RELATIONSHIP BETWEEN MORPHOLOGICAL CHARACTERISTICS AND VARIETAL RESISTANCE OF SWEET POTATO TO SCAB INFECTION CAUSED BY *Sphaceloma batatas* Saw.

Gracia B. Bajit and Ruben M. Gapasin

Research Assistant and Assistant Professor, Department of Plant Protection, Visayas State College of Agriculture, Baybay, Leyte 7127-A, Philippines.

Portion of B.S. thesis conducted by the senior author at ViSCA.

ABSTRACT

The morphological characteristics of sweet potato cultivars which are resistant and susceptible to *Sphaceloma batatas* Saw. were determined. Susceptible cultivars have thinner cuticle, more stomates in the leaves, and more lenticels in the petioles and stems than resistant cultivars.

The scab pathogen had longer incubation period, lower infection frequency and smaller lesions in resistant than in susceptible cultivars.

Highly significant positive correlation was found between thickness of cuticle and incubation period as well as between number of stomates and lenticels, and infection frequency.

Ann. Trop. Res. 9:75-83.

KEY WORDS: Sweet potato. *Sphaceloma batatas* Saw. Cuticle. Stomates. Lenticels. Incubation period. Infection frequency. Lesion diameter.

INTRODUCTION

The stem and foliage scab disease caused by *Sphaceloma batatas* is one of the most prevalent and destructive diseases of sweet potato. The disease is recognized by the presence of scabby lesions on the leaf laminae as well as on young petioles and stems. The lesions are small, circular initially, and become elongate with maturity.

Infection by the pathogen is favored by wet and cool weather and disease incidence is lower during the drier months of the year (Chupp and Sherff, 1960; Lao, 1978). The disease causes malformation of shoots and cupping of leaves during severe infection and also reduces crop yield by about 27-35% (Divinagracia and Mailum, 1975; Nayga and Gapasin, 1986).

Resistance to a certain pathogen may be brought about either by various defense mechanisms present in the plant even before inoculation or by those which develop in

response to the presence of the pathogen. The structural and biological defense mechanisms of the plant could stop or slow down development of the pathogen from inoculation to dissemination (Agrios, 1978).

Paningbatan and Ilag (1984) found that susceptible peanut cultivars produced symptoms caused by *Cercosporidium personatum* ahead of resistant varieties. Age-related resistance to superelongation disease caused by *Sphaceloma manihoticola* was also observed in cassava. More disease symptoms appeared on young internodes than on mature ones (Ziegler et al., 1973). Younger tissues of sweet potato showed symptoms of scab infection earlier than mature ones. The sixth and seventh leaves from the plant tip were the most resistant, requiring longer time for lesions to develop and showing fewer lesions and lower percentage infection than younger leaves (Regis, 1982; Chupp and Sherff, 1960). Likewise, Gapasin and Paningbatan (1984) observed that incubation period of the scab pathogen ranges from 6 to 13 days depending on the susceptibility of the variety and the age of foliage affected. The mean incubation period of the fungus on the oldest leaves of four varieties tested was longer by 6 days than that on young leaves.

Since literatures on the development of the scab fungus on host tissues and characterization of resistance are seemingly lacking, this study was thus undertaken to provide benchmark information on these aspects. Specifically, it was conducted to determine the morphological characteristics of resistant and susceptible cultivars, to describe certain aspects of scab development in the host tissues, and to correlate the morphological characteristics and scab development with varietal reaction to the disease and with each other.

MATERIALS AND METHODS

Preparation of Test Plants and Selection of Samples

Sweet potato cultivars and hybrids which are resistant (VSP-2 and V5-26), moderately resistant (VSP-3 and LO-323) and susceptible (VSP-1 and V3-158) to scab disease based on the ratings of Gapasin and Paningbatan (1984) during the 1983 wet season, were used as test plants. They were planted in 15 cm dia. clay pots and arranged in the greenhouse following the completely randomized design. Each cultivar served as the treatment and was replicated 5 times.

Leaves, petioles and stems were used as test samples. Starting from the tip of the plant, the first eight leaves (including petioles) were tagged. The first five leaves were considered young and the other three (sixth, seventh and eighth leaves), mature. The stems bearing the sample leaves were measured and the first 5 cm from the tip was regarded as young while the remaining portion as mature.

Inoculum Preparation and Inoculation

Two-week old pure culture of *Sphaceloma batatas* grown in sweet potato decoction agar medium was used as the source of inoculum. Spores were suspended in sterile water, counted using a haemacytometer, and adjusted to a concentration of 5 x 10^4 per mL. The spore suspension was then inoculated to 2-week old potted plants. After inoculation, the plants were individually covered with plastic bags and left overnight to maintain high relative humidity which is favorable for infection.

Determination of the Morphological Characteristics of Resistant and Susceptible Cultivars

Thickness of Cuticle. Healthy leaves were cut into pieces about 5 mm^2 in size and prepared for histological study using the procedure of Jensen (1962). The prepared slides were air-dried overnight and then examined under a compound microscope. The cuticle which includes the outer epidermal wall was measured using an ocular micrometer. Ten samples were used for each cultivar.

Frequency of Stomates and Lenticels Per Unit Area. Leaf tissue sections about 2 mm^2 in size were fixed overnight in Carnoy's solution and mounted in lactophenol. Stomates in the leaves and lenticels in the petioles and stems were counted under a compound microscope with the aid of a hand tally counter. Ten samples per leaf tissue of each cultivar were used.

RESULTS AND DISCUSSION

Morphological Characteristics of Resistant and Susceptible Cultivars

Thickness of Cuticle. This morphological feature varied with age of leaf tissue and level of resistance of the six sweet potato cultivars studied. In general, mature tissues of each cultivar had thicker cuticle than younger tissues (Table 1).

The susceptible and moderately resistant cultivars had significantly thinner cuticle both in the young and mature leaves than the resistant VSP-2 and V5-26 cultivars. This conforms with the findings of Melander and Craigie (1927) as reported by Tarr (1972) that the cuticle of mature leaves of resistant *Berberis* spp. was thicker than that of 2- to 3-day old leaves.

Thickness and toughness of the outer epidermal wall are apparently important factors in the resistance of some plants to pathogens. A thick and tough wall makes direct penetration by fungal pathogens difficult or impossible and plants with such characteristics are often resistant (Agrios, 1978). The thick cuticle of the resistant sweet potato cultivars studied possibly inhibited penetration of the scab pathogen. A significant positive correlation ($r = 0.65$) between incubation period and thickness of cuticle was observed among cultivars (Table 2). This finding implies that the scab pathogen could easily penetrate the

Table 1. Some morphological characteristics of sweet potato plants with varying levels of resistance to *Sphaceloma batatas*.[1]

Cultivar/ Disease Reaction[2]	Cuticle Thickness (mm)		No. of Stomates/2mm^2		No. of Lenticels/2mm^2			
	Leaf		Leaf		Petiole		Stem	
	Young	Mature	Young	Mature	Young	Mature	Young	Mature
VSP-1 (S)	0.82c	1.73c	466.40bc	188.79d	66.36a	41.99ab	60.76b	33.39a
V3-158 (S)	0.72d	1.20d	604.32a	384.39a	73.88a	42.26ab	83.28a	38.45a
VSP-3 (MR)	0.90c	1.84c	561.96a	272.05c	69.40a	34.43b	59.92b	36.76a
LO-323 (MR)	0.79c	1.79c	602.76a	354.13b	62.20b	30.38c	60.24b	40.39a
VSP-2 (R)	1.57a	3.06a	407.28c	208.20d	71.92a	52.19a	66.92b	46.80a
V5-26 (R)	1.56b	2.87b	411.48c	214.19d	72.04a	45.86ab	56.36b	55.60a

[1]Means within a column followed by the same letter are not significantly different at 5% level, DMRT. Ten lesions were used per cultivar.
[2]S - susceptible; MR - moderately resistant; R - resistant

Table 2. Correlation between morphological characteristics of sweet potato plants and scab development.

Character	r[1]
Infection frequency vs number of stomates and lenticels	+0.84
Infection frequency vs thickness of cuticle	-0.58
Incubation period vs number of stomates and lenticels	-0.92
Incubation periods vs thickness of cuticle	+0.65

[1] All values are significant at the 1% level.

younger tissues due to their thinner epidermis, thus symptoms appeared earlier.

Frequency of Stomates and Lenticels. The number of stomates apparently influences the cultivars' resistance to the pathogen. As shown in Table 1, the two moderately resistant cultivars as well as the susceptible V3-158 had significantly more stomates in both young and mature leaves than the two resistant cultivars. This greater number of available entry points could be contributory to the lower level of resistance of the three varieties mentioned in addition to their thinner cuticle when compared with the resistant cultivars. This assumption is supported by the significant positive correlation obtained between infection frequency and the morphological feature mentioned (Table 2). Many pathogenic fungi enter plants only through open stomata although majority of them can force their way through closed stomata like stem rusts of wheat (Hart, 1929). Certain structural features of stomata like very narrow entrance and broad elevated guard cells, may make some varieties resistant to certain pathogens (Agrios, 1978).

The number of lenticels does not appear to significantly influence cultivar resistance except in LO-323. The significantly fewer lenticels in the petioles of LO-323 than in the two susceptible cultivars could partially account for the moderate resistance of this cultivar. No significant differences in lenticel abundance in the stems were noted among the cultivars except for V3-158 which had the highest number in the young stems.

Based on the results, cuticle thickness is apparently more important in the infection process by an organism than number of natural openings. Lao (1978) reported that

the scab pathogen usually penetrates the host tissues directly if the cuticle is not thick enough to totally prevent entry. Inadequacy of cuticle thickness to totally prevent pathogen penetration is suggested by the occurrence of some infection in the resistant cultivars. This implies that natural openings were used as the next entry points. However, infection was much less than in susceptible host plants.

Development of Scab Pathogen

Incubation Period. The incubation periods of *Sphaceloma batatas* in the different cultivars are presented in Table 3. The scab fungus had significantly longer incubation period in resistant than in susceptible cultivars particularly in the leaves and stems.

The incubation period of *S. batatas* on V3-158 as reported by Gapasin and Paningbatan (1984) was shorter (4 days only) than that observed in this study. The discrepancy could be attributed to differences in stage of development of the host and in the environmental conditions under which the two experiments were conducted.

According to Paningbatan and Ilag (1984), a resistant peanut cultivar (PI 259747) significantly prolonged incubation period of *Cercosporidium personatum* by 15% compared to susceptible cultivar CES 101. This could be due to delayed entry of the pathogen into host tissues caused by impediments to penetration. Based on results of this study, the length of incubation period could therefore be used as a measure of the resistance or susceptibility of cultivars to the scab pathogen. Parlevliet (1979) also reported that host resistance may be manifested in terms of delayed incubation period.

Infection Frequency. Younger leaves, stems and petioles of susceptible V3-158 showed the highest infection frequency. Among the cultivars, V3-158 also had significantly higher infection frequency (more than 3 times) than the resistant V5-26 (Table 3). Results conform with the findings of Chupp and Sherff (1960), Gapasin and Paningbatan (1984) and Regis (1982) that scab infection was severe in young tissues of sweet potato.

Diameter of Lesions. The diameter of lesions produced differed significantly among cultivars (Table 3). Comparatively, the susceptible varieties had the biggest lesions while the resistant varieties had the smallest lesions.

Paningbatan and Ilag (1984) also found that genotypes resistant to *C. personatum* exhibited significantly smaller lesions than susceptible cultivars. This implies that invasion of tissues adjacent to the infection site was inhibited in resistant cultivars. It is not known whether this was due to biochemical factors present in the resistant host. However, histopathological study on lesions of a resistant sweet potato variety (VSP-2) showed formation of cork layers (Pers. Comm. with Gapasin, R.M., Department of Plant Protection, ViSCA). Cork

Table 3. Incubation period, infection frequency and lesion diameter of scab disease caused by *Sphaceloma batatas* in sweet potato plants with varying levels of resistance.[1]

Cultivar/ Disease Reaction[2]	Incubation Period (days)			Infection Frequency[3]			Lesion Diameter (mm)[4]
	Leaf	Petiole	Stem	Leaf	Petiole	Stem	
VSP-1 (S)	6.67d	7.08ab	6.40c	9.95a	5.44bc	16.60abc	1.86a
V3-158 (S)	5.72e	5.88b	5.60d	11.92a	11.52a	32.20a	1.72b
VSP-3 (MR)	7.44c	6.68ab	6.40c	5.56c	6.40bc	17.20abc	1.55c
LO-323 (MR)	6.52d	6.84ab	6.00d	7.68b	7.60b	4.80c	1.18d
VSP-2 (R)	8.04b	8.76a	7.40b	5.56c	4.64bc	30.60ab	1.01e
V5-26 (R)	9.72a	7.16ab	7.60ab	3.08d	3.24c	6.60c	0.94e

[1] Means within a column followed by the same letter are not significantly different at 5% level, DMRT.

[2] S - susceptible; MR - moderately resistant; R - resistant

[3] Number of lesions per 5 cm^2 leaf area or 5 cm stem or petiole length; average of five replications with five samples per replication.

[4] Average of five replications with 10 lesions per replication.

layers could inhibit further invasion by the pathogen beyond the initial infection site and also block the spread of any toxic substance that the pathogen might secrete. Furthermore, cork layers could stop the flow of nutrients and water from healthy to infected areas and thus deprive the pathogen of nourishment (Weimer and Harter, 1921).

Results indicate that the data on incubation period, infection frequency, lesion diameter, thickness of cuticle and frequency of stomates and lenticels could be used as criteria in assessing resistance of sweet potato to scab disease. The incubation period would influence the spread of the disease from earliest-infected plants to other plants. Infection frequency and lesion diameter could reflect the amount of inoculum that would be produced for dissemination, thus could indicate the degree and frequency of disease infection. Thickness of cuticle and frequency of stomates and lenticels could gauge the extent of the structural defense mechanisms that the sweet potato plant could use against the scab disease. These may contribute to delay in host reaction to scab infection thereby enhancing sweet potato resistance.

LITERATURE CITED

AGRIOS, G.N. 1978. How plants defend themselves against pathogens. *In* Plant Pathology. Academic Press Inc., New York. pp. 72-79.

CHUPP, C. and SHERFF, A.N. 1960. Vegetable Diseases and Their Control. The Ronald Press Inc., New York. 518 p.

DIVINAGRACIA, G.G. and MAILUM, N.P. 1975. Sweet potato (*Ipomoea batatas)*. Fungicides and nematicides test results of 1975. American Phytopath. Soc. 3:14.

GAPASIN, R.M. and PANINGBATAN, R.A. 1984. Studies on plant diseases especially the sweet potato scab. Unpublished Year-end report. Study 2. IDRC/PCARRD study.

HART, H. 1929. Relation of stomatal behavior to stem rust resistance in wheat. J. Agric. Res. 39:929-948.

JENSEN, W.A. 1962. Botanical Histochemistry. W.H. Freeman and Co., London. 264 p.

LAO, F.O. 1978. Culture, morphology and pathogenicity of *Sphaceloma batatas*. Unpublished M.S. Thesis. UP at Los Baños, College, Laguna, Philippines. 105 p.

NAYGA, J. and GAPASIN, R.M. 1986. Effect of stem and foliage scab disease on sweet potato VSP-1. Ann. Trop. Res. 8(3):115-122.

PANINGBATAN, R.A. and ILAG, L.L. 1984. Resistance of peanut cultivars to *Cercosporidium personatum* (Berk. and Curt.) Deighton. Phil. Agric. 67:17-24.

PARLEVLIET, J.E. 1979. Components of resistance that reduce the rate of epidemic development. Ann. Rev. Phytopath. 17:203-222.

REGIS, T.M. 1982. Dissemination of and infection by the sweet potato scab pathogen *(Sphaceloma batatas)*. Unpublished B.S. Thesis. Dept. of Plant Protection, ViSCA, Baybay, Leyte. 25 p.

TARR, S.A.J. 1972. Principles of Plant Pathology. The Macmillan Press, London. 632 p.

WEIMER, J.L. and HARTER, L.L. 1921. Wound-cork formation in the sweet potato. J. Agric. Res. 21:637-647.

ZIEGLER, R.S., ALVAREZ, E. and LOZANO, S.C. 1973. Cassava resistance to superelongation disease. Trop. Res. Management 29:14-15.