Crush cultures were made at once from the diseased material. Some forty poured plates of nutrient agar were made. In five days a pure culture of a fungus appeared in all the plates with the exception of one, which showed a Fusarium. The cultures were watched closely and in two weeks perithecia developed. The fungus proved to be an ascomycete belonging to the genus Chætomium, and determined by Mrs. Flora Patterson as *C. spirochæte Patt.* In mid winter of that same year, more diseased specimens were sent in to my laboratory by a grower in Illinois. These were greenhouse plants showing the same symptoms as those observed on the plants sent by Professor Beal. Cultures made from this material gave the typical fungus Chætomium spirochæte. A search through the literature showed that several species were recorded but none were stated to be parasites.

Symptoms. At the first glance Chætomium root rot is difficult to tell from Thielavia. Infected plants lose their green color, become pale and yellow, and cease growing. The root system is usually found wanting or partly destroyed. The disease seems to be primarily a seedling trouble.

Pathogenicity. The fact that a pure culture of *Chætomium spirochæte* was obtained from numerous platings of diseased material from two different states at once led to the supposition that the organism was the cause of the disease. Inoculations with pure cultures of the fungus into healthy seedlings proved the organism to be a weak parasite, favored by an excess of moisture in the soil.

The Fungus. The mycelium of the

fungus is hyaline, closely septate, and branched (fig. 10*a*) when grown in the substratum of the media. The aërial my-

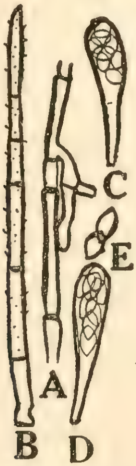


FIG. 10. *a* SHOWING *mycelium* OF *Chætomium Spirochæte.* *b* HAIRS. *c and d asci. e ascospores.*

celium consists of long unbranched filaments varying in color from light to deep lemon. The yellow seems to be produced within the fungus hyphæ which later is also transmitted to the media. In pure culture the fungus produces its perithecia or fruit bodies in about two weeks after sowing. These perithecia are covered with dark hair-like appendages. The hairs are straight or coiled at the apex and septate at unequal intervals, and covered with very minute pointed warts (fig. 10*b*). The asci are very evanescent and can only be seen in very young cultures just as the perithecia are forming. In old cultures the ascus wall is easily ruptured so that it is difficult to make out the arrangement of the ascospores within. There are eight ascospores in each ascus (fig. 10*c* and *d*). The ascospore is apiculate (fig. 10*e*) at both ends. Its wall is smooth, light brown when young and dark when old. It will germinate readily in distilled water or in any nutrient broth.

Chætomium root rot is not likely to prove troublesome in greenhouses where the ventilation and the watering are properly attended to.

FUSARIUM ROOT ROT

Fusarium lathyri Taub.

There is no record in the mycological literature of a Fusarium disease of the sweet pea. Numerous complaints from florists showed that sweet peas often did not grow well under glass because of a root rot which developed early and in some cases destroyed the entire planting. Cultures made by the writer from infected material or from the infected soil gave in each case a pure culture of Fusarium.

SYMPTOMS. The disease produces a sudden flagging of the leaves accompanied by sudden wilting and collapse of the seedling. Usually a fair percentage of the seeds germinate and the plants reach the height of about eight to ten inches when they are attacked by the fungus. If the collapsed seedlings are allowed to remain on the ground, the dead stems will soon be covered with the sickle shaped spores. Eventually the dead tissue rots and disintegrates and is soon invaded by small fruit flies which now begin to distribute the spores of the fungus to different places in the same house.

Pathogenicity. The pathogenicity of this fungus is readily proven by inoculating a pure culture (fig. 9) of the fungus into healthy seedlings planted in sterile pots and soil. The seeds germinate and grow up to a height of seven to eight inches and then succumb to the parasite which was artificially introduced into the soil (fig. 11).

The Fungus. The mycelium of the fungus is hyaline, branched and septate.

Fig. 11.—Fusarium Wilt or Root Rot. At left, healthy plant; at right, infected.

At an early age the hyphæ begin to form chlamydospores or resting spores. These are round hyaline bodies often filled with oil globules and are formed in the center of the hypha. Usually also the chlamydospores are born at the tip end of the hyphæ in chains of twos, threes, and even fours. Old cultures consist largely of a mass of chlamydospores. There are also two other types of spore forms, and these appear as early as the third day in the pure culture. These are micro-conidia or small one-celled spores, and macro-conidia or large cycle-shaped spores, varying from two-celled to four-celled. The usual form is three-celled. In old cultures the macro-conidia shrink so that the septa become slightly prominent. These old macro-conidia soon lose their protoplasm, or they break up, presenting a granular appearance. In young cultures the outer wall of the chlamydospores is smooth, but in old cultures it becomes slightly warty or covered with minute points. No perfect stage has been found to accompany this fungus, either on the host or in pure culture.

Fusarium root rot is a serious disease which threatens to undermine the growing of greenhouse sweet peas. The grower should do everything possible to prevent its introduction into the house. In places where this disease has already gained a foothold, soil sterilization becomes a necessary part of sweet pea culture under glass.

THIELAVIA ROOT ROT

Thielavia basicola Zopf.

In 1912, Chittenden[1] was asked by the National Sweet Pea Society of England to investigate the "streak" disease of the

[1] Chittenden, F. J., Diseases of the Sweet Pea, *Sweet Pea Annual:* 14–24, 1912. London.

Fig. 12.—Root Rot caused by Thielavia. Roots of diseased and healthy plants of the same age compared.

sweet pea. In his report before that society, Chittenden gives an accurate description of the "streak," so that there can be no doubt that he had the disease well in mind, that is, he described it as a stem disease. Chittenden, however, attributed "streak" to *Thielavia basicola Zopf.* In this Chittenden erred, for streak has since been found to be caused by a bacterium. Massee,[1] too, made the same mistake, for he also considered Thielavia as the cause of "streak." Streak however is different from Thielavia root rot.

SYMPTOMS. Plants severely infected with Thielavia have practically no root system, since the roots are destroyed by the fungus as rapidly as they are formed (fig. 12). All that is left of the root system is

[2] Massee, George, A disease of sweet peas, asters and other plants. Roy. Bot. Gard. Kew Bul. of Misc. Inform. No. I:44–52, 1912, London.

a charred blackened stub. The fungus sometimes works upon the stem to a distance of two to three inches above ground. It is probably due to this that some workers have mistaken this disease for the "streak." Although their root system is destroyed, affected plants seem to linger for a long time. Diseased plants, however, cease growing, and maintain a dwarfed sickly appearance (fig. 13). These are useless for any purpose, as they fail to bloom and merely contaminate the beds by their presence.

Pathogenicity. Healthy seedlings may be readily infected by placing a pure culture of the fungus in the soil. In two to three weeks the roots of the infected plants will be thoroughly diseased. Overwatering does not seem to be a necessary factor in infection, although it no doubt helps to weaken the plants and further

Fig. 13.—Root Rot caused by Thielavia. A healthy plant contrasted with a diseased plant.

aids the fungus in its destructive work. *Thielavia basicola* also attacks a number of hosts other than the sweet pea. Pure cultures of the fungus obtained from cow-pea, violets, parsnip, and tobacco, when inoculated on the sweet pea will readily infect the latter. This shows that the disease will cross from other hosts to the sweet pea and vice versa.

THE FUNGUS. The mycelium of *Thielavia basicola* is hyaline, septate and branched. The mycelium becomes somewhat grayish with age. Three kinds of spore forms are produced—endospores, chlamydospores, and ascospores. Endospores are so called because they are formed inside a special thread of the mycelium (fig. 14*a*). This is the spore form that commonly occurs in pure cultures of artificial media and on the host. The endospore case is formed on terminal branches

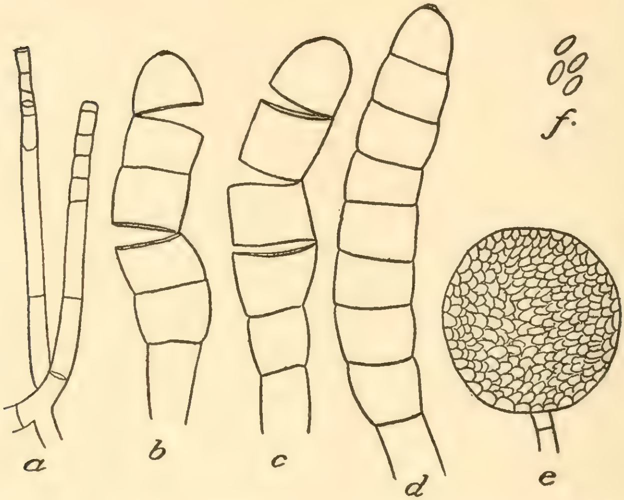


FIG. 14. *a Endospores. b c Chlamydospores* BREAKING UP INTO INDIVIDUAL SPORES. *d Chlamydospores* UNBROKEN. *f Ascospores. e* SINGLE *perithecium.*

with a somewhat swollen base and a long tapering cell. The endospores are formed in the apex of this terminal cell and are pushed out of the ruptured end by the growth of the unfragmented protoplasm of the base. They are hyaline, thin walled, and oblong to linear in shape. The chlamydospores (fig. 14*b* to *d*) are thick walled, dark brown bodies, borne on the same mycelium as the endospores. This type of spore is formed in great abundance on the host and particularly within the affected tissue. The ascospores (fig. 14*f*) are lenticular in shape and are borne in asci (or sacs) within black perithecia (fig. 14*e*). This stage, however, has not been found on the sweet pea or in pure culture.

Thielavia is perhaps next in importance to Fusarium root rot. The fungus is often introduced with manure or more commonly with diseased violets, since this flower is profitably grown in conjunction with sweet peas.

Growers, therefore, cannot be too careful in trying to keep out Thielavia from the greenhouse.

POWDERY MILDEW

Microsphæra alni (Waller) Salm.

The sweet pea mildew was described by Massee [1] as being prevalent in England. *Erisiphe polygoni* was thought to be the cause both of the sweet pea and the garden pea mildew. In the United States, Professor Stewart [2] was the first to record the finding of powdery mildew on sweet peas in the United States. However, Stewart did not find the perithecial stage which would help in the determining of the fungus.

Powdery mildew is a very prevalent disease on greenhouse sweet peas, although it is also very common on out-of-door plants. The fungus which causes mildew

[1] Massee, George, Fungoid diseases of the sweet pea, *Sweet Pea Annual:* 20–21, 1906, London.

[2] Stewart, F. C., Notes on New York plant diseases. New York (Geneva) Agr. Expt. Station Bul. 328:394, 1910.

Fig. 15.—Powdery Mildew, healthy and diseased leaves.

Notice the white covering of the affected leaves, due to the growth of the mildew fungus on the surface of the former.

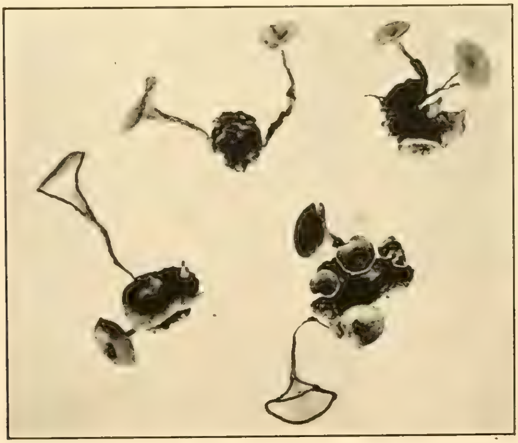


Fig. 16.—Germinated sclerotia of the Sweet Pea Sclerotinia which had wintered outdoors.

grows on the surface of the leaves, thus giving them the white powdery appearance (fig. 15). Affected leaves eventually lose their green color, shrivel and fall off prematurely. The perfect stage of this fungus is found on fallen and dead leaves. Powdery mildew is perhaps universally found in every greenhouse where sweet peas are grown. It is worse in overwatered houses, and in overheated houses with excess of moisture. Powdery mildew is perhaps the easiest disease to control.

STEM OR COLLAR ROT

Sclerotinia libertiana Fckl.

Observations seem to indicate that this disease is limited to sweet peas grown under glass. A special effort was made to find this disease outdoors, but without success. Under certain conditions unfavorable to the host this fungus may attack a variety of plants in the open. That this fungus has not been found to attack sweet peas out of doors does not preclude its appearance in the field at any time in the future.

SYMPTOMS. Collar rot is usually a seedling disease which causes "damping off." It is most severe in poorly ventilated houses or in beds which are over-watered and lack the proper drainage. The disease does its work quickly. Affected plants first show a wilting of the tip and flagging of the leaves, and then the seedling falls over and collapses (fig. 17). The fungus, *Sclerotinia libertiana*, although a soil organism, cannot attack the roots of its host. The parasite penetrates the collar of the stem, completely invading the inner vessels, thus cutting off the upward flow of water from the roots to the

Fig. 17.—Sclerotinia Wilt of Sweet Pea seedlings: a. healthy plants; b. and c. infected seedlings.

parts above. Plants which have recently died have a water soaked appearance, and later covered by a white weft of fungus mycelium, and by sclerotia which appear irregularly on or within the affected stem.

Pathogenicity. The pathogenicity of this fungus may be readily established by inoculating healthy seedlings with a pure culture of the fungus. The latter is easily re-isolated and the disease produced at will. Moisture is the main factor in favoring infection.

The Fungus. *Sclerotinia libertiana*, is a fungus too well known to plant pathologists and even to practical growers to require much description. Under greenhouse conditions, the same fungus causes a serious disease on lettuce, cucumbers, tomatoes, violets, and many other plants. When grown on artificial media, there are no differences observed on the different strains isolated from the sweet pea, lettuce, cucumbers, tomatoes or violets. Moreover, any one of these strains will produce a disease on any of the hosts enumerated. When the sclerotia, after being placed outdoors in the cold to over winter, are taken in and placed on moist sand kept at room temperature, they germinate and produce the typical grayish stalks with their apothecia or fruit bodies (fig. 16). The latter contain the asci in which are the ascospores of the fungus.

Like *Thielavia basicola*, and because of its omnivorous nature, the fungus *Sclerotinia libertiana* may prove a great drawback to the culture of greenhouse sweet peas. The parasite is usually carried with the manure or may be introduced on other diseased plants. Failure to recognize collar rot or carelessness in maintaining proper conditions in the house may entail serious losses to the grower.

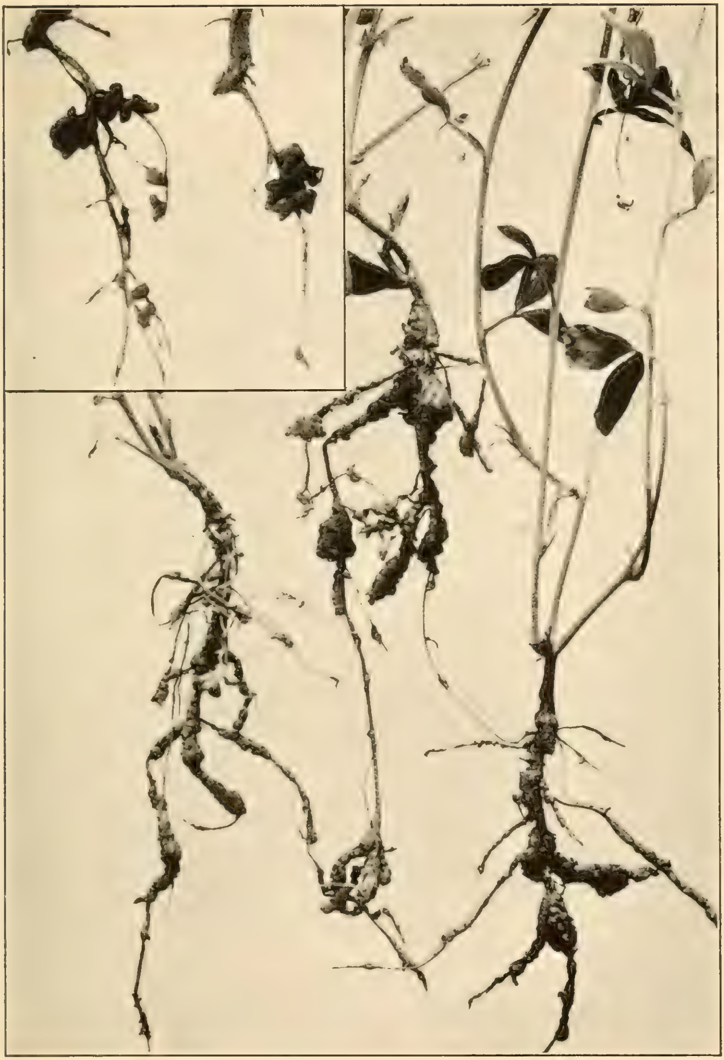
ROOT KNOT OR EEL WORM

Heterodera radicicola (Greef) Müller

Root Knot, (*nematode galls*) no less important than Rhizoctonia and Fusarium root rots, causes great loss to greenhouse sweet peas. It does not, however, produce a damping off in young seedlings. It seems very probable, too, that root knot in the case of the sweet pea opens the way to the attacks of Rhizoctonia and several other root troubles, producing also the greatest amount of damage in light sandy soils.

Symptoms. The disease is characterized by swellings on the roots. These are either small knots formed singly, in pairs, or in strings, thus giving the affected root a beaded appearance; or else the swellings are very large (fig. 19) so as to be mistaken for bacterial nodules, which occur normally in great abundance. Root galls, however, cannot be mistaken for legume nodules, since the latter in the case of the sweet pea are lobed and are attached at one end (fig. 18); whereas, the root galls produce a swelling of the entire surface of the part affected. Infected plants usually linger for a long time, but they can be distinguished by a thin growth and yellow sickly looking leaves and stems.

DISTRIBUTION. The eel worm of the root knot, as it is more often called, seems to be of wide distribution, being found in Europe, Asia, Africa, Australia, and both North and South America. Although it is found in most parts of the world, there are many localities in which the pest has never been known.



Figs. 18, 19.—Root knot of Sweet Peas, a root trouble which may be mistaken for the true legume root nodules.

The insert cut in the top left-hand corner shows the normal root nodules of the Sweet Pea formed by nitrogen-fixing bacteria.

Life History. The eel worm is a very minute organism seldom exceeding one-twenty-fifth of an inch in length, and since it is semi-transparent, it cannot be easily detected with the naked eye. In searching for eel worms, endeavor to break a fresh knot. Close examination will usually reveal two types of worms: a spindle shaped worm, the male, and a pearly white pear shaped organism, the female, firmly embedded in the gall tissue. The female is very prolific, depositing no less than 400 to 500 eggs during her lifetime. The eggs are whitish semi-transparent bean shaped bodies and too small to be noticed without the aid of a magnifying glass. The time which elapses until the eggs hatch depends largely upon weather conditions. With warm days the eggs hatch sooner than in colder weather. Upon hatching, the young larvæ either remain in the tissue of the host plant in which they have emerged, or, as is more often the case, leave the host and enter the soil. This is the only period during which the worms move about to any great extent in the soil, where they either remain for some length of time or immediately penetrate another root of the host. The nematodes in most cases become completely buried in the root tissue, establishing themselves in the soft cellular structure which is rich in food. The head of the worm is provided with a boring apparatus consisting of a sharply pointed spear, located in the mouth; this structure not only aids it in getting food but is also valuable in helping the young worms to batter through the cell walls before becoming definitely located. The two sexes during development are indistinguishable up to fifteen or twenty days, both being spindle shaped. In the molting or shedding of the skin, there is a marked change in the case of the female, especially in the posterior region of the body, which no longer possesses a tail-like appendage. Fertilization occurs soon after this molt, and many radical changes occur in the shape and structure of the organization of the worm. The fertilized female increases rapidly in breadth and becomes a pearly white flask- or pear-shaped individual. This creature is far from being worm-like and may therefore be overlooked by one unfamiliar with the life history of the eel worm. The adult male is much like that of the larvæ, being spindle shaped in outline. The male does not cause as much damage to root tissue as the female, and its purpose in life seems to be only that of fertilizing the female, for after this function has been performed it is quite probable that the male worm takes no more food.

Omnivorous Nature of the Eel Worm. Root knot injury is not confined to sweet peas alone. There are two hundred and thirty-five species of plants known to suffer from it. This number includes all the important families of flowering plants, gymnosperms, and ferns. Of the greenhouse plants practically all are subject to root knot. Violets, carnations, chrysanthemums, tomatoes, cucumbers, and lettuce are often ruined by this pest.

Among the plants which are not affected by eel worm are the following: crab grass, red top, Johnson grass, rye, corn, perennial rye grass, timothy, and Zinnia. For the purposes of greenhouse rotation none of the foregoing plants is of any value. Should root knot attack sweet peas outdoors, however, especially where they are grown on a large scale for seed purposes, rotation of crops will have to be resorted to.

THRIPS [1]

Heliothrips hæmorrhoidalis Bouché

The damage done to the sweet pea by Thrips is confined mostly to the foliage. Thrips feed by sucking on the juices of the sweet pea plants. New places and new leaves are continually attacked so that the affected parts are full of tiny pale spots. In severe attacks the spots unite and form regular white blotches. Ordinarily it is on the under surface of the leaves that the mites feed, but when they become very numerous they also migrate to the upper surface. Both sides of the affected foliage thus become covered with minute drops of

[1] For a more detailed technical description, see Bull. 64 Bur. Ent. U. S. Dept. Agr.

a reddish fluid secreted by the thrips. As these drops dry they gradually turn black. As the attack progresses, the leaves lose all their green color, become limp, and drop off.

Life History of Thrips. An adult thrip is about one-twenty-fourth of an inch in length, and is dark brown in color, with the tip of the body somewhat lighter. The female deposits her eggs within the leaf tissue, and these hatch after about eight days. The young larvæ feed in the same way as the adults, but it is the young which in feeding exude the reddish drops previously mentioned. In reaching full growth the larvæ undergo two resting stages—prepupa and pupa, during which they take no food and remain motionless. Twenty to thirty days after the eggs have hatched the adult is ready for reproduction (figs. 20*a* to *c*).

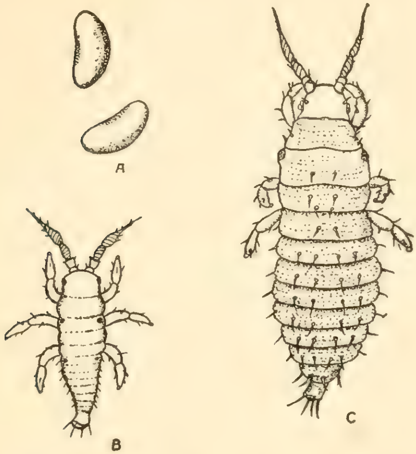


FIG. 20. GREENHOUSE *Thrips, a* EGG. *b* LARVA FIRST STAGE. *c* LARVA FULL GROWN. (AFTER RUSSELL.)

Besides the sweet pea, thrips feed on lilies, azaleas, croton, dahlia, phlox, verbena, pink, and ferns, and on a number of other ornamentals, both in the greenhouse and in the open.

RED SPIDER

Tetranchys bimaculatus Harv.

Even more dangerous to sweet peas than mites are Red Spiders (fig. 21), which at-

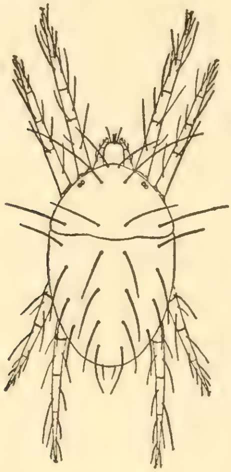


FIG. 21. THE RED SPIDER, ENLARGED. (AFTER BANKS.)

tack both leaves and stems, the method of attack and the resulting injury somewhat resembling that of mites. However, the spots caused by red spiders are reddish instead of a pale white.

LIFE HISTORY. The adult female is usually brick red in color and the male is reddish amber. Frequently, however, the color of the red spider changes according to locality and food plants. The female lays

50 to 60 eggs, depositing about six per day for a period of nine days or so. The eggs hatch after about four days. After two days' activity, the young larvæ pass into

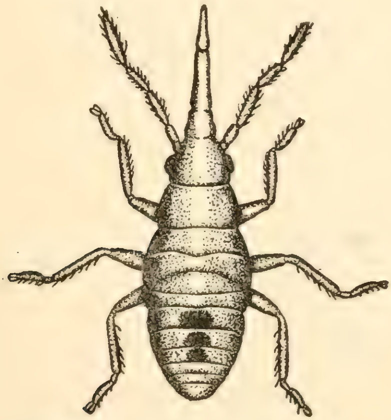


FIG. 22. TRIPHLEPS INSIDIOSUS, AN ENEMY OF THE RED SPIDER. (AFTER MC GREGOR.)

the pupal or resting stage. The adults mate and the female is soon capable of laying.

In the greenhouse the red spider migrates from the tomato and other plants to the sweet pea. The violet especially is a favorite host. Outdoors the red spider may attack sweet peas, tomatoes, wild and cultivated violets, beans, cowpeas, dahlia, Jamestown weed, wild blackberry, and the wild geranium. Although red spiders have few natural enemies, yet the insect *Thriphleps insidiosus* (fig. 22) frequently helps to keep it in check.

CHAPTER V

FIELD DISEASES OF SWEET PEAS

As previously noticed, the diseases which affect sweet peas under glass may also be present out-of-doors. In fact the fungi such as Thielavia, Rhizoctonia, Fusarium, Sclerotinia, etc., are all known to induce, very commonly, diseases on plants in the field. Indeed their appearance in the greenhouse indicates their presence somewhere in the field or in the manure pile, whence they are usually introduced into the soil. The spread of these fungous pests is favored by unnatural conditions which may occur in the field as well as in the greenhouse. Continuous foggy and damp hot weather, together with infected soils, will naturally cause loss and disease. Thielavia root rot commonly found in the greenhouse produces a similar disease on sweet peas in the field. In the latter case it assumes greater economic importance, especially on trial grounds. Root knot has so far been encountered only on greenhouse sweet peas. It will doubtless be found in the field, however, before long. The same is also true for the Rhizoctonia root rot, the Fusarium root rot, and the Sclerotinia collar rot. Growers of sweet peas on a large scale for seed or for ornamental purposes should be on their guard to prevent the introduction of these troubles into their soils. It is much easier to prevent infection than to eradicate a disease that has once gained a strong foothold. Powdery mildew, a common leaf trouble in the greenhouse, is found also outdoors to some extent. On irrigated sweet peas it assumes the nature of an epidemic and may cause death of all the foliage.

ANTHRACNOSE

Glomerella rufomaculans (Berk.) V. Sch. and Sp.

Of all field diseases Anthracnose is perhaps the most dreaded in the United States because of the great losses it occasions. Anthracnose on the sweet pea may exist wherever apples are suffering from bitter rot, for, as the writer has definitely proven, bitter rot of apples and anthracnose of sweet peas are caused by the same fungus, *Glomerella rufomaculans*.

SYMPTOMS. The symptoms of anthracnose are varied. Sometimes it is manifested by a wilting or dying of the tips (fig. 23) which become whitish and brittle and readily break off. At other times the injury extends further down and involves the entire branch. On the leaves the disease starts as whitish spots, which enlarge until all the green gradually fades entirely, hence causing death (fig. 24). Such infected leaves become brittle and soon drop off. Examination of an infected leaf with a hand lens shows that it is peppered with minute salmon colored pustules. At the time of blossoming the fungus also attacks the peduncle at the point of union with the buds, producing a bud blight; or the fungus attacks both the flower bud and the peduncle, in which case both dry up but do not fall off. The most easily distinguishable symptoms of this disease are on the seed pods. Infected pods lose their green color, become shriveled, and are soon covered with salmon colored patches which frequently attract

Fig. 23.—Anthracnose Disease of Sweet Pea on stem and peduncles.

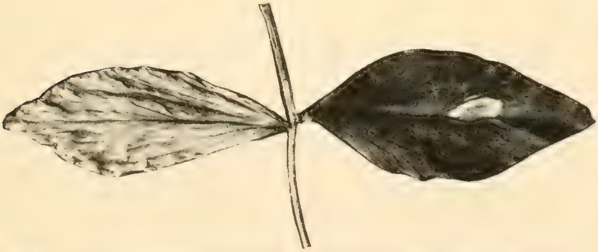


Fig. 24.—Anthracnose Disease affecting Sweet Pea leaf.

attention. The disease is often worse where green Aphids are very active. In this case the older vines may be affected at any point. Very often, too, the harder vines may escape the disease which attacks the thin blades on each side. Here the affected blades become white and dry and break at handling. If not disturbed they become covered with pink pustules or fruits of the parasitic organism.

The anthracnose, like the "streak," is of great economic importance. When once introduced into a field the disease spreads rapidly, often destroying the entire crop. Unlike "streak," the anthracnose may attack young seedlings, a condition sometimes found in the greenhouse. In the field, the disease starts about July 1, when the plants are in full bloom and in the prime of beauty. This is also the time when the bitter rot disease of the apple (fig. 25) makes its appearance in the orchard. The fungus is carried over winter on cankered limbs and mummied fruits of diseased apples or on the diseased pods of the sweet pea as well as in the soil.

Mode of Infection and Period of Incubation. The anthracnose of the sweet pea is mainly a disease of the tender parts of the plant. Infection usually starts first at the tips, although, as previously shown, the fungus may attack the older parts of the plant once they have been injured by green Aphids or by red spiders. The spores of the parasite usually germinate in from six to twenty-four hours, according to the amount of moisture present. The germ tubes enter the host by breaking through the epidermal cells of either leaf or stem.

The period of incubation varies from three to five days, according to the amount

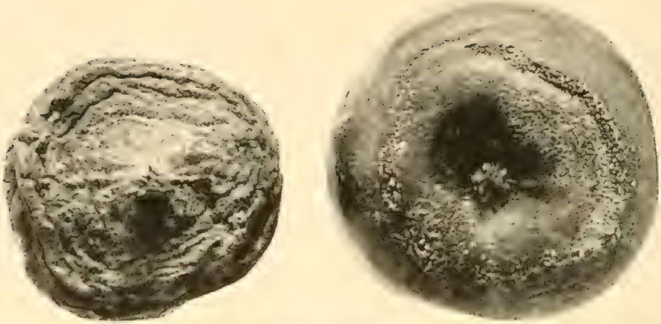


Fig. 25.—Bitter Rot of Apple induced by the same fungus which causes Anthracnose of the Sweet Pea, viz. *Glomerella rufomaculans.*

a b

Fig. 26.—Sweet Pea Mosaic, showing, a. leaflet affected with the disease, b. healthy.

of moisture in the atmosphere. The acervuli or spore pustules appear within five days after wilting begins, unless the weather is dry, when they may not appear until considerably later.

MOSAIC DISEASE OF THE SWEET PEA

Sweet Pea Mosaic is a serious disease. It greatly checks greenhouse peas and is equally injurious to sweet peas grown out-of-doors. Although the cause of the trouble is not as yet known, nevertheless all indications tend to show that it is induced by a definite pathogenic organism. The same or a similar mosaic is known to attack a number of plants such as tobacco, egg plant, pepper, tomatoes, and clovers. Its occurrence on the sweet pea has been recorded only by the author [1] though it has

[1] Taubenhaus, J. J., Present knowledge of sweet pea diseases. Florist Exchange 34: 108–110, 1912.

probably been seen by a number of growers.

SYMPTOMS. Mosaic is readily distinguishable by a yellow dotting or mottling of the leaf, presenting in some instances a beautiful mosaic structure, whence its name (fig. 26). Affected leaves linger for a time but they eventually lose all their chlorophyll and soon drop off. Another symptom of this disease is a curling of leaves (fig. 27) resembling the curling induced by the green Aphids, but in this case the insects have no association with it. The disease makes its appearance after the seedlings are from two to three weeks old. Often, the trouble is so serious and the curling so pronounced that the plants thus affected cannot make any headway and remain dwarfed. An attempt is made by these curled plants to produce a few flowers, but the latter are borne on very

Fig. 27.—Mosaic Disease causing dwarfing of the plant and a rolling of the tip leaves.

short peduncles as compared with the long peduncles of healthy plants of the same variety. Frequently, however, the affected plants outgrow the disease entirely, and thus a distinct line of demarcation is observed between the previously diseased part and the healthy part of the new growth (fig. 28). In rare cases, infected plants seem to thrive in spite of the disease. Such plants should be selected for the purpose of breeding resistant strains.

Pathogenicity. Like peach yellows and the mosaic disease of tobacco and tomato, mosaic of the sweet pea can be reproduced by puncturing with a sterile needle from the diseased leaf into a healthy one. As yet it has not been possible to find an organism associated with the disease. Nevertheless the disease is contagious. It takes from ten to fifteen days for the disease to appear when artificial inoculation is carried out. The symptoms produced in artificially inoculated plants are similar to those in the field.

STREAK DISEASE

Bacillus lathyri Manns and Taub.

Streak is the only bacterial disease which affects this plant and no disease of the sweet pea is so little known to the growers. The attention of Professor Manns and the author was called to it in the course of our investigations, that is to say, only about three years ago. It probably has existed, however, a long time in this country, since it attacks so many other members of the legume family, the red clovers particularly, upon which it causes trouble of considerable economic importance. In England this disease is ruining the sweet pea crop every year. In this country it has gained a strong foothold

Fig. 28.—Mosaic Disease, shewing where the plant has outgrown the trouble.

x indicates the area where the disease has ceased activity.

and it is to be found wherever clovers are grown.

SYMPTOMS. Like the bacteriosis of the bean, streak makes its appearance in the season of heavy dew. On the sweet pea the disease usually appears just as the plants begin to bloom; it is manifested by light reddish brown to dark brown spots and streaks (the older almost purple) along the stems, having their origin usually near the ground, which indicates distribution by spattering rain and infection through the stomata or through insect injury. The disease becomes distributed quickly over the mature stems until the cambium and deeper tissues are destroyed in continuous areas, and the plant dies prematurely. From the stem the disease spreads to the petioles, flowers, peduncles, and pods, the symptoms in these cases being similar to those on the stems. On the leaves, however, the disease appears as small circular spots, which gradually coalesce and eventually involve the entire leaf, which when killed presents a dark brownish appearance.

PATHOGENICITY. The pathogenicity of the causative organism may be proven by diluting a pure culture of the organism in sterile water and by spraying it on the healthy plants with an atomizer. This is done in the evening when the temperature is cooler and there is less chance for evaporation of the infectious liquid which is applied. The disease makes its appearance from seven to ten days after artificial infection and the symptoms are similar to those produced in nature. The organism may be re-isolated from the artificially infected plants and the disease induced again at will on healthy plants, in each case the uninfected check plants remaining healthy.

Natural or artificial infection can only take place on mature plants which have started to bloom. All attempts to inoculate plants in all stages of growth previous to the blooming period have failed. It seems that the host previous to blooming possesses certain protective properties which inhibit the growth of the parasite. The disease in the field does not make its appearance until the plants have started to bloom.

Over 1,500 plate cultures of incipient or young lesions were made from the sweet pea and clover. The organism may almost invariably be taken in pure cultures from the young lesions in the stems of sweet peas when the surface is properly sterilized. The parasite is a yellow organism which will grow luxuriantly upon any nutrient media containing sugars. On standard nutrient glucose agar the colonies appear within 24 to 36 hours. The center becomes granular and the colonies have a marked tendency to become stellate or auriculate (fig. 29).

Morphological studies show the organism to be a comparatively small rod-shaped bacillus, which in fresh cultures is rarely found in chains, and seldom united in twos or fours. The flagella or appendages of the organism are not easily demonstrated; they are shed so readily that usually not more than two to five may be found in stained material and these are generally quite short. However, when the proper material is selected, carefully fixed and stained, the flagella may be demonstrated to be very long and delicate, and to be from 8 to 12 in number and well distributed peritrichially.

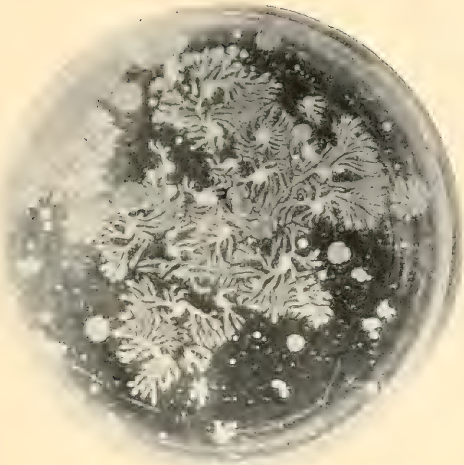


Fig. 29.—Pure culture of the streak organism, *Bacillus lathyri.*

Fig. 30.—Sweet Pea aphis parasitized by a fungus, *Empusa aphidis.*

CHAPTER VI

DISEASES NOT YET KNOWN TO ATTACK SWEET PEAS IN AMERICA

In an article in the *Sweet Pea Annual*, Massee [1] describes a pea blight and a pea spot, which as far as is known have not yet made their appearance in this country.

PEA BLIGHT

Peronospora trifoliorum DeBy.

According to Massee, this disease is very destructive to peas, lupines, and most other plants of the pea family. The disease may appear and spread quickly when the plants are only a few inches high, or it may attack older plants. In dry

[1] Massee, G., Fungoid diseases of the sweet pea. *Sweet Pea Annual*, pp. 20–21, 1906, London.

weather the mycelium of the fungus spreads in the tissue throughout the leaf, which soon assumes a sickly yellow-green color, and finally bleaches, shrivels, and dies without showing any or only a small amount of the mold on the surface. In damp cloudy weather infected leaves show yellow patches, which soon become covered on one or both surfaces with a very delicate grayish lilac colored mold.

The summer spores are produced on the leaves or on any other part of the host. The winter or resting spores are imbedded in the tissue of the host that has been previously killed by the fungus. The resting spores have a very thick smooth brown wall.

Peronospora viciæ also produces a disease on sweet peas.

PEA SPOT

Ascochyta pisi Lib.

According to Massee, this disease attacks sweet peas, French beans and several other leguminous crops. The first indications of disease is the appearance on the pods of pale green spots of variable size and irregular shape. These blotches continue to increase in size for some time and eventually become whitish, bordered with a dark line, and the surface is studded with minute black points which are the pycnidia or spore sacks of the fungus.

It should be remembered that both *Ascochyta pisi* and *Peronospora trifoliorum* are fungi very prevalent on other hosts in this country. It is only a matter of time until these parasites will be found to attack sweet peas. Growers, therefore, should be on their guard against these two troubles.

CHAPTER VII

INSECT PESTS

THE SWEET PEA APHIS

Macrosiphum pisi Kalt.

OF all the sweet pea insects, not one perhaps rivals in economic importance the green aphis. Specimens were submitted to Professor Chittenden of the United States Department of Agriculture, who identified them as M. pisi Kalt. Since this pest is the same which also attacks the garden and field pea we will quote in part Professor Chittenden.[1]

DESCRIPTION. "The pea aphis is one of unusual size among those found infesting

[1] Chittenden, F. H., The pea aphis (Macrosiphum pisi Kalt.) U. S. Dept. Agr. Bur. of Entomol. Circ. 43 Second Edition, 1909.

gardens, and the largest of the green species which attacks the pea and related plants (fig. 31 *a* to *e*). The general color

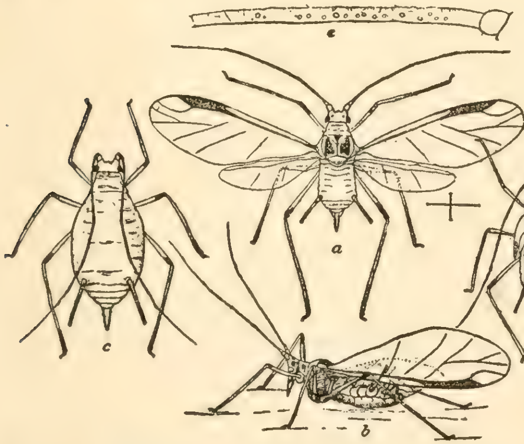


FIG. 31. SWEET PEA *Aphis, a* WINGED FEMALE. *b* SAME FROM SIDE WITH WINGS FOLDED IN NATURAL POSITION, AS WHEN FEEDING. *c Apterous* FEMALE. *d* NYMPH IN LAST STAGE. (AFTER CHITTENDEN.)

of the insect is uniform pea green, the same color as the insect's favorite food plant. The eyes are prominent and reddish brown in color. The antennæ are lighter than the body and the tubercules prominent. The legs are long and conspicuous.

"Like the gipsy moth, the pea aphis seems to have been present in this country for about twenty-five years before it became a pest. It is now found practically wherever the garden pea and the sweet pea are grown, causing much injury to both hosts.

"The reasons why the species has become so troublesome a pest are many: First, because of its ravages to a crop hitherto little troubled by insects except the pea weevil, which has always been present in gardens and fields and has come to be looked upon as a necessary evil. Second, it is a species never before noticed so far as records go as having been destructive to peas of any kind in this country. Third, because of the great difficulty in keeping it in check.

"Although garden and field peas are the crops most injured by this pest, sweet peas and red and crimson clover, as well as vetches, are affected. Attacks begin on the young pea vines; the 'lice' gather in clusters at first under and within the terminals, and as the leaves become covered they attack also the stems and by their numbers and veracity sap the life of the plant. Whole areas of vines are seen covered with the aphis."

How the Aphids Multiply. The "lice" spend the winter in the egg stage. When the young sweet pea seedlings appear in the spring the lice hatch from the eggs, and instead of being partly males and partly females, all are females, known as stem mothers. These without the intervention of the male give birth to a second generation, all of which are likewise females. These females in turn give birth to a third generation of females and in this manner a large number of successive generations are produced, in none of which

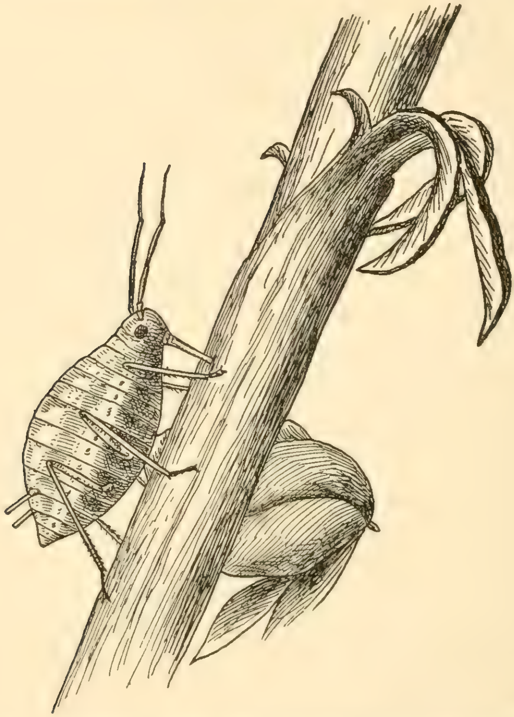


FIG. 32. SHOWING HOW APHIDS FEED AND THE NECESSITY OF A CONTACT SPRAY TO KEEP IT IN CHECK. (COURTESY OF THE KENTUCKY TOBACCO PRODUCTS CO.)

do any males occur. This form of reproduction without the intervention of the male is known as parthenogenesis. On the approach of cool fall weather a generation composed of both males and females are produced, the sexes mate, and eggs are laid which pass the winter on dead stems or in the ground. According to present knowledge the eggs hibernate on clover or vetch. The sweet pea aphis derives its food by sucking on the plant juices (fig. 32).

The sweet pea aphis is not only a pest by itself, but it also aids in carrying the virus of mosaic from plant to plant. Moreover, plants which have their juices constantly depleted by numerous sucking aphids are thereby weakened and easily fall the prey to diseases, especially streak and anthracnose. If the green aphis could be successfully controlled, nearly 80 per cent of the other troubles would be prevented from getting a start.

Greenhouse sweet peas are not exempt from the attacks of the aphis. In the greenhouse, too, the prevalence of the aphis is always correlated with an abundance of mosaic, as well as with weak spindly plants.

The sweet pea aphis is very prolific. It is estimated that each individual if allowed full sway would be the progenitor of 423,912 aphids in one season. These lice, however, are fortunately kept in check by natural enemies. The list of insects known to feed on the sweet pea aphid includes seven species of lady beetles, three species of Syrphus or lace wing fly, a soldier beetle, and a few minute four winged Hymenopterous parasites.

Lady Beetles. *Hippodamia convergens.* It behooves every grower to learn to recognize this friendly insect. Its eggs are laid in clusters, found everywhere on board fences or on trees. The eggs are small, salmon color, and pointed at both ends. The larvæ as they emerge from the eggs soon begin to feed on very small insects. Their body is long, very rough, hairy, and dark with red or yellow markings on its back. As soon as they reach maturity they attach themselves by the tail end to some twig and there pupate. From this stage emerges the adult lady beetle. The sexes mate and the females lay the eggs which are to begin a new life cycle (fig. 33 *a* to *c*).

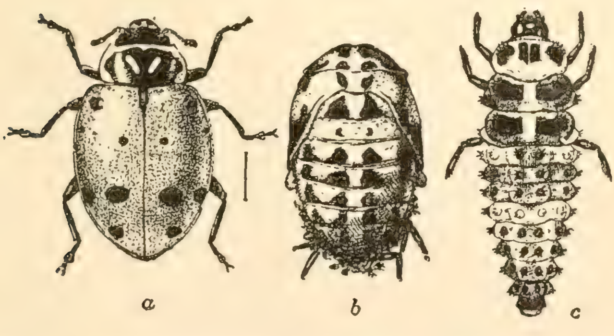


FIG. 33. THE CONVERGENT LADY BEETLE (*Hippodamia convergens*) AN ENEMY OF THE SWEET PEA APHIS, *a* ADULT BEETLE. *b* PUPA. *c* LARVA. (AFTER CHITTENDEN.)

Syrphid Flies. *Syrphus ribesii.* In company with the plant lice are seen greenish, flat sticky looking "worms,"

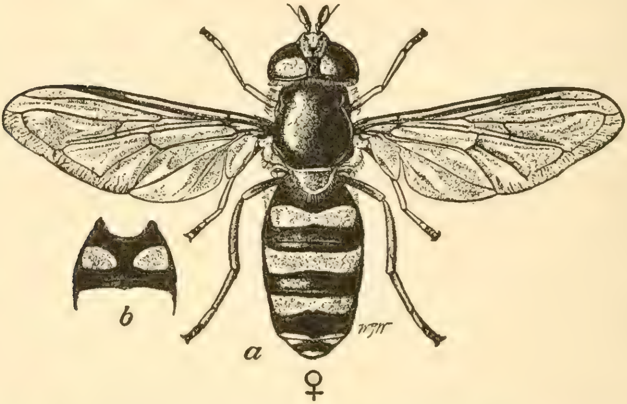


FIG. 34. SYRPHID FLY, *Syrphus Americanus,* WHOSE LARVA FEEDS ON THE SPRING GREEN APHIS AND ALSO ON THE SWEET PEA APHIS, *a* FEMALE FLY. *b* SECOND ABDOMINAL SEGMENT OF MALE. (AFTER WEBSTER AND PHILIPS.)

which are pointed at one end and seem to have no distinct head, eyes, or legs. These are larvæ or maggots of a two-winged fly commonly known as Syrphid or Flower Fly. The maggots obtain their food by puncturing the body wall of the aphid and by sucking out its content. When the maggot is full grown it seeks some sheltered spot where it pupates and becomes transformed into the adult fly. The adults are dark, with transverse yellow bands across the abdomen (fig. 34 *a* and *b*). They are swift fliers and are often mistaken for bees. They feed on the nectar of flowers and because of this habit are often called Flower or Honey Flies. On hot days they are very numerous and are called Sweat Flies. They lay their eggs on vines attacked by the aphids.

GREEN LACE WING. *Chrysopa californica.* This insect is called Aphis Lion because of its destructiveness to all green plant lice. The larvæ of these beneficial flies are provided with two long curved mandibles upon which the aphids are held prisoners until they are sucked dry. They

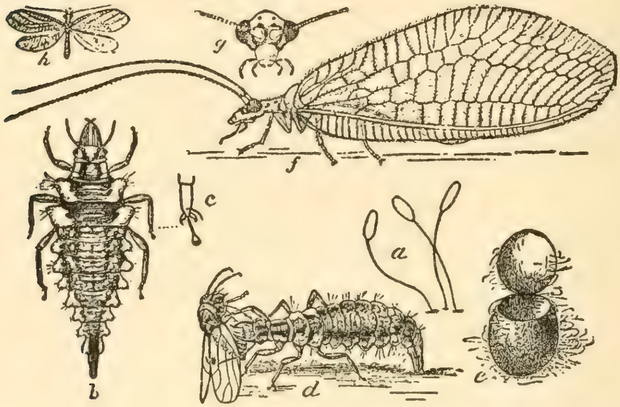


FIG. 35. GREEN LACE FLY (*Chrysopha oculata*) AN ENEMY OF THE SWEET PEA APHIS, *a* EGGS. *b* FULL GROWN LARVA. *c* FOOT OF SAME. *d* LARVA DEVOURING AN INSECT. *e* COCOON. *f* ADULT INSECT. *g* HEAD OF SAME. *h* ADULT NATURAL SIZE. (AFTER MARLATT.)

are then released and others caught and destroyed in a similar way (fig. 35 *a* to *h*).

APHIDUIS. Of still greater importance in the natural control of the sweet pea aphis, is the parasite known as *Aphiduis testaceipes* (fig. 36). The adult female of this fly possesses a long sharp pointed ovipositor which pierces the body wall of the louse depositing her eggs within its tissue. When the female Aphiduis comes in contact with an aphis, she quickly thrusts her abdomen beneath its thorax and head, giving the aphis a quick stab, and deposits her

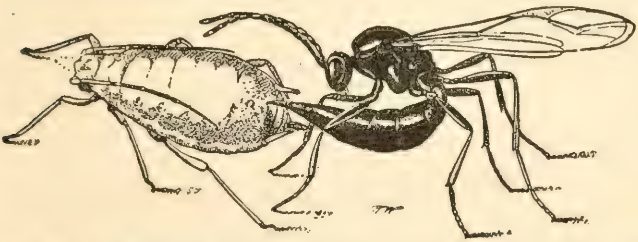


FIG. 36. *Aphiduis testaceipes* OVIPOSITING IN THE BODY OF AN APHIS. ENLARGED. (AFTER WEBSTER.)

eggs in its body. After being stung by her enemy, the aphis kicks up the posterior part of the abdomen as though in pain. It is probable that only one egg is deposited within the body of each attacked aphid. The egg upon hatching gives birth to a small legless larva which begins at once to feed upon the interior vital parts of the louse. The latter soon becomes less active, loses its natural color, then turns gray and dies, remaining attached to the part of the plant upon which it has been feeding. When the larva is fully developed it pupates and cuts a circular hole on the top of the body of the now "mummied" aphis, emerging as a winged insect to attack other living aphids in the same way as its mother. The circular hole cut by the escaped parasites is always a sure sign of the presence of these beneficial insects.

In the summer of 1911, the author noticed that *Aphiduis testaceipes* alone destroyed and kept in check what seemed an epidemic of the sweet pea aphis. On the other hand, in the summer season of 1912, this beneficial parasite was rather scarce. It is, therefore, interesting to know the conditions which determine its presence or absence. The following are observations recorded by Webster and Philips:[1] The dispersion of Aphiduis may be accomplished by the larvæ in the bodies of the winged aphids whence it is carried from place to place and also by the wind. While the young larvæ are within the body of the aphis they are not easily detected. It is only when the larva becomes nearly full grown that it may be detected, and then only by an expert observer. There may be millions of larvæ of Aphiduis in a field and yet present no visible indication of their presence. A few warm days bring about their final development, whereupon the presence of the leathery brown bodies of the parasitized aphids begin to attract the attention. Climatic conditions are important factors in determining the abundance of Aphiduis.

[1] Webster, F. M., and Philips, W. J., The spring grain aphis or "green bug." U. S. Dept. Agr. Bur. Entom. Bull. 110, 1912.

Aphelinus. Another insect which parasitizes the sweet pea aphids is *Aphelinus nigritus*, a parasite also known to attack a number of other green plant lice (fig. 37).

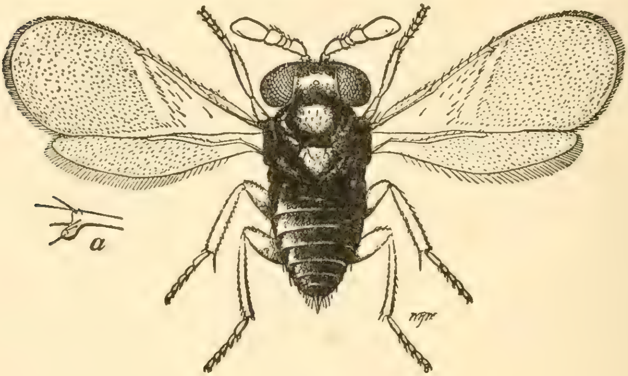


FIG. 37. *Aphelinus Nigritus;* A PARASITE OF THE SWEET PEA *Aphis.* (AFTER WEBSTER AND PHILIPS.)

This insect, however, is not so active as the Aphiduis previously mentioned.

Fungous Pests. The fungi which help to destroy the sweet pea aphids are not as yet well known. *Empusa aphidis* (fig. 30) is the only fungus which has received some attention and study. The others remain to be investigated. The development of *Empusa aphidis* depends upon rather warm, humid weather for its spread and is retarded by drought. This fungus was found fairly active during the summer of 1912. It is possible to cultivate the fungus artificially and it may be used to inoculate broadcast the aphids in the field.

THE TWELVE-SPOTTED CUCUMBER BEETLE

Diabrotica 12 punctata Oliv.

The larva of this insect feeds on roots and stalks of corn and on a number of other plants but as far as is known does not feed on roots and stems of sweet peas. It is the adult beetle of this insect that is troublesome to outdoor sweet peas. The beetle is one of the earliest pests seen to feed on the plants, as soon indeed as they are no more than six inches high. The injury is confined to the leaves, where it extends over large areas. The beetle is often known as the 12 spotted cucumber beetle, the color of its body being yellowish green and its wing covers marked by twelve black dots. Besides the sweet pea, the adult beetle also feeds on cucumber, squash, and melon blossoms. It also feeds on alfalfa, clover, cotton, rye, and tobacco. This species is abundant in the Southern states; although its range in the North is also very wide. Despite its being an early species, the beetle is also found feeding on sweet peas which have long passed blooming.

THE BLISTER BEETLES. *Epicauta sps.* Blister beetles feed on sweet pea plants from the beginning of the seedling stage up to maturity. Two species of blister beetles are troublesome to sweet peas; the black and the striped.

The Black Blister Beetle. *Epicauta pennsylvanica DeG.* As the name implies, this bettle is uniformly black. It measures a little over a quarter of an inch in length. It feeds on a wide range of plants such as the potato, tomato, cabbage, carrot, beet, corn, bean, aster, clematis, zinia, sweet pea, and a number of other ornamentals. In the absence of other food it is commonly found feeding on different ragweeds (Ambrosia sp.), on golden rod, on amaranth, and on iron weed. This beetle, too, has a wide range of territory.

The Striped Blister Beetle. *Epicauta vittata Fab.* This species is about half an inch in length with blackish wing covers, each of which is bordered with yellow and has a yellow stripe down the center (fig. 38). It injures potatoes, tomatoes, beets and mangels, turnips, beans, peas, radishes, melons, corn, clover, alfalfa,

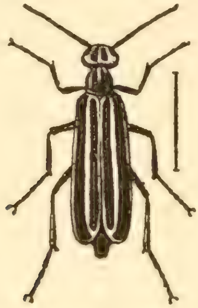


FIG. 38. THE STRIPED BLISTER BEETLE. (AFTER CHITTENDEN.)

and sweet peas. According to Professor Chittenden[1] the beetle lays its eggs on plants or on the ground. From each egg hatches a small long-legged larva, which runs actively in search of a grasshopper egg pod which it enters and feeds upon. Afterwards it casts its skin several times and finally becomes transformed into a beetle.

There are also a number of caterpillars which feed on the sweet pea, but they have as yet not been studied carefully.

[1] United States Department of Agriculture, Year Book, 1898.

SOIL INFESTING INSECTS

VARIEGATED CUTWORMS. *Peridroma saucia.* These are common garden pests attacking a number of other plants as well in addition to the sweet pea (fig. 39 *a* to *f*). Cutworms are troublesome the first year when sweet peas are planted

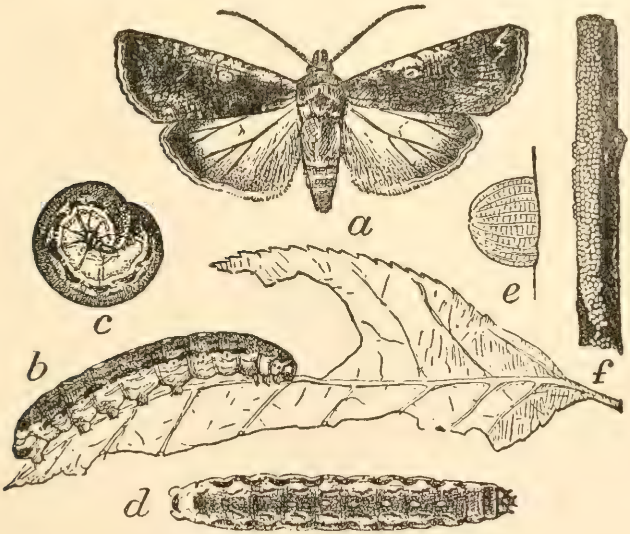


FIG. 39. VARIEGATED CUT WORM, *a* MOTH. *b* LARVA FEEDING. *c* LARVA RESTING. *d* EGGS LAID ON DEAD TWIGS. *e* CLUSTER OF EGGS MAGNIFIED. (AFTER CHITTENDEN.)

on old sod. They are sometimes introduced into a new place with the compost. The larvæ of cut worms have the habit of cutting herbaceous plants at the stem end. The injury is inflicted at night or on dark days: the worms return to the ground as soon as the sun appears. The adult of the cutworm is a moth which lays her eggs in old fields or pastures where there is plenty of grass for the young larvæ to feed upon. As the young hatch, they feed on roots of grass. The first season the young cutworms usually attain about half an inch in length. As winter approaches they build earthen cells in the ground and thus protect themselves from cold weather. In the spring, if the field is allowed to remain in grass, plenty of food is on hand for them. However when the sod is plowed under, and other garden crops planted, such as the sweet pea, the natural food supply of the worms is cut off and they are compelled to feed on the cultivated plants. These are severely injured if the insects are abundant.

WIREWORMS *Melanotus communis* are a prominent pest of field crops. They are the young of click beetles, also known as snapping bugs. Wire worms are brown hard bodied larvæ of nearly uniform size throughout. They bore into various seeds after planting or work on the roots of various plants, often causing serious injury. The eggs are laid on old pasture land, and the larvæ which hatch from them normally work on the roots of grasses. If the sod is replaced by any other cultivated crop, the larvæ are forced to feed on that crop for want of its normal host plant. Sweet peas often suffer from this pest, although the injury is not apparent until they are in bloom.

Differing from cut worms, wireworms pass from three to five years in the larvæ stage; hence wireworms of different ages may be found in the same place feeding side by side.

White Grubs. *Lachnosterna sp.* White grubs are the larvæ of May beetles (fig. 40 *a* to *f*). They are injurious to a

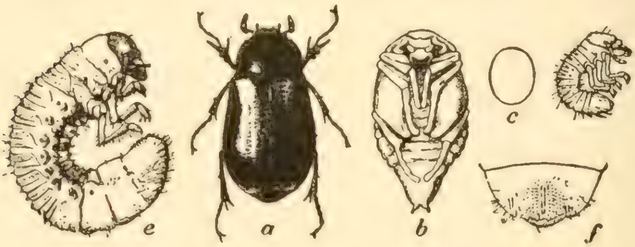


FIG. 40. WHITE GRUB OR MAY BEETLE, *a* BEETLE. *b* PUPA. *c* FULL GROWN LARVA OR WHITE GRUB. (AFTER CHITTENDEN.)

number of cultivated plants, the sweet pea being included. May beetles lay their eggs in sod, in corn fields, or in the garden. The grubs hatch about the middle of July and begin feeding on roots, growing slowly, and requiring two years or more to become full size. Larvæ of proper age and size change to pupæ in midsummer and the adult stage is reached by September, but the beetles remain in the earthen cells made by the larvæ until the following spring. Thus it is seen that the life cycle of white grubs is similar to that of wireworms. Larvæ of different ages are present in the soil at all times in the year; hence injury caused by them may be continuous.

CHAPTER VIII

DISEASED SEEDS

Anthracnose. Under the discussion of anthracnose we have already seen that disease may be transmitted with the seed. In that case infection starts on the pods and the disease works inwards, gradually penetrating the seed coat and the seed proper (fig. 41). Such seeds when harvested have a shriveled appearance and when planted with healthy seeds introduce the trouble into the soil.

Streak. Another disease that may be transmitted with the seeds is the "streak." In examining infected plants we can readily see that the disease has invaded the pods and the seeds within. When such

Fig. 41.—Anthracnose Disease of pods and seeds.

The arrows shew the diseased spots.

seeds are planted, they may introduce the parasite into the soil.

Shriveled Seeds. Sweet pea seeds, as sold by seedsmen, as put up in small paper packages. In very few cases are all the seeds plump and full. A certain per cent are shriveled and give the appearance of being diseased. Such seeds are not always diseased. These shriveled seeds often germinate as readily as the plump ones, and as they swell cannot be told from others. It seems that the shriveling is correlated with loss of water, and this seems to be characteristic of some varieties more than of others. However, it is difficult to tell whether such seeds in the long run produce weaker plants which are more susceptible to disease. A small percentage of the shriveled seeds fail to germinate. Some of these no doubt are hard seeds which cannot germinate because of their impervious seed coats. Others upon culturing in the laboratory are found to contain a variety of fungi, such as Alternaria, Fusarium, Clonostachys, Rhizopus, and Botrytis (fig. 42). These seem to play the rôle of saprophytes on the growing plants, but they may be weak parasites, capable of attacking these few shriveled seeds which may lack in vigor and resistance.

THE DRUG STORE BEETLE.[1] *Sitodrepa panicea.* This minute beetle (fig. 44) is of considerable economic importance to seedsmen, since sweet pea seeds in the storehouse are very frequently seriously injured by it. This pest is often found feeding on dry bread, and because of this, it is known in Europe as the bread beetle. In this country it is found to

[1] See also Bull. 4. Bur. Entom. U. S. Dept. Agr., 1896.

Fig. 42.—To the left, Fusarium and Botrytis fungi from shriveled and non-germinated Sweet Pea seeds; to the right, shriveled seed soaked 3 minutes in a 2% formaldehyde solution.

be a very common pest in drug stores, whence its name. It also invades mills, granaries, and warehouses of all kinds. It also invades the kitchen where it feeds on red pepper, flour, and all sorts of breakfast foods. It also eats ginger, rhubarb, chocolate, dried fruits, beans, peas, coffee, rice, and other seeds of every description. Its larva is often found as a book worm. The larva of this beetle is so voracious that it is said to "eat anything except cast iron." It is also the larva of this beetle that is so fond of sweet pea seeds, tunneling the inside, and thus completely destroying the germinating power of the seed. The adult beetles mate and the female lays her eggs on sweet pea seeds and elsewhere. The young upon hatching at once begin to tunnel into the seeds. In the storehouse there are usually four broods formed during the winter and if allowed free range may destroy large quantities of seed.

Seedsmen whose storehouses are seriously infested with these pests will find relief by the use of bisulphide of carbon evaporated at the rate of one pound of the chemical to each 1,000 feet of cubic space. While fumigating, the room should be closed tightly and care taken to keep away lighted cigars, matches, or burning candles.

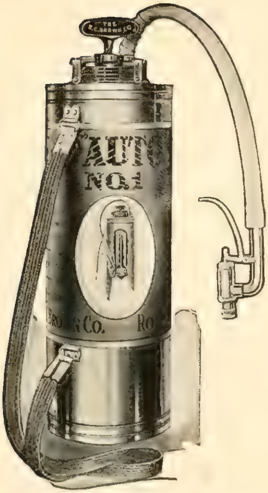


Fig. 43.—Auto Spray
No. 1.

Courtesy of E. C. Brown Co.,
Rochester, N. Y.

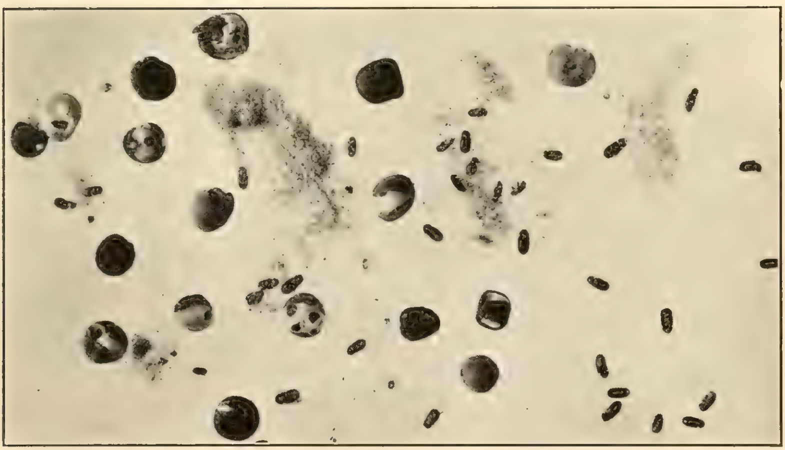


Fig. 44.—The Drug-store Beetle, an enemy to stored
Sweet Pea seeds.

CHAPTER IX

PHYSIOLOGICAL DISEASES

Physiological diseases are those disturbances of the normal activity of a plant which are not induced by fungi, bacteria, or insects.

Bud Drop. The young flower buds at a very early age, turns yellow and drops off. This disease is sometimes confused with the drop produced by the anthracnose disease. In the latter case the flower develops into a normal spike, but it is attacked soon by the fungus, *Glomerella rufomaculans*, which girdles it at the point of attachment between the flower and the peduncle. In this case the blossom falls off, leaving behind the beheaded peduncle. In bud drop, however, the minute young blossoms fail to develop, and drop off while very young.

This form of drop is attributed to an unbalanced condition of food elements in the soil. This may occur in a soil that has been excessively fed or in a soil that is lacking in plant food. Bud drop has actually been found in the laboratory on sweet pea plants grown in pots which received heavy applications of manure, and in pots filled with a very poor clay soil. The trouble has been overcome by the application of 150 lb. of muriate of potash and 600 lb. of acid phosphate per acre. As a result of this treatment the drop ceased within a week, and a luxuriant crop of flowers was produced. An application of a balanced fertilizer to the pots above mentioned readily helped the plants to overcome the drop.

Root Burn. This trouble, probably, is

a physiological disease. It is induced by the excessive use of fertilizers. The following facts from the letter of a grower who wrestled with this trouble will help to confirm the belief in the physiological nature of this disease: "The seeds were sown November 1 in pots and planted December 15 in the beds in the greenhouse. Previous to the planting, the beds were well manured with horse manure, which was applied six months before planting. Besides this, wood ashes were also applied at the rate of 1,500 lb. to 4,500 square feet of bed space. This would be equivalent to nearly seven and one-half tons per acre. About one month after planting, some of the plants turned yellow and died; others remained dwarfed and offered a languid appearance." Upon examining some of the plants, they were found to be dwarfed and to have a sickly yellowish look. The roots were dwarfed, blackened as though burned, resembling the injury of Thielavia root rot. Upon testing the soil it was found to be strongly alkaline. Hard wood ashes, contain about 30 per cent caustic lime and from 5 to 12 per cent potash. It was the excess of both of these substances that made the soil so alkaline, the roots of the sweet peas becoming burned and inhibiting growth. This kind of injury could be considered purely physical; nevertheless any injury which interferes with the normal functions of the parts of the plants also results in a disturbance in its metabolism, and is therefore considered as a physiological trouble. A remedy for this was found in the use of acid phosphate, followed by a good drenching of water. This helped to neutralize the alkalinity and to balance the food rations in the soil.

CHAPTER X

METHODS OF CONTROL

GROWERS who expect to find in these pages a "cure all" for their sweet pea troubles will be disappointed. Once a tender sweet pea plant is invaded by fungi or bacteria it can rarely be cured. Insects, however, may be destroyed, since it is possible to poison them, although the task is often difficult because they are not easily accessible.

The problem, therefore, is one of prevention. Sweet pea growers would win ninety per cent of the battle if they would realize the importance of preventive methods. Here, as elsewhere, the old dictum holds true, "an ounce of prevention is worth a pound of cure." Yet even here, the personal element is the determining factor in success. Growers too often work by "rule o' thumb." Some have their pet theories as to causes of disease; others have their remedies, favorite fungicides intended to act as a cure all but which do not often yield the promised results. Progressive growers find it profitable to keep in close touch with Plant Pathologists in the various Experiment Stations. More than this, every grower should develop the power of keen observation, for plant diseases are too often not detected until too late.

RESISTANT VARIETIES

The most promising means of control is the use of resistant varieties. It is true that resistant varieties will encourage the lazy man to neglect his seed, disregard rotation, and overlook all sanitary methods;

nevertheless, resistant varieties are often the only protection against complete annihilation of a species by disease. In passing through a sick field, one cannot help but notice that not all the plants of the same kind are subject alike in the same way to the disease. Some are killed outright; others are partly affected, or if badly affected, resist the disease; and still others are not at all diseased. If, therefore, we are able to select the seed from the resistant strain and multiply it rapidly, we will obtain resistant plants capable of producing 100 per cent healthy plants in a sick soil. That this is possible there can be no doubt. A strain of cowpeas has been obtained which is resistant to wilt, and a strain of clover has also been obtained which is resistant to anthracnose. Of course, it cannot be expected that a strain will be resistant to every disease, but there is no doubt that we may obtain strains resistant to more than one disease.

SEED TREATMENT

It was previously shown that the seeds are capable of carrying anthracnose and possibly also the streak disease. It is therefore unwise to plant sweet pea seeds without first treating them. Heating the seed in hot water at various temperatures of 100 degrees, 90, 80, 70 and 60 degrees C. from one second to five minutes does not seem to yield promising results. Soaking the seed in sulphuric acid from five to fifteen minutes helps to accelerate germination, especially of the hard seed; and it also destroys all harmful germs which adhere to the seed coat. After soaking the seeds in the sulphuric acid, they should be thoroughly washed in running water, then dried and planted in the usual way. Treating the seed with the acid for one hour will greatly reduce its percentage of germination, and by prolonging the treatment to one and a half hours, germination will be inhibited altogether.

Soaking the seed in a solution of one pint of formaldehyde in 30 gallons of water for ten minutes will also destroy spores which adhere to the seed coat. The formaldehyde treatment however does not seem to help the germination of the seed. It should not be expected that the seed treatment will remove all evils. It is only beneficial in that it kills all spores of parasitic fungi which may adhere to the seed coat. Seeds which are diseased and which have their interior tissue invaded by parasitic organisms will not be benefited by the treatment, since the chemical cannot penetrate the seed to reach the interior lodging parasite. The use and selection of clean, healthy, plump seeds is as important as the seed treatment.

CONTROL OF SICK SOILS

The habit of many growers of sweet peas is to use the same soil in the beds for a period of years. It is even claimed that this practice tends to produce stronger vines. This may be true as long as the soil remains uninfected. However, no sooner does contamination set in with either Rhizoctonia, Fusarium, Thielavia, Chaetomium, or the eel worm, than it becomes difficult, if not impossible, to obtain a stand of sweet peas. The remedy of course is to throw out the old soil and bring in fresh dirt free from disease. This unfortunately is not always a safe method, for the reason that the new soil too may be contaminated, or that it may readily become infected as soon as it is placed in the

Fig. 45.—Soil infected with *Fusarium lathyri*, the cause of Sweet Pea Wilt: a. the soil was steam-sterilized, resulting in a perfect stand; b. check unsterilized. The seedlings in both pots are of the same age.

previously contaminated bed. Infected greenhouse soil may be rendered useful and free from disease by either the steam or the formaldehyde methods of sterilization.

(a) Steam Sterilization. This method is practical in the greenhouse (fig. 45) or on seed beds only where the areas are limited. Its use is possible only where steam is to be had from a boiler capable of producing from 80 to 90 lb. pressure. The method of sterilization is as follows: before planting, prepare the soil in the regular way, adding the necessary amount of manure and fertilizers. At the bottom of the bed or bench, pipes or drain tiles are laid parallel to each other two feet apart. The pipes are perforated with 1-6-inch holes throughout. These pipes or tiles are closed at the farthest end so that the steam may come out through the cracks or holes.

The other end of the tiles or pipes fits into a cross-pipe which is connected with the main steam pipe in the boiler. The steam is now turned on and as fast as it escapes from the holes it penetrates and heats the soil in the bench or bed. The steam is turned on from one to two hours according to the constancy and strength of the pressure. A good method of determining when to turn off the steam is to bury a few raw potatoes at the surface of the bed and cover them with some straw or sacking. When the potatoes are cooked the sterilization has been completed. This method of sterilization has the advantage of killing the eel worm and all the other soil troubles as well as the weeds. As above described, it is somewhat expensive in the initial cost of installation. But once put in, it serves a number of years, and the pipings too may be used for sub-irrigation, a very desirable method of watering the beds.

A cheaper method of steam sterilization is the "inverted pan method," which may also be used to sterilize seed beds and frames outdoors. The method has given excellent results and because of its simplicity and small cost is recommended for use in large or small areas. It is the invention of Mr. A. D. Shamel of the United States Department of Agriculture. The apparatus consists of a galvanized iron pan 6 ft. by 10 ft. and 6 in. deep, which is inverted over the soil to be sterilized, and steam is admitted under pressure. The pan is supplied with steam hose connections, has sharp edges which are forced into the soil on all sides to prevent the escape of steam, and is fitted with handles for moving it from place to place, the weight of the entire pan not being over 400 lb. The soil to be sterilized is prepared as in the previous method, a few potatoes being buried to gauge the amount of heat produced. The steam is kept at as high a pressure as possible, 80 to 100 lb. being best, for one to two hours according to the pressure maintained. When one section of the bed is treated, the pan is lifted and carried to an unsterilized portion and the operation is repeated until the entire bed is steamed.

(b) FORMALDEHYDE. When steam sterilization is not feasible because of the absence of a steam boiler or for some other reason, the formaldehyde treatment is the next best. It will kill Thielavia, Fusarium, Rhizoctonia, Pithyium, and Chaetomium in infected soils. It is doubtful, however, if it will entirely remove eel worms from such soils. The formaldehyde method is applied as follows: The beds are thoroughly prepared in the same way as in other methods of sterilization and are drenched with a formalin solution composed of one pint of commercial formaldehyde to 25 gallons of water, one gallon of this solution being used to each square foot of bed space. The solution should be put on with a watering can and distributed as evenly as possible over the bed so as to wet the soil thoroughly to the depth of a foot. It will in most cases be necessary to apply this solution two or three times, as the soil will not absorb this quantity of liquid at one time. After the treatment the beds should be covered with heavy burlap to keep in the fumes for a day or so, and then aired for a week before planting. Stirring the soil at this time helps the escape of the formaldehyde fumes.

(c) Infected Areas. In the greenhouse, damping off or any other of the soil troubles usually starts at one part in the bed and from there spreads all over the bed. Where only a few of these centers of infection occur, much damage may be prevented by immediately removing the infected plants and soil from the bed together with the surrounding area somewhat beyond the last signs of disease.

(d) Cultural Considerations. Every factor which leads to a weakening of the plants should be eliminated. In the greenhouse, overfeeding as well as underfeeding, overwatering, and excessive high temperatures with lack of ventilation should be avoided.

(e) Other Preventive Methods in the Greenhouse. Usually the soil in the greenhouse is infected with manure, with potted plants started early in a cold frame, or with diseased tomatoes, the violets, and a number of other hosts grown as alternating crops. It goes without saying that the grower should not knowingly bring in sick soil into the greenhouse, nor should a sick soil from indoors be dumped in the open where sweet peas or any other crops are likely to be grown for ornamental or commercial use. Care should be taken to allow no access to diseased violets or diseased plants of any kind.

CONTROL OF OUTDOOR SICK SOILS

Unlike greenhouse soils, affected areas outdoors are not so easily treated. In a small garden plot, as in the home garden for instance, a sick soil may be sterilized either with steam, using the inverted pan method, or with formaldehyde, as in the case of the greenhouse. Where sweet peas are grown on a large scale, as for seed purposes, the problem of handling sick soils becomes a more difficult matter. In this case neither the formaldehyde nor the steam methods are applicable, since either is too expensive when used on a large scale and hence is not practical. There are, however, other control measures which may prove helpful.

(a) CLEANLINESS. It is a common practice to allow sweet pea plants which have passed their usefulness to winter over in the field. As spring comes, the dead vines are plowed under. In cases of fall plowing and sowing the old vines are immediately turned under. Should these vines have suffered from disease the previous season, they would at once re-infect the soil. As time goes on the land may become so contaminated as to be unfit for sweet peas for a number of years. To obviate this the old vines should be burned as soon as they pass all usefulness and as soon as they have sufficiently dried. The expense and the labor of this operation should not influence the grower to neglect this. This is especially true for the seedsman whose success depends largely on clean lands in order to produce clean seed which will meet the market requirements.

(b) Manure. Florists and growers often dump potted plants on the manure pile or on the compost. Such plants may often be infected with some of the soil troubles to which the sweet pea is susceptible. The use of such infected manure or compost may mean the ruin of an entire field. To avoid outdoor contamination of our sweet pea soils, extreme care must be taken that no contaminated manure or compost find its way into the plantations.

(c) Crop Rotation. This is an essential and effective means of controlling soil sickness. With this system the parasite is starved out for lack of the proper hosts. With the sweet pea, the selection of hosts for proper rotation is a difficult one. So many of the cultivated and ornamental plants, for instance, are subject to the root rots which also attack sweet peas. The safest method, perhaps, for seed growers, would be to have sweet peas alternated every second or third year with a cereal such as sweet corn, sugar cane, or millet. Where soils are already badly affected, sweet peas should be grown on the same land every fifth or sixth year.

(d) Fertilizers. Outdoor sweet peas are not as yet known to suffer from eel worm attacks. However, should this occur, increase of fertilizer will undoubtedly prove to be a good method of handling root knot by forcing the growth of the root system. Observations show that nematode injury is confined to the upper roots of the plant, that is, those which are 12 to 16 inches deep. Hence, if the roots are induced to penetrate deeper in the soil, part of the injurious effect will be overcome. Potassium salts have been found to be beneficial, especially in soils poor in potash. It has been found in Germany that the sugar beet nematode removes equally all mineral salts from the roots. Therefore to improve such a condition we would need to add only that mineral which was originally lacking. This may explain the effect of potash in combating this disease.

Control of Soil-Infesting Insects. Spraying the soil will be of little value in the control of underground insect pests. Where wire worms are causing injury to the roots of sweet pea plants, sow corn which has been soaked for ten days in water containing arsenic or strychnine before the sweet pea seeds are planted. The larva will attack the poisonous corn kernels and die. Another way is to scatter poisoned and sweetened corn meal dough which will act as a bait.

White grubs may be controlled by the use of bisulphide of carbon and kerosene emulsion. The latter is diluted about ten times and poured on the ground about the infected plants. This, however, is a risky procedure. Fall plowing is a valuable remedy since many of the grubs are thus exposed to the cold winter weather and killed.

Cut worms may be controlled by the use of a poisoned bran made as follows: to three ounces of molasses add one gallon of water, and sufficient bran to make a fairly stiff mixture. To this add Paris green or arsenic and stir well into a paste. A heaping teaspoonful of the mixture is scattered here and there over the infested land.

CHAPTER XI

SPRAYING

General Considerations. The orchardist, the nurseryman, the gardener, and the florists have already learned the necessity of spraying. It often determines whether they shall lose a large part of the crop or get from it the largest possible profit obtainable. It is doubtful if sweet pea growers have come to this important realization. Many writers on sweet peas have in the past attempted to give the impression that this species is usually free from insect and fungous pests. This has unfortunately led to an indifference that resulted in the quick dissemination of a number of dangerous diseases. The streak which is causing so much loss to sweet peas in England has gained a strong foothold in this country, yet prominent growers and seedsmen strenuously deny the existence of this disease here. The anthracnose is another serious disease, and yet few growers have a first hand knowledge of its existence. The time is rapidly coming when the sweet pea like every other important crop will have to be sprayed. The grower who fails to do so will be crowded out because of competition with others more careful. It is true that spraying is no pleasant pastime for the grower; nevertheless, it is a necessary evil, if evil it may be called.

Spraying has two aims: to kill the insect and animal pests, and to control fungous diseases. The substances which are used for the one are without effect on the other.

Insecticides. All animal and insect

pests are best controlled by the use of poisonous mixtures applied in the form of liquid sprays or powders. Insecticides may be classified as internal or stomach poisons, and external or contact poisons. The former kill the biting insects which take it into the stomach with the food; the latter kill by direct contact, and either causes an irritation of the surface of the body or clogs the respiratory openings of sucking pests.

(a) Stomach Poisons. Paris green is one of the best known of stomach poisons. When chemically pure, it is composed of copper oxide, acetic acid, and arsenious acid. It destroys cutworms, caterpillars, beetles, grubs, slugs, etc. On the sweet pea it should be applied preferably as a liquid, using one pound of the poison and one pound of lime to two hundred gallons of water. Paris green tends to sink to the bottom of this mixture, and to avoid this it must be constantly stirred while being applied. This chemical is often adulterated with white arsenic, causing it to badly scorch the treated plants.

For sweet peas, the use of arsenate of lead is to be preferred to Paris green, since it is less liable to scorch the foliage, and adheres better. Its chemical composition consists of acetate of lead and arsenate of soda. It is applied to the best advantage as a liquid, using about three pounds to 100 gallons of water.

Arsenite of zinc may also be used. It is a very finely divided fluffy white powder which distributes and adheres well to the foliage. It is intermediate between Paris green and lead arsenate in strength, and costs less than either.

It is essential when arsenicals are used to see that they are correctly labeled, and kept under lock and key as they are poisonous to man and animals.

Hellebore or white hellebore is somewhat less dangerous than the arsenicals. However, it loses its insecticidal value by being exposed to the air. It is a specific against slugs in the greenhouse.

(b) CONTACT POISONS. All the tobacco or nicotine products sold principally as extracts or powders belong to this class. A common brand much used is the preparation known as "Black leaf 40," diluted 1 part to 700 or 800 of water. An addition of soap at the rate of two bars to each 100 gallons of the solution increases its effectiveness by making it spread out better. Aphine, Sulpho tobacco, and a number of other products found on the market are usually valuable as contact poisons if properly tested out and guaranteed by the dealers.

Fungicides. These are poisons used to control fungous pests. As previously stated, some parasitic fungi live on the surface of the leaves and stems and are therefore easily controlled. An example of this is the sweet pea mildew. Other fungi, and these are by far in the majority, are those which live parasitically in the tissue of the host, and therefore cannot be reached. Fungicides are only helpful in preventing entrance of the parasite in the host. Fungicides are ineffective in controlling insect pests, as are insecticides in controlling fungous pests.

(a) Bordeaux Mixture. This is the standard fungicide, especially valuable in controlling the sweet pea anthracnose. The strength used should be 3 lb. of copper sulphate, also known as blue stone, 4 lb. lime, and 50 gallons of water. The easiest way to prepare it is to dissolve thoroughly the blue stone in 25 gallons of water. Use the best quality of lime and slake it in a little hot water, being careful, however, not to flood it while slaking, nor to let it become too dry. When the slaking is completed, add enough water to make 25 gallons. Mix the lime water and the blue stone solutions, using first one part of lime water, then another part of the blue stone. Strain and use at once. It is essential that the lime shall not be air slaked before it is used.

The lime water and the blue stone solutions will keep a long time if they are kept in separate receptacles and well covered. However, after they are once combined, it must be used the same day. Bordeaux mixture more than a day old is useless. Where Bordeaux is used extensively, stock solutions of lime and blue stone should be prepared and ready for use.

(b) Ammoniacal Copper Carbonate. The objection to the use of Bordeaux is that it stains the leaves and foliage of the sweet pea plant. This is not a serious objection when sweet peas are grown for seeds or even commercially as a cut flower. However, when grown in conservatories or in public parks for ornamental purposes, the use of Bordeaux becomes objectionable. In this case ammoniacal copper carbonate may take the place of Bordeaux, since the former is a colorless material. It is prepared as follows:

Copper carbonate	5 oz.
Ammonia (26° Baume')	3 pints
Water	50 gallons

This fungicide should be used as soon as it is made, as the ammonia evaporates quickly.

(c) Potassium Sulphide. This is a valuable fungicide for the control of the sweet pea mildew. The following strength is recommended:

Potassium sulphide	4 oz.
Water	10 gallons

(d) SULPHUR. Flowers of sulphur are often used in greenhouses to control the sweet pea mildew. It may be applied either by hand or with a duster.

There are a number of other fungicides on the market which are not mentioned. They should be thoroughly tested before they are used. Considerable discretion should be exercised before using a new fungicide which claims to be a "cure all."

COMBINATION SPRAYS. In the discussion of the foregoing chapters on fungous and insect pests, it is seen that the sweet pea is subject to the attacks of more than one disease. Spraying, if properly done, is effective in controlling or in keeping in check all the pests which attack all the parts of the plant above ground. The various spray solutions which may or may not be combined are indicated by Cooley and Swingle [1] in the following table:

	Tobacco extracts	*Lime sulphur*	*Bordeaux mixture*
Paris green	yes	no	yes
Arsenate of lead	yes	yes	yes
Arsenite of zinc (ortho)	yes	*	no
Arsenite of lime	yes	no	yes
Lime sulphur	yes	....	....
Bordeaux	yes	....	....

* The advisability of making these two combinations needs further investigation.

Each of these preparations is mixed and applied just as if it were used alone. A combination of the ammoniacal copper carbonate with an arsenate would be unsafe, since the ammonia renders the arsenic

[1] Cooley, R. A., and Swingle, D. B., A spraying program for Montana orchards. Montana Agr. Expt. Station, Circ. 17: 119–151, 1912.

more soluble, and hence may result in the burning of the sweet pea foliage. However, it may be mixed to advantage with the tobacco products.

Careful investigations of Professor Safro, Entomologist to the Kentucky Tobacco Product Co., show that "Black leaf 40" may be used in combination with such spray chemicals as lime sulphur, arsenate of lead, arsenite of zinc, and iron sulphate for controlling sucking and chewing insects and fungous diseases, the soap in this case being omitted. Professor Safro's work further shows that "Black leaf 40" may be safely combined with Bordeaux, and the desired results obtained. Professor Safro writes as follows: "For purposes of spraying sweet peas, add to every 100 gallons of Bordeaux three-fourths of a pint of 'Black leaf 40.' As far as safety to the foliage is concerned, much greater strengths of nicotine may be added to the Bordeaux, but no additional effectiveness will be given to the mixture as an insecticide. Any nicotine solution that is used for Aphis containing four-hundredths of one per cent nicotine will be effective if the work is thoroughly done."

For greenhouse purposes the Auto Spray No. 1 is a very desirable spraying machine (fig. 43). It may also be used outdoors on small garden lots. In California, where large acreages of sweet peas are grown for seed, a gasoline sprayer is the proper machine. However, as the plants reach three to four feet and as the rows begin to touch, spraying by power machinery which has to be drawn by horses becomes prohibitive. In this case two to three Auto Sprays No. 1 will answer the purpose very well.

PRINCIPLES INVOLVED IN SPRAYING SWEET PEAS

It should be remembered that to destroy chewing insects such as caterpillars, etc., the stomach poison must be evenly distributed all over the plant. This should be done as soon as the presence of the pest is suspected. Intelligent and observant growers will, of course, remember the time of appearance of the pest every year, although the time depends somewhat on the climate of each season. In destroying the green aphids the contact poison should be distributed as evenly as possible on the insect itself. It is, therefore, best to spray for aphids as they are actually found working on the plants. With chewing insects and with fungous pests, however, the applications are made even before the parasites appear. Before spraying it is necessary to have well in mind the organism which is to be destroyed, and the proper ingredients used. To keep fungous pests in check it is necessary to have the plant covered with the fungicide all the time infection is feared or suspected. It must be remembered that spraying for fungi is a form of insurance. It protects the plant from becoming infected. However, when the parasite penetrates the host, spraying is of little value in saving the infected plant although it will protect others which are as yet healthy. It is essential that the sweet pea grower be ever ready to spray on time (fig. 46). Sometimes the retardation of even a day may yield negative results. The timely destruction of one insect, or of one spore, undoubtedly means the destruction of countless generations of these pests.

Thoroughness is as important in spraying as it is in everything else in life. Especially is this true for the control of fungous diseases. A spore accidentally lodged on a portion of a leaf overlooked by the sprayer is like a fortified city guarded by rusty cannon.

DIFFICULTIES IN THE SPRAYING OF SWEET PEAS. The difficulties in spraying sweet peas is that the average fungicide will not stick. This is especially true where coarse nozzles are used; the liquid in this case collects into large drops and then rolls off. This difficulty is eliminated by the use of very fine nozzles, since the finer the spray the greater the success. The use of stickers often helps to make the spray liquid adhere better to the foliage. With the sweet pea the use of soap answers well the purpose of a sticker. Add two to three pounds of soap to about every 100 gallons of the spray mixture

Fig. 46.—Spraying a young Sweet Pea field.

Courtesy of C. C. Morse and Co.

used. Where combination sprays are used the soap is to be omitted.

Spraying Greenhouse Sweet Peas. Under greenhouse conditions, insect and fungous pests are more easily controlled than out of doors. In the greenhouse, conditions are more nearly under the control of the grower. By proper cultural care many troubles may be kept in check, so that spraying may be dispensed with. There are, however, certain days when the weather is such that proper ventilation is difficult if not harmful. The greenhouse air then becomes saturated with moisture, which favors the development of mildew. At other times the house is allowed to get too dry and red spiders and aphids make their appearance. Theoretically red spiders and mites may be controlled by frequent syringings with plain water. Practically, however, the syringing is not always done in the proper way to become effective. In this case spraying with a standard contact poison becomes necessary. Next to red spiders, the only insect that is of economic importance is the green aphid. Both of these may be kept in check by the use of "Black leaf 40," using a dilution of one part to one thousand (by volume). Aphin or sulpho tobacco may answer the same purpose. Some growers prefer the use of nico fume tobacco papers. With these all that is necessary is to hang the paper on any convenient nail and to light the end of it. Should mildew appear it may be readily controlled by dusting with flowers of sulphur, or by spraying with potassium sulphide, dissolving four ounces of the chemical in ten gallons of water. The solution should be used at once, as it loses its strength by exposure to the air.

Outdoor Spraying of Sweet Peas. Under our present conditions, it is difficult to raise a crop of sweet peas outdoors without its becoming infested with most of the pests enumerated in this book. Spraying therefore becomes a necessity. However, the grower cannot afford to spray for each pest separately. A combination of spray mixtures becomes imperative so that one application may reach at the root of many evils. Red spider, the green aphid, the chewing insects, as well as the fungous diseases of stems and leaves, may be controlled by a combination of the following materials in the following given proportions:

1. Make the regular 5–5–50 Bordeaux formula.

2. If the green aphid is present add to every 100 gallons of the Bordeaux three-fourths of a pint of "Black leaf 40."

3. To each 100 gallons of 1 and 2, add 1 lb. of arsenate of lead to keep in check the biting insects. If Paris green is used instead of arsenate of lead, add one pound of extra lime to every pound of the above insecticide used. These formulæ apply to sweet peas grown on large scales. On smaller plots, such as the home garden, the same formulæ hold good except that calculations are made so that less of the spray mixture is prepared at one time.

With outdoor sweet peas, spraying should begin as soon as the plants are six inches high and should be continued until the plants are about to lose their usefulness. The frequency of the applications will depend largely on the weather. The more it rains the more often spraying is necessary. The object should be to keep the plants covered a large part of the growing period with spray materials. Under ordinary conditions, spraying every other week is a desirable practice.

INDEX

INDEX