Management of common scab of potato using planting and harvest dates

D. Waterer

Department of Plant Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 5A8 (e-mail: waterer@sask.usask.ca). *Received 23 February 2001, accepted 15 August 2001.*

Waterer, D. R. 2002. **Management of common scab of potato using planting and harvest dates**. Can. J. Plant Sci. **82**: 185–189. The influences of planting and harvest dates on yields and grade-out due to tuber damage by common scab (*Streptomyces* spp.) were evaluated over three cropping seasons using two cultivars of potato (*Solanum tuberosum*) grown on land heavily infested with pathogenic *Streptomyces* species. Early planting and delaying the harvest enhanced yields in both cultivars, but also increased tuber grade-out due to excessive levels of scab. Delaying the harvest reduced marketable yields more than did early planting. The longer harvest was delayed after top-kill, the greater was the grade out due to scab. Increased losses to scab exceeded any increase in tuber yields obtained by delaying harvest. This study demonstrates that common scab of potato may be managed by minimizing the period the crop is in the ground, but that this method of disease management is achieved at the expense of yields. Early planting coupled with timely harvesting after kill-down of the tops appears to be an effective compromise between the objectives of maximizing yields while avoiding excessive grade-out due to common scab.

Key words: Potato scab, *Streptomyces scabies*, *Solanum tuberosum*, agronomy

Waterer, D. 2002. **Lutte contre la gale commune de la pomme de terre par sélection des dates de plantation et de récolte**. Can. J. Plant Sci. **82**: 185–189. L’auteur a évalué l’incidence des dates de plantation et de récolte sur le rendement de deux cultivars de pomme de terre (*Solanum tuberosum*)et sur le nombre de tubercules rejetés à cause de la gale commune (*Streptomyces* sp.) durant trois campagnes successives. Les pommes de terre étaient cultivées dans un sol fortement infesté d’espèces pathogènes de *Streptomyces*. Une mise en terre précoce et une récolte tardive améliorent le rendement des deux cultivars, mais accroissent le nombre de tubercules inacceptables parce que trop atteints par la gale. Un arrachage tardif diminue plus le rendement en tubercules commercialisables qu’une plantation hâtive. Plus la récolte est retardée après le défanage, plus le nombre de rejets attribuables à la gale augmente. Les pertes résultant de la gale dépassent l’augmentation du nombre de tubercules obtenus à la suite d’une récolte plus tardive. L’étude révèle qu’on peut lutter contre la gale commune de la pomme de terre en limitant le laps de temps que les tubercules passent en terre, mais qu’on le fait au détriment du rendement. Une mise en terre précoce et une récolte en temps opportun après le défanage semblent constituer un bon compromis entre la maximisation du rendement et de trop lourdes pertes à cause de la gale commune.

Mots clés: Gale de la pomme de terre, *Streptomyces scabies*, *Solanum tuberosum*, agronomie

Common scab of potato (*Solanum tuberosum*) is caused by several *Streptomyces* spp. (Loria et al. 1997), but *Streptomyces scabies* (Thaxter) Lambert and Loria is the predominant causal organism (Lambert and Loria 1989). Common scab is a problem on potatoes worldwide, primarily due to its adverse effects on tuber appearance and processing efficiency (Loria et al. 1997). Once established in a field, pathogenic *Streptomyces* species can survive for extended periods on plant residues and consequently crop rotation provides limited control of this pathogen (Rich 1983). Seed, soil or foliar-applied chemicals are ineffective for control of soil-borne scab (Davis et al. 1974). Fumigation may provide short-term control of soil-borne scab, but the economic and environmental costs of repeated fumigation are prohibitive. Varietal resistance to scab is available, but many of the potato varieties of commercial importance in North America have only limited scab resistance (Powelson et al. 1993). This combination of factors makes common scab one of the more serious diseases of potatoes in North America (Slack 1991).

The extent to which common scab damages a tuber is determined by the number of infection points and the relative size of each resulting scab lesion. Both the extent of tuber infection and the rate and duration of subsequent growth of the scab lesions are influenced by the pathogenicity of the predominant *Streptomyces* spp. (Loria et al. 1997), host resistance (Goth et al. 1995) and environmental conditions during the growing season (Lapwood and Hering 1970). The scab organism infects the newly formed tubers through stomata and immature lenticels (Loria et al. 1997). Once the periderm has differentiated, tubers are no longer susceptible to infection (Loria et al. 1997). Cultivar, soil temperatures and moisture conditions determine the duration of the susceptible tuberizing period, thereby influencing scab damage. Losses to scab can be reduced by minimizing soil moisture deficits during tuber set and early tuber development (Lapwood and Hering 1970), possibly because the moist conditions favor soil-borne microbes antagonistic to the scab organism (Flint 1992). Irrigation at the crucial stage of tuber formation is commonly recommended as a means for reducing tuber infection by scab (Lapwood and Hering 1970).

Once *Streptomyces* is established in the developing tuber, its hypha grow intercellularly through the lamellae of the sub-epidermis and phellogen (Waksman 1950). Phytotoxins produced by the scab organism trigger localized hypertrophy and then death of the host tissues (Loria et al. 1997). The resulting accumulated layers of dead plant cells produce the classic scab lesion. The rate at which the lesions grow in depth and diameter slows as the tubers mature or conditions become unfavorable to the scab organism (Butler and Jones 1949). Managing the crop in a manner that slows the growth of the scab lesions may represent an additional means for minimizing losses to scab. The optimum temperature for growth of *S. scabies* is relatively high (25–30°C) and losses to scab are more severe in warm regions or growing seasons (Hooker 1981; Loria et al. 1997). Timing planting to reduce the crop's exposure to temperatures suited to growth of the scab lesions may reduce crop losses, providing it does not excessively interfere with productivity of the crop. Time of harvest is already known to influence losses to several other soil-borne potato pathogens. The percentage of the crop graded out due to excessive amounts of black scurf (*Rhizoctonia solani*) and silver scurf (*Helminthosporium solani*) on the tuber surface increases the longer the crop stays in the soil (Dijst et al. 1986; Rodriguez et al. 1993). Vine senescence or destruction by chemical top-killing promotes the formation of sclerotia by *R. solani* (Inglis 1993). As a consequence, growers are advised to minimize the period from when the tops senesce or are chemically desiccated until the crop is harvested. The relationship between time of harvest and losses to common scab has not been documented. This study examined the relationship between the time of planting and harvest and losses to common scab in potatoes.

MATERIALS AND METHODS

Trials were conducted on the University of Saskatchewan Plant Science Department Potato Research plots located in Saskatoon, SK. The site features a sandy loam soil, pH 7.2, EC < l dS, with 4% organic matter. The site has been cropped to potatoes on a 3-yr rotation with dryland barley (potatoes:barley:barley) for the past 20 yr. Approximately 20 t ha^{-1} of cattle manure is applied to the plots every 3 yr. Common scab has been a consistent problem at the site.

Standard practices for production of irrigated commercial potatoes in western Canada were used in all trials. The fields were double disced prior to planting and sufficient N as 46-0-0 was applied to meet local recommendations for irrigated potatoes (175 kg N ha^{-1}). The crop was planted using single cut or drop-type Elite 2 potatoes treated with the fungicide metiram (160 g a.i. kg^{-1}) as a seedpiece treatment (0.5 kg product 100 kg^{-1} seed). The seedpieces were planted at 25-cm intervals in rows 1 m apart. Sufficient phosphorus (11-55-0) was applied in a band adjacent to the seed to raise soil P_2O_5 levels to 120 kg ha^{-1}. The cultivars tested were: Norland, an early-maturing, red-skinned cultivar with moderate resistance to common scab, and Shepody, a slower maturing, processing cultivar, which is highly sensitive to common scab (Powelson et al. 1993). The cultivars were grown in separate plots to enable cultivar-specific management. Weed control was achieved utilizing pre- and post-plant applications of registered herbicides. A rolling cultivator was used after ground crack and again 2 wk later for inter-row tillage and to throw hills. Soil moisture levels were monitored in the plots using tensiometers and/or electrical resistance meters. The plots were irrigated whenever soil water potentials fell below –60 kPa. No significant problems with insects or diseases were observed and the plots received no pesticides beyond those already described. The crop was top-killed using the recommended rate (160 g a.i. ha^{-1}) of the desiccant diquat (Reglone) applied in 250 L ha^{-1} of water using a ground rig sprayer. The crop was harvested 2 wk later, at which time it was graded for tuber size and absence of physical defects such as cracks. A sample of 100 tubers from each treatment replicate was then evaluated for scab damage based on the percentage of total tuber area covered with lesions. According to the Canada Food Inspection Agency grading standards (Canada Food Inspection Agency 1998), potatoes meet No. 1 Grade standards if less than 5% of the tuber surface is affected by scab lesions. Marketable yields in this study represent the tubers that met Grade No.1 standards for both size and freedom from excessive scab.

Time of planting and harvest trials were conducted in 1995 through 1997. The crop was planted in either the first week of May or the first week of June. Mid-May is the usual time for planting tablestock or processing potatoes in Saskatchewan. The experiment was designed to allow for three harvest dates (early August, late August and mid-September). Mid-September represents the typical harvest date for potatoes in the Canadian Prairies. The two planting date and three harvest date factors were arranged in a split-plot design with four replicates, with the planting dates serving as the main plots and the harvest dates as sub-plots. Each plot consisted of three, 8-m-long rows. Yield and quality data were collected from the center row of each three-row plot.

In 1998 and 1999, trials were conducted to determine how yields and grade out to scab changed as the interval between application of the chemical top-killer and harvest increased. The entire trial was planted in mid-May and was top-killed in the first week of September using a full rate of diquat (160 g a.i. ha^{-1}) in 250 l ha^{-1} of water applied by a ground rig sprayer. To obtain complete top-kill of cv. Shepody, diquat was applied a second time, 1 wk later (80 g a.i. ha^{-1}). Sections of the plot were harvested; a) prior to, b) 2 wk after, and c) 4 wk after application of the top-killer. The trial was arranged in a randomized complete block design with four replicates. Yields and the incidence and severity of common scab were determined as previously described.

Data for the 3 test years in the planting and harvest date trial were pooled, as error variances for the yield and scab rating data were homogeneous across years. Similarly, the error variances for the 2 yr of the time of harvest trial were homogeneous and the data for the 2 test years were pooled accordingly. Analyses of variance tests were conducted using the GLM program of SAS (SAS Institute, Inc. 1989).

Table 1. Treatment mean squares and main effect means for yields and scab levels of Norland and Shepody potatoes planted and harvested at varying times (1995–1997)

	Norland			Shepody		
Mean squares	Total yield	Grade out	Marketable	Total yield	Grade out	Marketable
Rep (R)	74	7.1	262	49	10.5	52
Year (Y)	443*	4.4	54	1	15.5	61
Y × R	75	1.5	133	108	9.8	222
Planting date (P)	5255**	3.2	2636**	3918**	8.9*	379**
Harvest Date (H)	1947**	20.7**	630**	2637**	71.8**	364**
P × H	250**	1.9	187*	175**	0.1	165*
Y × P	314**	1.1	769**	65	0.6	44
Y × H	62	2	74	43	3.8	102
Y × P × H	38	2.2	71	44	2.4	19
Means	Total yield ($t\ ha^{-1}$)	Grade out (%)	Marketable ($t\ ha^{-1}$)	Total yield ($t\ ha^{-1}$)	Grade out (%)	Marketable ($t\ ha^{-1}$)
Year						
1995	44.3	28	31.3	21.8	31	13.4
1996	38.0	20	29.9	21.6	37	12.6
1997	36.0	21	28.3	21.6	33	13.7
LSD (0.05)	3.3	NS	NS	NS	NS	NS
Planting						
early May	47.9	24	35.9	29.0	34	18.4
early June	30.9	20	23.8	14.3	27	9.6
LSD (0.05)	2.7	NS	3	2.2	6	2.4
Harvest						
early August	29.7	17	24.1	10.8	14	9.6
late August	41.0	18	34.0	22.4	29	16.3
mid-September	47.5	33	31.4	31.8	49	16.1
LSD (0.05)	3.3	6	3.6	2.7	7	3

*,** Significant at $P = 0.05$ and $P = 0.01$, respectively; NS, not significant.

The percentage grade out data were arcsin-transformed prior to analysis. Years were treated as random effects in the model (Gomez and Gomez 1984). When the analysis indicated significant treatment effects, the treatments were compared using Fisher's protected LSD tests ($P = 0.05$).

RESULTS AND DISCUSSION

Planting and Harvest Date Trials

Norland yields prior to grading for scab were higher in 1995 than in the other 2 test years (Table 1). However, grade out to scab was higher in 1995 than the other years and consequently, marketable yields were similar over the 3 yr of the study. Averaged over the 3 yr, total yields for the early-planted Norland crop were 55% greater than the later planted crop. Delaying planting had no effect on grade out to scab in Norland and consequently marketable yields for the early planting were, on average, significantly higher than the later planting (Table 1). The influence of planting date on yields and grade out to scab were less pronounced in 1995 than in the other 2 yr. Total yields for Norland also increased with each delay in the harvest date (Table 1). Grade out to scab for the earlier harvest dates was significantly lower, averaged over the three seasons, than for the last harvest date. The increase in grade out to scab with the delayed harvest negated any associated increase in yield. Marketable yields for Norland at the second harvest date were equivalent to the last harvest date, while marketable yields for the first harvest date fell well below both the others (Table 1).

Yields and scab levels for cv. Shepody were very similar across the 3 yr of the study (Table 1). Total yields for the early-planted Shepody crop were 113% greater than in plantings delayed by 4 wk. Delaying planting significantly reduced grade out to scab, but marketable yields for the early planting were still significantly higher than the later planting (Table 1). Total yields of Shepody increased progressively with each delay in the harvest, as did the amount of grade out to excessive scab. The increase in grade out to scab with the delayed harvest negated some of the yield advantage obtained by delaying the harvest. Marketable yields of Shepody for the second harvest date were, on average, equivalent to the last harvest date, while marketable yields for the first harvest date were well below the others.

Of the various planting × harvest date combinations examined in this trial, planting early and harvesting in late August produced, on average, the highest marketable yield in both cultivars (Fig. 1). For the early planting, differences between marketable yields for the various harvest dates were small. Late planting, coupled with an early harvest consistently produced the lowest marketable yields.

In general, growers wishing to maximize their yields, plant as early as possible and delay harvest as long as possible. This study confirmed that early planting enhanced total yields, particularly in slower developing indeterminate cultivars such as Shepody. Delaying the harvest also had a greater impact on yields of Shepody than for Norland. Norland is an early-maturing, determinate variety, which senesces naturally by early September in Saskatchewan. It

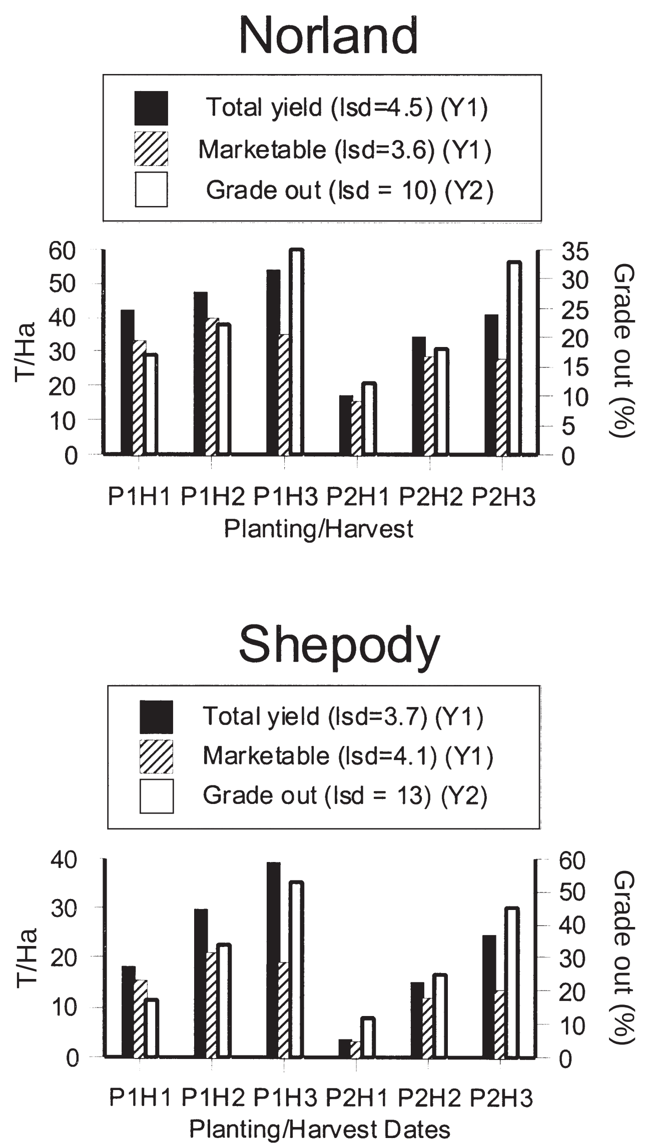

Fig. 1. Total and marketable yields and percentage grade out due to common scab for Norland and Shepody potatoes as influenced by planting (P) and harvest (H) dates (average for 1995–1997). P1 = early May, P2 = early June, H1 = early August, H2 = late August, H3 = mid-September.

is, therefore, not surprising that Norland does not benefit as much from an elongated season as the slower maturing Shepody. Grade out to scab for both cultivars increased with the duration of time the crop was in the ground. This is to be expected as the scab lesions increase in size over time. Once the lesions cover more than 5% of the tuber surface, the tuber is no longer marketable. Similar increases in disease severity in response to a lengthened growing season have been observed for other soil-borne potato pathogens such as silver scurf caused by *H. solani* (Rodriguez et al. 1993) and black scurf caused by *R. solani* (Dijst et al. 1986). Extending the length of the growing season by delaying harvest resulted in more scab problems than did early planting. Environmental conditions in the fall may be more conducive to development of scab than earlier in the season. The optimal time for harvest balanced the increase in yields obtained by delaying the harvest versus the associated increase in grade out to common scab. In both cultivars tested, the highest yields following grading for scab were obtained in early planted crops harvested in late-August.

Time to Harvest Following Top-kill

Losses to scab in 1998 were greater than in 1999, but the yield and scab responses of both cultivars to the interval from application of the chemical top-killer until harvest were similar in the 2 test years (Table 2). Yields were not strongly influenced by the length of time between application of the top-killer and the harvest date (Table 2). This was expected for Norland as the tops died very quickly, however, for Shepody, some yield increase had been expected from the delay in achieving kill-down. As expected, scab damage was more severe in Shepody than Norland (Table 2). Although the tubers did not grow significantly following application of the chemical desiccant, the scab lesions appeared to continued to increase in size because tuber grade-out due to excessive scab damage for both cultivars increased with the period between application of the chemical top-killer and harvest. Consequently, yields of tubers free from excessive levels of scab declined the longer the crop was left in the ground after application of the top-killer. These results suggest that growers seeking to reduce losses to common scab should strive to minimize the period the crop is left in the ground following death of the tops. Similar recommendations have been made as means for reducing tuber damage by soil-borne *R. solani* (Dijst et al. 1986) and *H. solani* (Rodriguez et al. 1993).

This study demonstrates the importance of harvesting as soon as possible after kill-down as a means of minimizing losses to common scab. When scab-sensitive cultivars are grown on heavily infested soils, growers may reduce losses to scab by employing top-killing methods that minimize the time between treatment and harvest. The label for diquat states that a minimum of 2 wk is required between application and harvest to achieve vine desiccation and skin set in the tubers. This study indicates that a substantial increase in losses to scab occur during this waiting period. Mechanical flailing used in conjunction with chemical desiccants may facilitate vine removal and promote crop maturity, thereby potentially reducing losses to scab. Growers should also schedule desiccation treatments to match the progress of the harvest, with the objective of minimizing the time the crop is in the ground after the vines have died.

In summary, this study demonstrated that common scab of potatoes may be managed by minimizing the period the crop is in the ground, but that this method of disease control is achieved at the expense of yield. The proportion of the crop with excessive levels of scab increased substantially in the period between when the chemical desiccant was applied and when the crop was harvested. Minimizing this period should reduce losses to scab, but growers must avoid harvesting too early as they risk problems with the green

Table 2. Treatment mean squares and main effect means for yields and scab levels of Norland and Shepody potatoes harvested at varying intervals after application of a chemical top-killer (1998 and 1999)

	Norland			Shepody		
Mean squares	Total yield	Grade out	Marketable	Total yield	Grade out	Marketable
Rep (R)	11.4	4.2	61.5	119.3	6.3	44.6
Year (Y)	144.5*	19.8*	98.2	378.9**	61.1*	832.9*
Harvest (H)	16.4	9.9*	156.8*	2.2	11.4*	93.3*
Y × H	0.2	2.6	55.5	3.7	1.0	6.4
Means	Total yield (t ha^{-1})	Grade out (%)	Marketable (t ha^{-1})	Total yield (t ha^{-1})	Grade out (%)	Marketable (t ha^{-1})
Year						
1998	43.8	34	28.9	22.4	76	5.8
1999	38.9	12	34.3	30.3	44	17.6
LSD (0.05)	4.1	6	NS	4.4	11	6.1
Harvest						
Immediate	41.2	10	36.4	26.8	48	15.2
After 2 wk	39.9	22	31.0	25.8	59	11.4
After 4 wk	42.6	33	28.2	26.2	72	8.5
LSD (0.05)	NS	4	3.3	NS	6	3.3

*,** Significant at $P = 0.05$ and $P = 0.01$, respectively; NS, not significant.

vines plugging the harvest machinery and skinning damage to immature tubers. Early planting, coupled with timely harvesting, appears to be an effective compromise between the need to maximize yields while avoiding excessive grade-out due to common scab.

ACKNOWLEDGEMENTS

This study was funded by the Saskatchewan Water Corporation and Saskatchewan Department of Agriculture and Food, with technical assistance from Jacqueline Bantle.

Butler, E. J. and Jones S. G. 1949. Plant pathology. MacMillan Co., London, UK.

Canada Food Inspection Agency. 1998. Canada Agriculture Products Act – Grades and Standards for Potatoes. Ottawa, ON.

Davis, J. R., Garner, J. G. and Callihan, R. H. 1974. Effects of gypsum, sulfur, terraclor and terraclor super-X for potato scab control. Am. Potato J. **51**: 35–43.

Dijst, G., Bouman, A., Mulder, A. and Roosen, J. 1986. Effect of haulm destruction supplemented by cutting off the roots on the incidence of black scurf and skin damage, flexibility of the harvest period and yield of seed potato in field experiments. Neth. J. Plant Pathol. **92**: 287–303.

Flint, M. L. (Ed.). 1992. Integrated pest management for potatoes in the western United States. University of California, Division of Agriculture and Natural Resources. Publ. No. 3316.

Goth, R. W., Haynes, K. G., Young, R. J. and Lauer, F. L. 1995. Relative resistance of the potato cultivar Krantz to common scab caused by *Streptomyces scabies* as determined by cluster analysis. Am. Potato J. **72**: 505–511.

Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for agricultural research. 2nd ed. John Wiley and Sons, New York, NY.

Hooker, W. J. (Ed.). 1981. Compendium of potato diseases. APS Press, St. Paul, MN.

Inglis, D. A. 1993. Effects of mechanical plant destruction and chemical vine killing on potato tuber black scurf caused by *Rhizoctonia solani.* Proc. Washington State Potato Conf. 61–63.

Lambert, D. H. and Loria, R. 1989. *Streptomyces scabies* sp. nov., rev. Int. J. System. Bacteriol. **39**: 387–392.

Lapwood, D. H. and Hering, T. F. 1970. Soil moisture and the infection of young potato tubers by *Streptomyces scabies* (common scab). Potato Res. **13**: 296–304.

Loria, R., Bukhalid, R. A., Fry, B. A. and King R. R. 1997. Plant pathogenicity in the genus *Streptomyces*. Plant Dis. **81**: 836–846.

Powelson, M. L., Johnson, K. B. and Rowe, R. C. 1993. Management of diseases caused by soilborne pathogens. Pages 149–158 *in* R.C. Rowe, ed. Potato health management. APS Press, St. Paul, MN.

Rich, A. E. 1983. Potato diseases. Academic Press, New York, NY.

Rodriguez, D., Secor, G. A. and Gudmestad, N. C. 1993. Effect of planting and harvest date of incidence of silver scurf. Am. Potato J. **70**: 836 (Abstr.)

SAS Institute, Inc. 1989. SAS/STAT users guide, version 6. 4th ed. SAS Institute, Inc., Cary, NC.

Slack, S. A. 1991. A look at potato leafroll virus and potato virus Y: Past, present and future. Badger Common 'Tater **43**: 16–21.

Waksman, S. A. 1950. The Actinomycetes. Chronica Botanica Co., MS.