Etiology and Control of Onion Flower Blight

L. A. Ellerbrock and J. W. Lorbeer

Graduate Research Assistant and Professor, Department of Plant Pathology, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, NY 14853.

Portion of a thesis submitted by the senior author in partial fulfillment of the requirements for the Ph.D. degree, Cornell University.

This research was supported in part by the Orange County Vegetable Improvement Cooperative Association, Goshen, NY 10924.

Accepted for publication 16 August 1976.

ABSTRACT

ELLERBROCK, L. A., and J. W. LORBEER. 1977. Etiology and control of onion flower blight. Phytopathology 67: 155-159.

In recent years, a severe blighting of onion flowers and immature seed capsules has occurred in a number of Orange County, New York seed fields. *Botrytis cinerea, B. squamosa,* and *B. allii* frequently were isolated from blighted flowers. Field inoculation of inflorescences with *B. cinerea, B. squamosa,* and *B. allii* conidia caused flower blighting and seed yield losses of 98, 93, and 47%, respectively, compared to noninoculated controls. Lesions on main seed stalks, apparently caused by *B. allii* or *B. squamosa,* often girdled the stalks and resulted in death of the entire inflorescence, but incidence of such damage generally was less than 5%. Sprays of chlorothalonil (2.5 kg/ha), benomyl (1.1 kg/ha), and mancozeb (2.7 kg/ha) controlled flower blight in that order in four replicated field experiments and increased seed yield by an average of 142, 93, and 60%, respectively. Fungicide sprays did not appear to interfere with pollination of onion flowers by honey bees.

Additional key words: Allium cepa, fungicide control.

Yields of onion (*Allium cepa* L.) seed in Orange County, New York recently have been poor, especially in years when wet growing conditions have prevailed from anthesis until harvest (H. A. Smith Jr., *personal communication*). The low yields generally have been attributed to poor seed set, but the cause(s) has (have) not been determined. Insufficient pollination usually has been considered the most plausible explanation.

Several diseases affecting onion seed production have been described. Among these are downy mildew (15), black stalk rot (3), purple blotch (12), Stemphylium leaf spot (13), and a stalk rot caused by *Botrytis allii* Munn (14). These diseases indirectly affect seed yield by damaging the leaves and peduncles of seed-producing plants. Clinton (2) observed a blasting of onion flowers by *Botrytis* sp. in Connecticut. Blodgett reported (1) that *B. allii* caused a blasting of onion seed heads in Idaho, and a similar disease was reported in Israel (10). *Botrytis allii* was assumed to be the cause of the symptoms in each instance because it sporulated on the affected plant parts; however, no inoculations or isolations were reported.

General observations in Orange County for some time have suggested that onion flowers are infected directly by fungi. This investigation was undertaken to determine if fungi commonly present in seed fields were responsible, at least in part, for the poor seed yields and to determine if fungicide application to onion flowers could improve seed yield.

MATERIALS AND METHODS

Fungal isolations.—Onion flowers and immature seed capsules were collected from seed fields during the period of 9-23 July 1975. Flower parts with early symptoms of blight were surface-sterilized in sodium hypochlorite solutions (2 minutes in a 0.5% solution for sepals, pistils, and stamens, or 2 minutes at 1% for capsules and pedicels). After several washings in sterile water, the floral parts were placed on acidified potato-dextrose agar in petri plates, and the plates were incubated at 16-18 C for 4-6 days. The plates then were examined for fungal growth and, when necessary, transfers were made to potato-dextrose agar slants to confirm identification.

Field inoculation.—Several fungi, including some previously reported as responsible for losses in onion seed production, were selected for field inoculations. These fungi, isolated either from leaves in seed fields or from onion seed, included: *B. cinerea* Pers., *B. squamosa* Walker, *B. allii, B. byssoidea* Walker, *Alternaria alternata* (Fr.) Keissler, *A. porri* (Ellis) Cif., and *Stemphylium botryosum* Wallr. Conidial suspensions, prepared from pure cultures of each fungus grown on onion-straw agar (5), were adjusted to 50,000 conidia per milliliter. Inflorescences similar in size (about 10 cm in diameter) and stage of development and located randomly in six adjacent rows of flowering onion plants (cultivar Early Yellow Globe) in a seed production field were sprayed with inocula of the respective fungi. Thirty inflorescences about 1 m apart were inoculated with each fungus during the early evening on 1 and 10 July 1975.

Each inflorescence was sprayed with 3 ml of the respective conidial suspensions with an atomizer, and controls similarly were sprayed with 3 ml of water. Approximately 85 and 100% of the flowers in the inflorescences were open

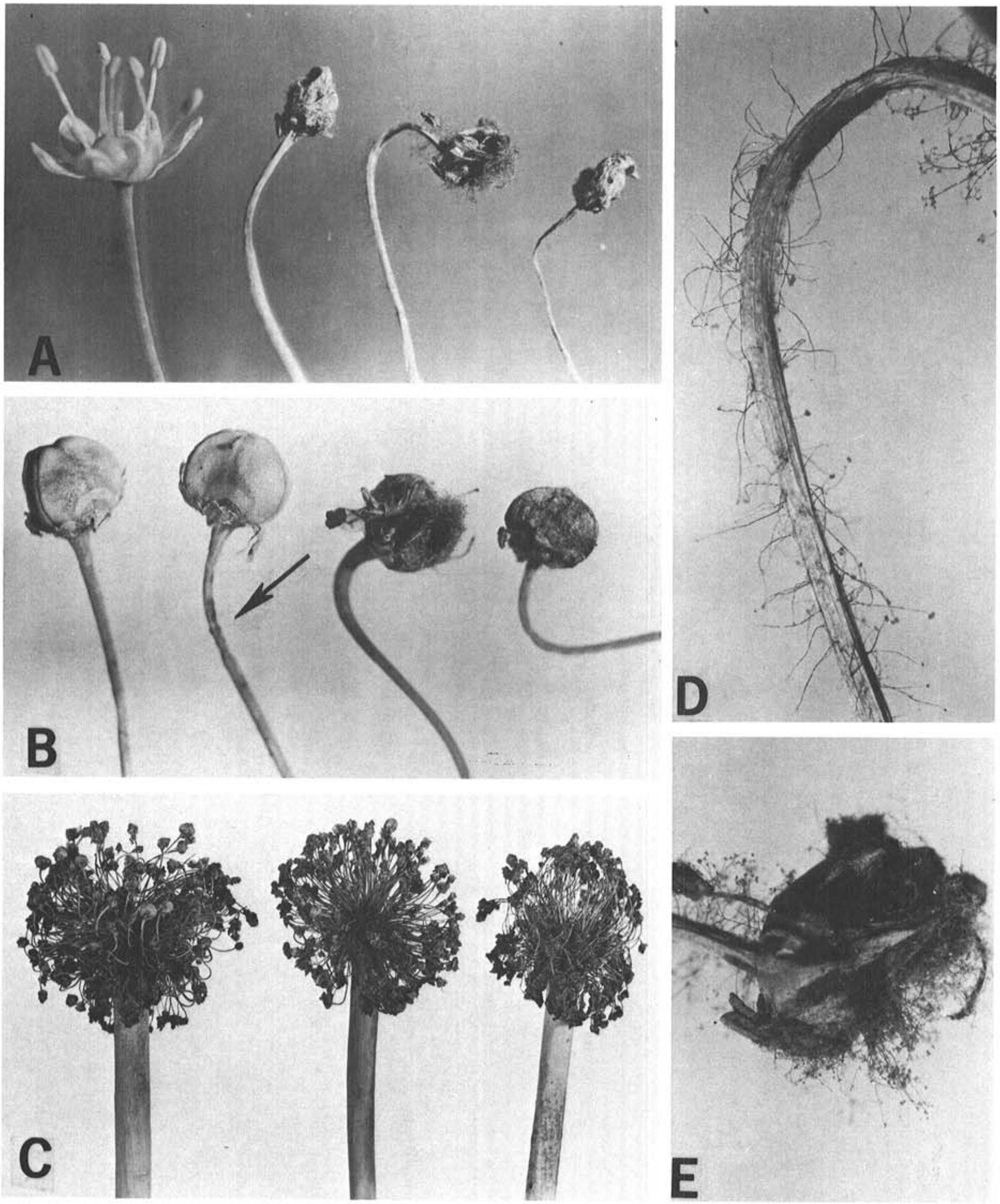

Fig. 1-(A to E). Onion flower blight symptoms and signs. **A)** Healthy flower on the left and three blighted flowers on right. **B)** Healthy seed capsule on the left and infected capsules on right; a lesion (arrow) has girdled the pedicel of one capsule. **C)** Inflorescences in which almost every flower has been blighted. **D)** Conidiophores of *Botrytis cinerea* on the pedicel of a flower. **E)** Conidiophores and clusters of *B. cinerea* conidia on a blighted flower.

at the time of the first and second inoculations, respectively.

On 6 August, the inoculated seed heads were harvested, placed in separate paper bags, and allowed to cure in a storage shed for 3 weeks. The seeds then were collected and weighed, and the average seed yield per seed head was determined for each fungal inoculation.

Fungicide trials.—Fungicide trials were conducted in four seed production fields in Orange County in 1975. The experimental design was a randomized block with single plots consisting of two rows of plants 6.1 m long. Cultivars used were Early Yellow Globe in Experiments I, III, and IV, and Wethersfield Red in Experiment II. Four treatments tested in each experiment included chlorothalonil 2.5 kg/ha (Bravo 6F, 3 pt/acre), benomyl 1.1 kg/ha (Benlate 50WP, 2 lb/acre), mancozeb 2.7 kg/ha (Dithane M-45 80WP, 3 lb/acre), and a control. Sprays were applied in 935 liters of water per hectare (100 gallons per acre) with a hand-carried carbon dioxide-powered sprayer, with two nozzles directed at each row of plants from 30-45 cm above the inflorescences. Sprays were applied on a 7-day schedule beginning on 19 June. At that time about 90% of the inflorescences in Experiment III had opened, whereas about 50% had opened in the other experiments. Applications were continued until approximately 2 weeks before harvest.

At harvest, the seed heads from the center 5 m of both rows in each plot were cut and placed in burlap bags. After curing for 1 month in a storage shed, the seed heads were threshed by hand, the seeds were cleaned and weighed, and the average seed yield per seed head for each treatment was computed.

TABLE 1. Frequency of isolation of different fungi (136 isolates) from 150 onion floral parts with disease symptoms

Fungus isolated	Percentage of total isolations
Botrytis cinerea[a]	40.4
Botrytis squamosa	28.7
Botrytis allii	14.7
Cladosporium sp.	3.6
Botrytis byssoidea	2.9
Alternaria alternata	2.3
Fusarium sp.	2.3
Unidentified fungi	5.1

[a]*B. cinerea* was the only fungus isolated from pedicel lesions.

TABLE 2. Effect of field inoculation of onion inflorescences with different fungi on seed yield

Fungus[y]	Seed yield[z] (g/seed head)
Alternaria porri	1.93 a
Uninoculated	1.88 a
Stemphylium botryosum	1.80 a
Alternaria alternata	1.67 a
Botrytis byssoidea	1.31 ab
Botrytis allii	0.99 b
Botrytis squamosa	0.13 c
Botrytis cinerea	0.04 c

[y]Inflorescences were inoculated on 1 and 10 July with 3 ml of a conidial suspension (50,000 conidia per milliliter) of the respective fungi.

[z]Means followed by same letter are not statistically different ($P = 0.05$) by Duncan's multiple range test.

RESULTS

Onion flower blight symptoms.—Severe blighting of onion flowers occurred in most Orange County seed fields in 1975, with several total seed crop failures. Although good growing conditions promoted excellent plant development early in the season, generally wet weather prevailed from anthesis until seed harvest. At harvest, many seed heads consisted only of blighted flowers (Fig. 1-C). All flower parts generally were blighted (Fig. 1-A), and sporulation by *B. cinerea* (Fig. 1-D, E) and/or *B. squamosa* usually was evident. Later, infections of immature seed capsules occurred (Fig. 1-B). The surfaces of affected capsules first turned brown and then black, followed by a shrivelling of the entire capsule and destruction of the seeds. Often the capsule appeared healthy but lesions on the pedicel enlarged and girdled the pedicel resulting in destruction of the capsule (Fig. 1-B).

In most seed fields, some entire seed heads were destroyed apparently as a result of infection of main seed stalks by *B. allii*. Most often *B. allii* apparently had invaded a seed stalk from the base of the inflorescence and sporulated on the outer surface of the seed stalk. In other cases, infection apparently had originated at the base of the seed stalk or along its length. Although some inflorescences were destroyed completely, the incidence of this type of damage generally was low (usually <5%) in all fields.

Infection of seed stalks by *B. squamosa* (usually <2%) also was observed in most fields, and inflorescences on affected seed stalks usually were destroyed. Sporulation was not observed, but sclerotia of *B. squamosa* formed on the surface of the seed stalks. The seed stalk usually broke and fell over at the site of sclerotial formation. Infection by *B. cinerea* was limited to the flowers or immature

TABLE 3. Effect of fungicide treatments on onion seed yield

Fungicide	Rate (kg/ha)[y]	Seed yield (g/seed head)[x]			
		Expt. I[z]	Expt. II	Expt. III	Expt. IV
Chlorothalonil	2.5	1.33 a	2.94 a	1.25 a	1.41 a
Benomyl	1.1	1.04 b	2.26 b	1.04 b	1.14 b
Mancozeb	2.7	0.70 c	1.86 c	1.02 b	1.03 b
Control	...	0.42 d	1.65 c	0.70 c	0.48 c

[x]Means followed by the same letter are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

[y]Active ingredients.

[z]Onion cultivar was Early Yellow Globe in Experiments I, III, and IV and Wethersfield Red in Experiment II.

capsules. Near harvest, large lesions supporting sporulation by *S. botryosum* or *A. alternata* were common on stalks in most fields, but such lesions did not appear to affect seed yield.

Fungal isolations.—One-hundred thirty-six fungal isolates were obtained from 150 flower parts. *Botrytis cinerea* was isolated most frequently (Table 1) and was most conspicuous on blighted flowers as evidenced by conidiophores and conidial clusters (Fig. 1-D,E). *Botrytis cinerea* also was isolated from lesions on pedicels of apparently healthy seed capsules (Fig. 1-B). *Botrytis squamosa* and *B. alii* were isolated 28.7% and 14.7% of the time, respectively. The other fungi listed in Table 1 were isolated only occasionally.

Field inoculations.—Weather conditions were relatively dry for 4 days following the first inoculation on 1 July, but 0.4 cm of rainfall and heavy dew kept the flowers wet for over 24 hours on 6-7 July. By 9 July, many perianths of flowers inoculated with *B. cinerea* and *B. squamosa* had shrivelled and turned brown. Pistils and stamens of recently opened flowers and developing ovaries of older flowers remained healthy. Over 13 cm of rainfall during the period of 12-14 July resulted in blighting of flowers in most seed fields. Although some flowers were affected in all inflorescences in the field where flowers had been inoculated, it became obvious during the next 2 weeks that some inoculated inflorescences were much more severely affected. Most *B. cinerea*- and *B. squamosa*-inoculated inflorescences were completely blighted. Blighted flowers were clumped together and supported profuse sporulation of these fungi. Approximately one-third of the seed stalks of *B. allii*-inoculated inflorescences were invaded from the base of the inflorescence. The fungus grew downward and sporulated on the seed stalk surface, and the entire inflorescence was destroyed. Where infection of the seed stalk was not observed, however, only slightly more flowers in *B. allii*-inoculated inflorescences were blighted than in uninoculated inflorescences.

Inoculation with *B. cinerea* and *B. squamosa* drastically reduced seed yield (Table 2). In fact, most *B. cinerea*-inoculated seed heads produced no seed. Inoculation with *B. allii* also reduced yield significantly, but the reduction was primarily due to infection of the seed stalk rather than infection of the flowers. Yields from *B. byssoidea*-inoculated seed heads were not significantly different from the control. Inflorescences inoculated with *A. alternata, A. porri,* and *S. botryosum* were not blighted and seed yield was not reduced.

TABLE 4. Effect of fungicide treatments on honey bee (*Apis mellifera* Linn.) activity in plots in Experiment I

Fungicide	Rate (kg/ha)[w]	Honey bees per plot[v]		
		26 June[x]	2 July[y]	9 July[z]
Chlorothalonil	2.5	30 a[z]	19 a	48 a
Benomyl	1.1	29 a	18 a	39 ab
Mancozeb	2.7	32 a	16 a	40 ab
Control	. . .	33 a	15 a	29 b

[v]Means followed by the same letter are not significantly different, $P = 0.05$, according to Duncan's multiple range test.
[w]Active ingredients.
[x]Counts made 7 days after the first fungicide application.
[y]Counts made 7 days after the second fungicide application.
[z]Counts made 1 day after the fourth fungicide application.

Flower blight control with fungicides.—It was obvious by 15 July that there was less blighting of flowers in fungicide-treated plots than in untreated plots. The differences became greater in late July as developing seed capsules in untreated plots prematurely turned brown and died, whereas those treated with chlorothalonil, and to a lesser extent with benomyl and mancozeb, remained green until maturity. Differences in the incidence of *B. allii*-induced lesions on seed stalks in treated and untreated plots were not discerned.

All fungicide treatments significantly increased seed yield in all four experiments. Chlorothalonil was significantly more effective than benomyl or mancozeb (Table 3). The greatest yield increase was achieved with chlorothalonil in Experiment I, in which yield was increased 217% over the untreated control. Benomyl was more effective than mancozeb in Experiments I and II, but the two fungicides were about equivalent in Experiments III and IV.

Honey bee (*Apis mellifera* Linn.) populations were similar in all plots in Experiment I until the second week in July, when higher populations were counted in chlorothalonil-treated plots (Table 4). The lower incidence of blighted flowers in chlorothalonil-treated plots presumably accounted for the higher honey bee populations. Throughout the season, honey bee populations generally were low in all seed fields.

DISCUSSION

Results of fungal isolations from blighted flowers, field inoculations of inflorescences, and fungicide trials provided evidence that several *Botrytis* spp., mainly *B. cinerea* and *B. squamosa,* caused a severe blighting of onion flowers and greatly reduced seed yield in Orange County in 1975. These results suggest that losses in previous years may have been caused by these fungi.

Botrytis cinerea is a common flower pathogen (7, 9, 11). Yarwood (14) stated that *B. cinerea* caused spots on onion seed stalks, but *B. cinerea* previously has not been reported as a pathogen of onion flowers. Although *B. squamosa* also has not been reported on onion flowers, it has long been recognized as the cause of leaf blight of onion (6). Both *B. cinerea* and *B. squamosa,* along with *B. allii* and *B. byssoidea,* were isolated from leaves of plants in seed fields during the 1971-74 growing seasons in Orange County (4). They may have caused seed losses in those years. All of these fungi also have been isolated from leaves of seed onions in Poland (8).

Our observation that *B. allii* apparently invades the seed stalk from the base of the inflorescence concurs with Yarwood's (14) observations, although he stated that infections originating at the bulb end of the seed stalk were more common. Blodgett (1) reported that onion flowers were blasted by *B. allii.* In the present experiments, *B. allii*-inoculated flowers were only slightly affected except when the seed stalk was girdled, in which case the entire inflorescence eventually died. The lack of blighting following inoculation with *A. porri* conidia agrees with Pandotra's (12) findings that *A. porri* infected leaves and seed stalks of onion plants, but did not affect inflorescences.

The simultaneous development of flower and capsule blight during periods of wet weather indicates the importance of moisture in the disease development and is in accord with the generally high moisture requirements for infection by *Botrytis* spp. Heavy rainfall also may have indirectly increased blighting by preventing insect pollination, resulting in senescent flowers which became suitable substrate for colonization by *Botrytis* spp. This could have increased inoculum buildup and thus enhanced further blighting.

Although evidence for involvement of several *Botrytis* spp. in attack of onion flowers and immature capsules is presented, further study is needed under controlled conditions to elucidate the relationship between these fungi and the seed crop failures. Moreover, aspects such as possible involvement of the *Botrytis* spp. with other microorganisms, the relationship between stage of flower or capsule development and susceptibility, and the relationship between weather conditions and infection deserve further study.

The fungicide trial results evince the need for protecting onion flowers during wet growing seasons. In spite of the yield increases obtained, only partial disease control was achieved. More frequent fungicide applications may improve effectiveness. Flowers that open following an application are unprotected until the next application. Infection and blighting appeared to occur within a few days; thus, 7-day intervals between applications probably are too long, especially during the critical 2-3 weeks following onset of anthesis. Other aspects affecting fungicidal control, including possible toxicity to insect pollinators, possible phytotoxic effects, and methods of fungicide application merit further study.

In addition to controlling flower blight, fungicide applications might reduce the number of *B. squamosa* conidia produced in seed fields. Conidia formed in seed fields apparently are important since they can initiate Botrytis leaf blight epidemics in nearby commercial bulb fields (4).

LITERATURE CITED

1. BLODGETT, E. C. 1946. Observations on blasting of onion seed heads in Idaho. Plant Dis. Rep. 30:77-81.
2. CLINTON, G. P. 1903. Report of the botanist. Conn. Agric. Exp. Stn. Ann. Rep. (New Haven) 27:279-370.
3. EDGERTON, C. W. 1921. Onion diseases and onion seed production. La. Agric. Exp. Stn. Bull. 182. 20 p.
4. ELLERBROCK, L. A., and J. W. LORBEER. 1977. Sources of primary inoculum of Botrytis squamosa. Phytopathology 67: (In press).
5. ELLERBROCK, L. A., and J. W. LORBEER. 1977. Survival of sclerotia and conidia of Botrytis squamosa. Phytopathology 67: Phytopathology 67:219-225.
6. HANCOCK, J. G., and J. W. LORBEER. 1963. Pathogenesis of Botrytis cinerea, B. squamosa, and B. allii on onion leaves. Phytopathology 53:669-673.
7. HUNTER, J. E., and R. K. KUNIMOTO. 1973. Reduction of macadamia nut set by Botrytis cinerea. Phytopathology 63:939-941.
8. LUTYNSKA, R. 1968. Investigations on diseases of seed onion caused by the fungus genus Botrytis in the vegetable plantations of the Cracow Province (In Polish, English summary). Acta. Mycol. 4:3-22.
9. MC CLELLAN, W. D., and W. B. HEWITT. 1973. Early Botrytis rot of grapes: time of infection and latency of Botrytis cinerea Pers. in Vitis vinifera L. Phytopathology 63:1151-1157.
10. NETZER, D., and I. DISHON. 1966. Occurrence of Botrytis allii in onions for seed production in Israel. Plant Dis. Rep. 50:21.
11. OGAWA, J. M., and H. ENGLISH. 1960. Blossom blight and green fruit rot of almond, apricot and plum caused by Botrytis cinerea. Plant Dis. Rep. 44:265-268.
12. PANDOTRA, V. R. 1964. Purple blotch disease of onion in Punjab. I. Its occurrence, pathogenicity and host range. Proc. Indian Acad. Sci. Sect. B 60:336-340.
13. RAGHAVENDRA RAO, N. N., and M. S. PAVGI. 1975. Stemphylium leaf blight of onion. Mycopathologia 56:113-118.
14. YARWOOD, C. E. 1938. Botrytis infection of onion leaves and seed stalks. Plant Dis. Rep. 22:428-429.
15. YARWOOD, C. E. 1943. Onion downy mildew. Hilgardia 14:595-691.