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PAPERS IN THIS ISSUE

Botrytis Blight of Bouvardia Flowers, by C. M. Tompkins

A serious blight is prevalent on bouvardia cut flowers when they are stored in waxed containers in commercial refrigerators at 48° F in San Francisco. Symptoms consist of small to large light-brown lesions on buds and open flowers. Often lesions coalesce to form larger lesions. In advanced stages, the flowers become shriveled and deformed.

The causal organism has been identified as *Botrytis cinerea* Pers. Its pathogenicity has been established. The disease may be controlled by spraying the flowers with an aqueous solution of copper oleate (1:800) immediately after packing.

Botrytis Stem Rot of Tuberous-rooted Begonia, by C. M. Tompkins

A stem rot of *Begonia tuberhybrida* Voss is prevalent in greenhouses at Capitola and on the San Francisco peninsula.

Principal environmental factors favoring the disease are relatively cool, foggy weather, overwatering, and crowding of the plants. Disease symptoms consist of dark-brown, watersoaked, occasionally sunken and shriveled, irregular-shaped lesions which usually occur at or near the base of the main stem of the plant. Lesions may also develop at some distance above the soil line, at nodes or internodes, and may coalesce to form larger lesions. In advanced stages, the internal tissues are completely invaded, the stem breaks at the lesion site, and the top of the plant falls. Infection may also occur on the axils of leaves and through leaf scars and growth cracks caused by heavy nitrogenous fertilization.

The causal organism has been identified as *Botrytis cinerea* Pers. Its pathogenicity has been established.

The disease may be controlled by removing all debris, excising all infected areas, and painting them, as well as leaf scars, wounds, and growth cracks, with Ziram (Zerlate) paste. This process is repeated daily from midseason until the seed is harvested. Hairy-stemmed varieties are generally more resistant to infection than varieties with smooth stems and few hairs.

BOTRYTIS STEM ROT OF TUBEROUS-ROOTED BEGONIA[1]

C. M. TOMPKINS

INTRODUCTION

During the past decade, a serious stem rot of potted and boxed tuberous-rooted begonia plants (*Begonia tuberhybrida* Voss), grown for pollen production and hybridization, has been prevalent in greenhouses at Capitola, California. Annual losses ranged from 20 to 50 per cent and up, the amount depending upon seasonal conditions. The disease has also been observed to cause heavy losses in lathhouses in the Santa Cruz area, where seedling begonia plants are grown in beds primarily for tuber production, and in greenhouses in the San Francisco Bay region, where plants from both seeds and tubers are raised in pots for cut flowers and for sale as potted plants.

This paper discusses the symptoms of the disease, the causal organism, and control measures.

REVIEW OF LITERATURE[2]

Botrytis cinerea Pers. has previously been reported as a pathogen of *Begonia* spp. Pape (1927, 1933) observed failures among leaf cuttings of the variety Gloire de Lorraine (*B. socotrana* Hook. × *B. dregei* Otto and Dietr.) which showed petiole and leaf decay.

Gray-mold blight, caused by *Botrytis* sp., was mentioned by Scott, Boillot, and Sullivan (1932) as sometimes attacking the foliage and inflorescences of *Begonia* sp., producing a moldy decay. For control of the disease, they recommended destroying blighted parts and avoiding high temperatures, overwatering, and poor ventilation.

Tilford (1932) has also recorded *Botrytis* blight on *Begonia* sp. in Ohio, where it affects the leaves and flowers.

In his monograph on begonias, Fotsch (1933) found the gray-mold fungus parasitizing leaves, stems, and inflorescences of varieties of fibrous-rooted begonia plants (*B. semperflorens* Link and Otto) in greenhouses during mild and cloudy winters.

In Great Britain, Ainsworth (1937) listed gray mold of begonia without specifying the species involved. A stem blight of tuberous-rooted begonia, caused by *Botrytis* sp., occurred in 1935 in New South Wales, Australia, according to Noble *et al.* (1937).

In their textbook, Dodge and Rickett (1943) described a blotch disease of *Begonia* sp. caused by *Botrytis cinerea,* affecting leaves and flowers. They recommended picking and burning diseased leaves and destroying badly infected plants, plus spraying with ammoniacal copper carbonate and bordeaux mixture.

Baker (1946) mentioned *Botrytis* rot of stem bases of fibrous-rooted and tuberous-rooted begonias under glass in California.

Forsberg (1946) referred to *Botrytis* sp. blight on *Begonia* spp. as prevalent on both leaves and flowers.

[1] Received for publication September 17, 1949.

[2] See "Literature Cited" for citations, referred to in the text by author and date.

A similar stem-rot disease of tuberous-rooted begonia plants grown under glass in the San Francisco Bay region and at Capitola, California, caused by *Pythium intermedium* de Bary and *P. ultimum* Trow, was fully described by Middleton (1942).

SYMPTOMS OF THE DISEASE

Under greenhouse conditions, the stems of healthy, tuberous-rooted begonia plants may become infected at any time during the growing season, irrespective of age and size. However, the principal losses from the disease commence in midseason, or from about August 1. Stem lesions are of irregular shape, dark-brown, water-soaked, and occasionally sunken. They range in size from 1 to 3 cm in width and from 1 to 12 cm or more in length (plate 3, *B, C, D*). Although they usually occur at or near the base of the stem, they may also develop at some distance above the surface of the soil. Stem lesions may first develop at the nodes or on internodes, later spreading to involve both areas. If the stem has been slightly bruised, the fungus enters and a lesion results. Axils of the leaves, leaf scars, and growth cracks on the stem resulting from heavy nitrogenous fertilization are favorite means of entrance for the pathogen. Direct penetration of the fungus into unwounded stem tissues is of common occurrence. Sometimes the lesions coalesce to form larger lesions which may encircle the stem (plate 3, *E*), or the stem may shrivel and mummify (plate 3, *F, G, H*), markedly contrasting with healthy stems (plate 3, *A*). In advanced stages of the disease, all internal stem tissues become invaded and the stem so weakens that it breaks at or above the ground line, depending upon the location of the lesion or lesions. Lodging of the plant parts (stems, leaves, and flowers) above the breaking point results in complete loss of the plant for pollen, seed, or flower production.

Infection may also occur on leaves, petioles, and inflorescences. Of the former, small, dark-brown lesions are typical of the disease. Infected flowers exhibit small, necrotic lesions. Later the petals may become water-soaked, flaccid, and fall to the ground. Sporulation of the fungus on the stems (plate 3, *F, G, H*), leaves, petioles, peduncles, and flowers of tuberous-rooted begonia plants is of common occurrence.

THE CAUSAL FUNGUS, *BOTRYTIS CINEREA*

Isolations made from infected stems of tuberous-rooted begonia plants on potato-dextrose agar have consistently yielded a fungus which has been identified as *Botrytis cinerea* Pers. Similar, if not identical cultures were also isolated from diseased leaves, petioles, and flowers. All isolates sporulated freely and produced sclerotia in pure culture.

Healthy, tuberous-rooted begonia seedling plants in 6-inch pots of autoclaved soil were inoculated with isolates of the fungus in the greenhouse (average daily temperature 75° F). Inoculum was prepared by growing the fungus on potato-dextrose agar in petri dishes. When ready for use, after eight days, small blocks of inoculum $1 \times 1 \times 0.3$ cm were cut with a sterile scapel. Inoculum was then pressed against the unwounded surface of a stem, at or above the soil line and either at a node or on an internode, and covered with sterile absorbent cotton pads saturated with sterile distilled water. The pads

were tied to the stem with white cord to maintain a close contact between the inoculum and the stem. Additional sterile water was added daily to the pads, as required, to maintain moist conditions. Sterile potato-dextrose agar blocks were placed on the stems and covered with moist pads, thus serving as controls.

The incubation period ranged from five to seven days, during which time typical lesions developed on the stems of inoculated plants (plate 4, *A, B, C*). Of 24 stems on 24 plants inoculated, none escaped infection, the resulting lesions measuring 3 to 6 cm in length and covering one half to the entire circumference of the stems. The 12 stems on 12 control plants remained healthy. The fungus was reisolated from a stem lesion on each infected plant, and the reisolates proved to be identical with each of the three isolates used. The reisolates proved highly pathogenic when tested under similar conditions in the greenhouse.

CONTROL OF THE DISEASE

In those greenhouses at Capitola which are used exclusively for pollen production and hydridization, it is customary daily to clean the plants of all debris (old leaves, broken branches, old flowers, and diseased parts). After this has been accomplished, the plants are inspected for stem lesions. Decayed areas are carefully excised with a flamed scalpel and then covered by applying a thick paste of Ziram[3] (Zerlate)-zinc dimethyldithiocarbamate- with a small brush. Also, all wounds, leaf scars, and growth cracks are painted. Ziram (Zerlate) is prepared commercially as a dust and is mixed with water to form a paste. In earlier tests, Ziram (Zerlate) had been applied to the stems as a dust but was not entirely satisfactory. As a paste, it has the advantage of better adhesiveness and requires fewer applications. With the application of Ziram (Zerlate) as a fungicide during the growing seasons of 1946, 1947, and 1948, the loss from stem rot was reduced to less than 5 per cent.

DISCUSSION

Botrytis stem rot is the principal limiting factor in the successful culture of tuberous-rooted begonia plants for pollen production and hybridization in Capitola greenhouses. Annually, five thousand one- to five-year-old tubers are planted in large, porous clay pots, as well as in small redwood boxes, placed on benches in the greenhouse, and spaced from time to time according to foliage and flower requirements. No seedling plants are used. The planting stock is extremely valuable and, if lost because of stem rot, often cannot be replaced. Most of the finest tuberous-rooted begonia seed is produced in Capitola where, consequently, it is highly important to protect the plants from *Botrytis* stem rot. For best results, the air temperature in the greenhouses is maintained at 70° to 80° F. Every attempt is made to keep the humidity low. The warmer and drier the atmosphere, the better for pollen production. Tuberous-rooted begonia plants thrive in these greenhouses in the early months after the tubers are potted in February or March, and there is usually

[3] Ziram is the common name for zinc dimethyldithiocarbamate selected by the Subcommittee on Fungicide Nomenclature of the American Phytopathological Society, in coöperation with the Interdepartmental Committee on Pest Control, and filed with the Trade-Mark Division of the United States Patent Office. It was formerly sold under the trade name of Zerlate. (Rohwer, 1949.)

little or no stem rot. About midseason, or August 1, heavy flower production begins. But, at this time, the foggy season commences and *Botrytis* stem rot, if left unattended, spreads with great rapidity. The disease is also favored in its development and spread by poor ventilation, overwatering, and crowding of plants.

It has been found that varieties with hairy stems are much less susceptible to infection than varieties with smooth stems and few hairs. Also, varieties producing red flowers and hairy stems show greater resistance to the disease than varieties with green or red smooth stems and lighter-colored flowers.

The flowering season starts in June, and the first pollen appears about August 1. Hybridization is conducted in September and October, and the seed is harvested in October and November. Accordingly the plants must be maintained relatively free from disease for a period of eight to ten months in order to insure a good crop of seed. There has been little or no flower and leaf infection by *Botrytis cinerea* on the breeding plants in the greenhouses at Capitola over a period of years.

In lathhouses at Capitola, seedlings are planted in ground beds for tuber production. *Botrytis* stem rot is prevalent during the foggy season, but control as practiced in the greenhouses is not attempted because of the greater difficulty in treating the plants, with correspondingly high labor costs and the tremendous increase in plant population.

In greenhouses in the San Francisco Bay region, seedling plants and plants from tubers are forced for flower production and for sale as potted plants. Some of the larger nurseries are now using Ziram (Zerlate) paste to control stem rot, since all plants are grown on benches and may be treated with ease. When prices for tuberous-rooted begonia flowers (used chiefly for corsages) are high, then there is far greater incentive to attempt control than when prices are low, because of overproduction.

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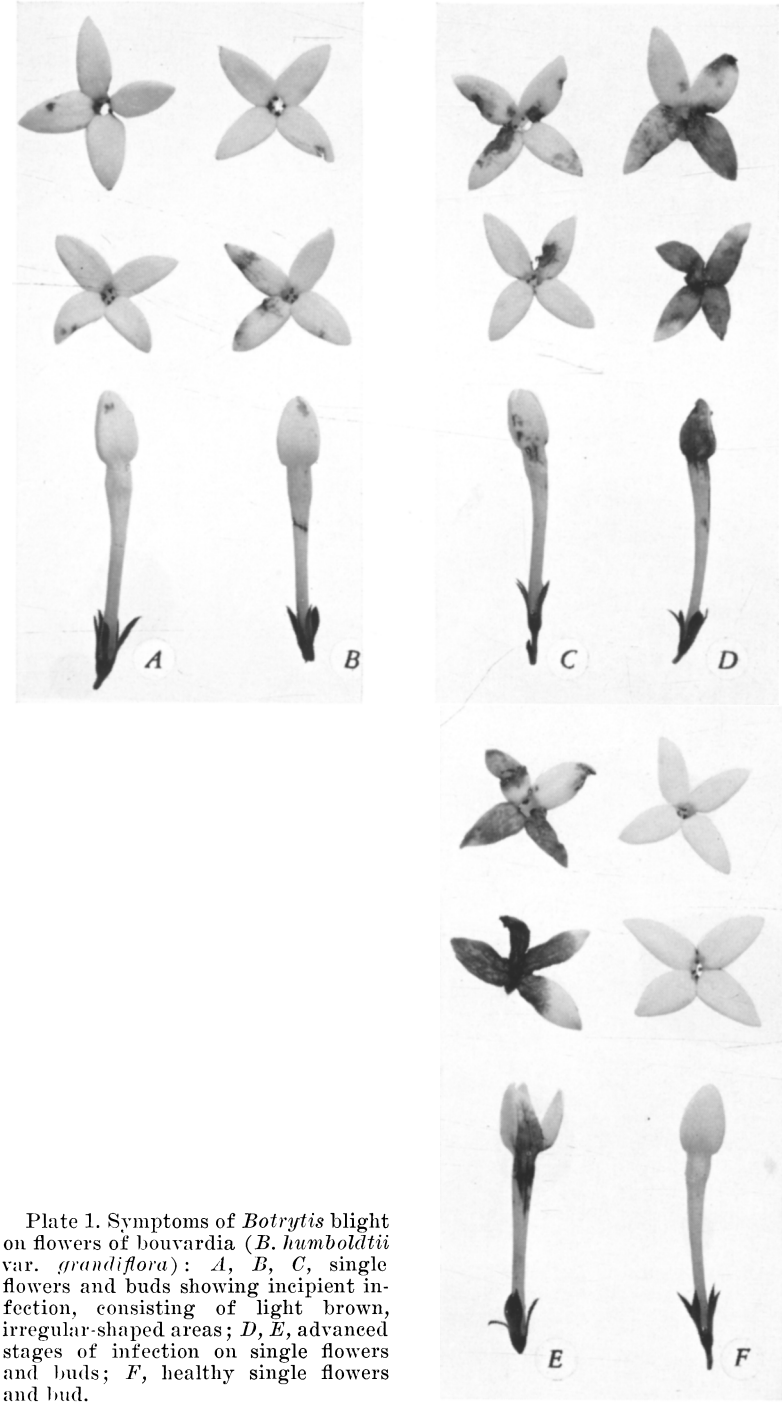

Plate 1. Symptoms of *Botrytis* blight on flowers of bouvardia (*B. humboldtii* var. *grandiflora*): *A*, *B*, *C*, single flowers and buds showing incipient infection, consisting of light brown, irregular-shaped areas; *D*, *E*, advanced stages of infection on single flowers and buds; *F*, healthy single flowers and bud.

Plate 2. Symptoms of *Botrytis* blight on pink and white flowers of bouvardia (*B. humboldtii* var. *grandiflora*) in a standard container after 3 days' storage in a refrigerator. Most of the flowers are infected, as indicated by the dark color.

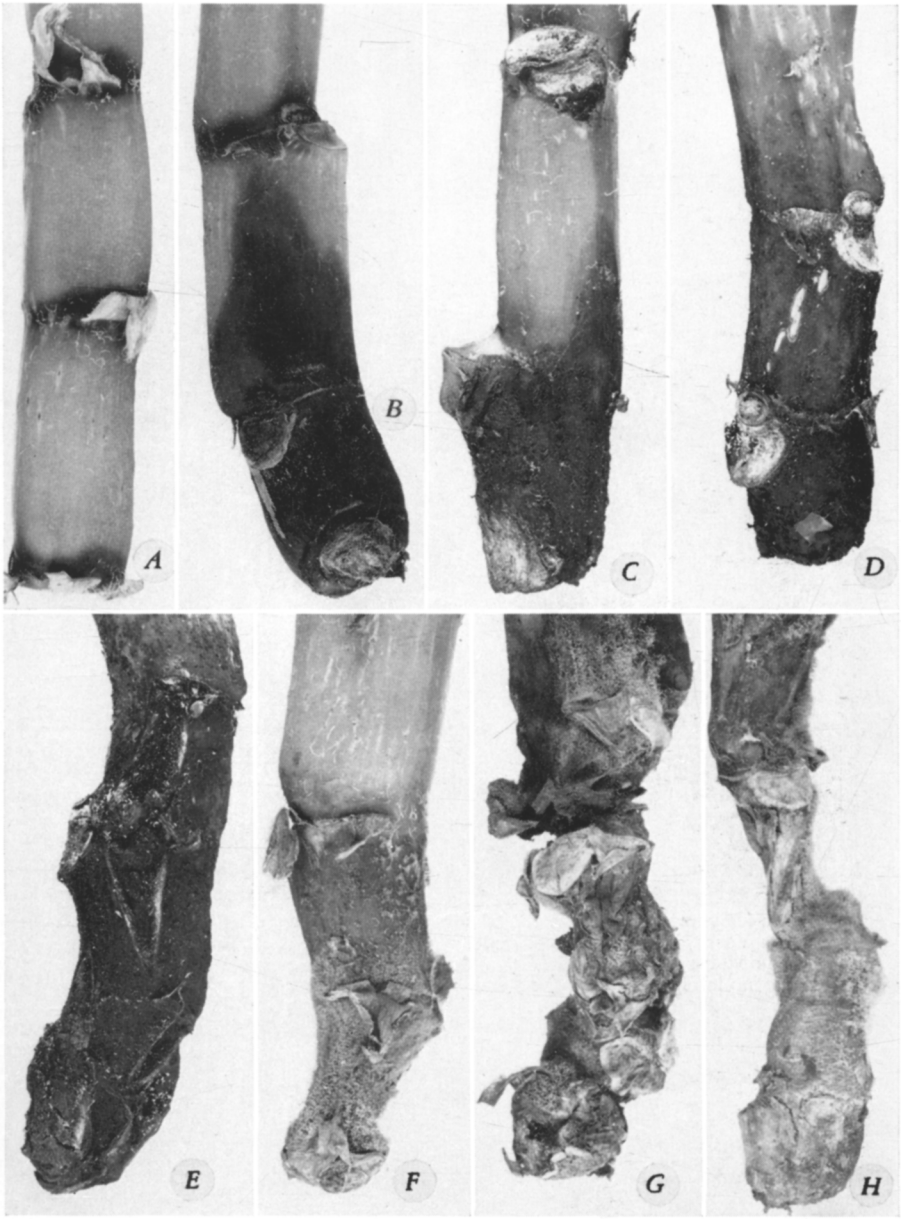

Plate 3. Symptoms of stem rot of tuberous-rooted begonia (*Begonia tuberhybrida* Voss) caused by *Botrytis cinerea* Pers.: *A*, healthy stem; *B*, *C*, *D*, typical lesions; *E*, lesion completely encircling the stem; *F*, shriveled constricted stem; *G*, *H*, shriveled mummified stems. *F*, *G*, *H* show sporulation of the fungus. Natural infection.

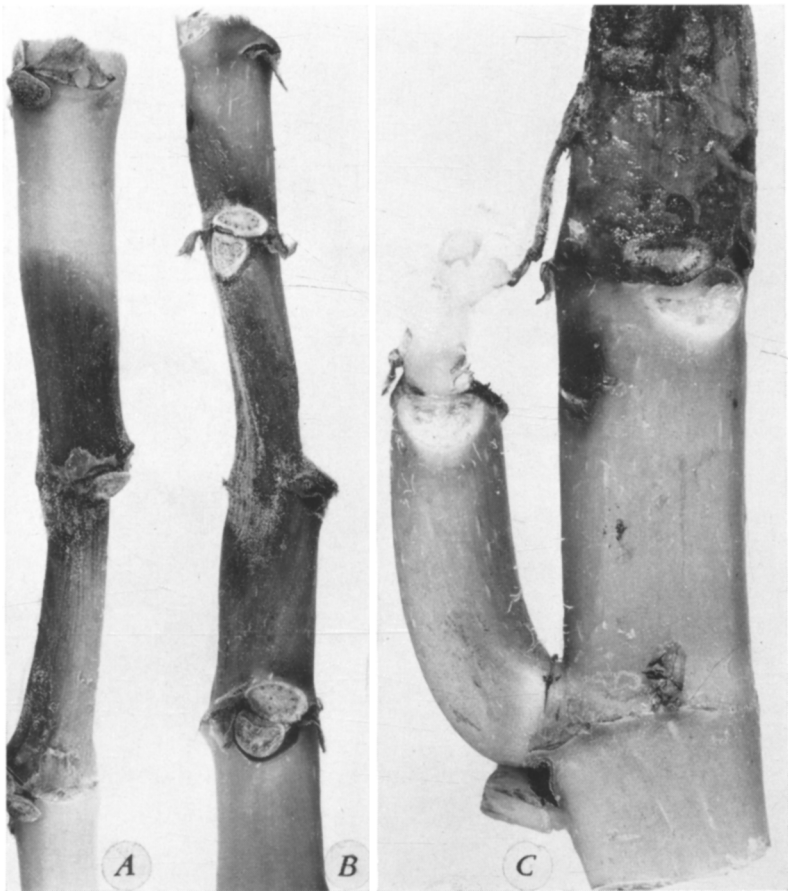

Plate 4. Symptoms of stem rot of tuberous-rooted begonia (*Begonia tuberhybrida* Voss), induced by artificial inoculation in the greenhouse with a pure culture of *Botrytis cinerea* in 5 to 7 days: *A*, *B*, young stem lesions; *C*, large lesion completely encircling the stem.

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