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ENVIRONMENTAL SITE CHARACTERISTICS AND INCIDENCE OF CHOKECHERRY BLACK KNOT IN UTAH

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ABSTRACT.— Black knot disease of chokecherries, induced by *Dibotryon morbosum* (Schw.) Th. & Syd., is widely distributed in Utah. The incidence of black knot was measured by determining the ratio of total black knot gall length to total stem length of plants and then expressing that value as a percentage of diseased stems in the sample plot. The environmental site factors measured were elevation, exposure, slope, soil pH, soil depth, distance to surface water, plant moisture stress, and associated vegetation. Numerical values were determined for each of these variables at each of 18 randomly located plots. Correlation coefficients for plant moisture stress and soil temperature were −.439 ($p = .065$) and −.440 ($p = .055$). Multiple regression analyses using plant moisture stress and soil temperature gave a regression coefficient of −.641 ($p = .05$). As plant moisture stress and soil temperature decreased, incidence of black knot increased.

Black knot, induced by *Dibotryon morbosum* (Schw.) Th. & Syd., is common on chokecherry (*Prunus virginiana*) in its native habitat throughout Utah. The disease is characterized by elongated black swellings on the stems and branches (Fig. 1). A slight swelling of the current season twigs in the fall is the first symptom of infection. The following spring, knots become larger, bark ruptures, and the surface of the gall becomes covered

Fig. 1. Black knot on chokecherry.

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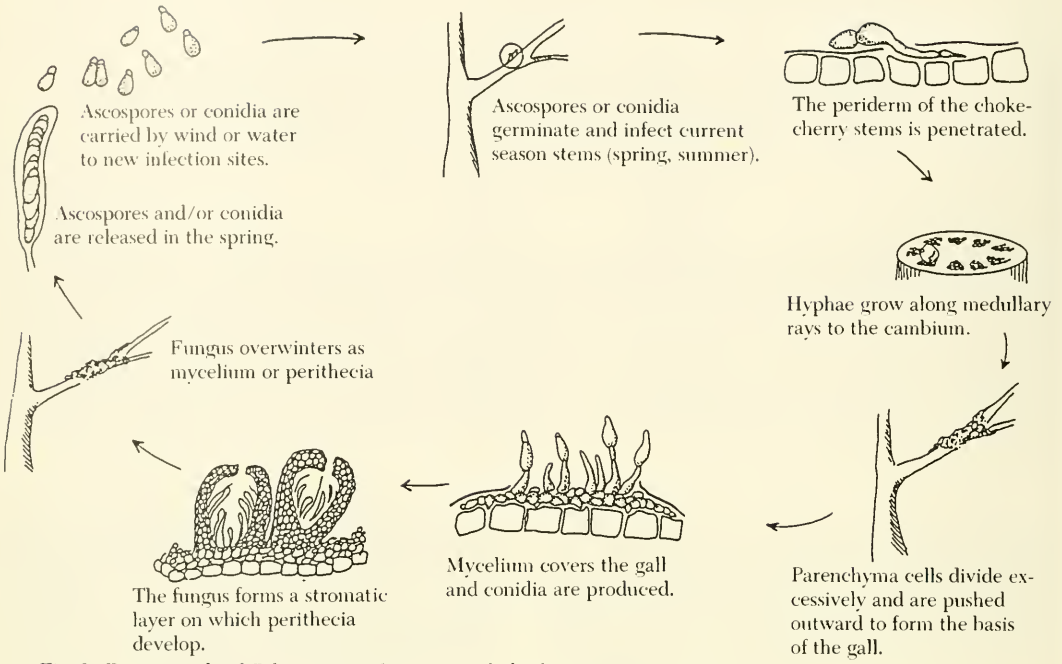

Fig. 2. Disease cycle of *Dibotryon morbossum* on chokecherry (*Prunus virginiana*).

with a velvety green pad of mycelial tissue. By fall, the green surface is replaced by black stromatic tissue (Koch 1935a). The disease cycle is illustrated in Figure 2.

Dibotryon morbosum is an ascomycetous fungus. The light green ascospores are two celled, with one cell much smaller than the other. The light brown conidia that are produced early in the spring arise from greenish gall elevations formed the previous year (Anderson 1956). The perithecia are produced on the surface of the black knots in hemispherical, closely appressed elevations. Ascospores or conidia initiate the primary infection in the spring. Conidia germinate and penetrate intercellularly up to seven cell layers of periderm to initiate a primary infection. Initial infection usually occurs on current season's growth before layers of periderm are well developed, though occasionally a primary infection may occur on older twigs (Koch 1935b).

After periderm penetration, hyphae grow inward to the cambium and along the meduallary rays of the xylem. Initially no host cells are killed. When the mycelia reach the cambium, they stimulate parenchyma cells to divide excessively. These cells push outward and form the basis of developing knots. Mycelia grow internally in either direction and give rise to galls some distance from the original infection. During the second summer, the size of the knots enlarge and the fungus develops a stromatic surface layer on the knot in which perithecia are formed. Ascospores are discharged from perithecia in spring and are spread by air currents or water (Anderson 1956, Koch 1933, 1934, 1935a,b).

Since Koch's study (1933, 1934, 1935) of the epidemiology of black knot disease on horticultural plants, very little research has been done on the disease. There is little information on environmental site factors that correlate with intensity and distribution of black knot on native hosts. Previous research has been confined to horticultural varieties of the genus *Prunus*. Although Koch studied temperature and moisture as affecting ascospore and conidia ejection and germination, he did not relate these to incidence and distribution of the disease (Koch 1934). This investigation was designed to test the hypothesis that environmental site factors such as location in relation to water, plant moisture stress, soil pH, slope, aspect, and elevation may be used to characterize sites of high black knot incidence.

METHODS AND PROCEDURES

Forty .01 hectare plots were selected by random means using a gridded topographical map. Examination showed only 18 of the sites supported chokecherry; thus all subsequent analyses were confined to those sites. Potential plots were restricted to the area between the mouth of Provo Canyon and Cascade Springs in the Wasatch Mountains of Utah County, Utah. Data on the following site factors were collected from each site during September 1982; (1) elevation, (2) steepness of slope, (3) slope aspect, (4) soil depth, (5) soil pH, (6) soil temperature, (7) plant moisture stress, (8) distance to surface water, (9) estimate of understory cover, (10) estimate of composition (i.e., proportions of total cover contributed by forbs, grasses, and woody plants), (11) soil parent material, and (12) average age of chokecherry plants.

A numerical value was determined for slope aspect using the procedure of Beers et al. (1966) for aspect transformation. Soil depth was measured by pushing a pointed rod into the soil as far as the rod would go. Two to four soil depth readings were taken at each site and averaged. To maintain consistency, the same individual determined soil depth at all sites. Soil pH was determined using a glass electrode pH meter and a saturated soil paste. Plant moisture stress was determined by placing a chokecherry leaf into a plant moisture press and applying pressure until free water was exuded from the petiole (K. Harper, Brigham Young University, pers. comm.). Sample leaves were similar in size and taken from similar positions on plants. Several readings were taken from each site and averaged. Both plant moisture stress and soil temperature data were collected within a period of five days, between the hours of

TABLE 1. Environmental site factors associated with black knot disease of chokecherry.

Site	Chokecherry stem diameter (cm)	Infection (% stem length)	Average stem height (m)	Average age (yrs)	Plant moisture stress (bars)	% Understory cover	Elevation (m)	Aspect[1]	Slope degrees	Distribution surface H_2O (km)	Soil pH	Soil temperature (°C)	Soil depth (m)	Parent material
1.	2086	1.0	1.8	7	6.55	80	2073	.29	20	.4	7.0	12	.23	Quartzite
2.	4090	1.3	1.1	9	6.89	80	2012	.29	45	.5	6.8	13	.11	Limestone
3.	1082	3.0	.6	6	10.69	80	2134	1.00	30	.8	7.2	12	.29	Quartzite
4.	2770	1.4	1.2	6	6.89	95	2444	.29	45	1.6	6.9	10	.20	Quartzite
5.	6646	4.3	6.1	5	7.58	95	2256	1.71	30	.8	6.8	11	.54	Quartzite
6.	4450	10.9	4.3	9	6.55	85	2195	.00	70	.8	7.0	8	.23	Sandstone
7.	1708	10.9	1.9	7	6.55	90	2316	1.00	60	.0	6.7	10	.36	Quartzite
8.	16213	3.8	5.1	8	7.58	90	2438	.29	30	.2	6.9	10	.40	Quartzite
9.	3856	3.8	2.1	5	6.55	90	2256	1.71	5	.0	6.9	12	.45	Quartzite
10.	3812	.0	3.4	5	12.41	90	1890	.29	70	.4	7.2	13	.10	Quartzite
11.	2513	13.4	1.5	5	6.21	55	2073	1.71	60	.0	6.7	10	.23	Quartzite
12.	6367	.4	3.7	11	15.17	70	1840	.29	45	.0	7.1	10	.20	Slate
13.	4671	.0	2.9	10	10.34	25	1585	1.71	30	.4	6.9	10	.08	Limestone
14.	2556	.0	.5	3	11.72	70	2463	2.00	35	1.6	6.9	11	.40	Quartzite
15.	1622	.0	1.2	5	14.48	95	2463	.29	15	1.6	6.5	8	.34	Quartzite
16.	2761	1.0	.9	10	12.41	70	2073	.29	45	.4	7.3	12	.17	Qrtz/Sand
17.	5025	.0	5.0	10	8.27	25	1524	2.00	75	.0	7.3	14	.25	Quartzite
18.	4983	.0	5.8	5	3.45	95	1646	.29	30	.2	7.3	13	.44	Quartzite
Mean	4289.5	3.1	2.7	7	8.91	77	2093	.85	41	.5	7.0	11	.28	
SD	3373.1	4.3	1.9	2.4	3.24	22	300	.74	20	.6	.2	2	.13	

[1]Transformed as suggested by Beers et al. (1966).

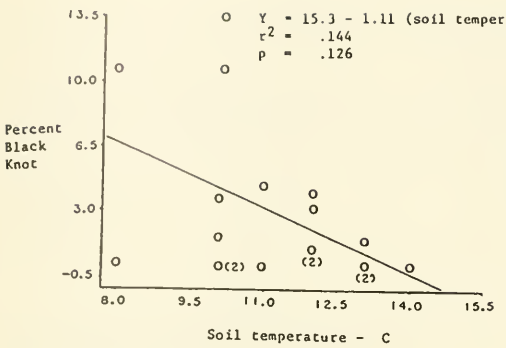

Fig. 3. Regression equation of percent black knot in relation to soil temperature.

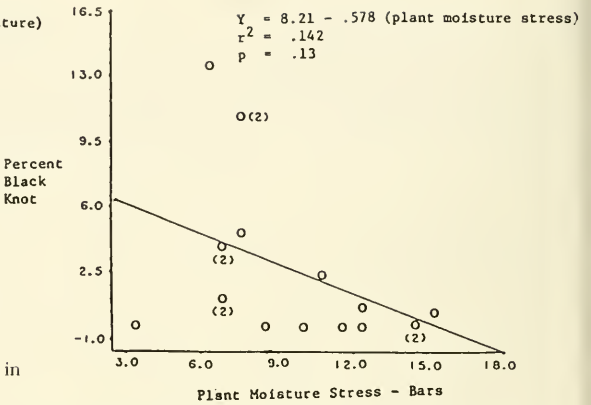

Fig. 4. Regression equation of percent black knot in relation to plant moisture stress.

0800 and 1000. To determine soil temperature, a soil temperature probe was inserted 15 cm into the soil. Average age of plants in a plot was determined by counting annual growth rings in stems of average diameter representative of the site.

All measurements on chokecherry plants and black knot galls were collected from four subplots (2 x 2 m) located in the corners of each of the 18 study plots. The degree of black knot infection was determined by measuring the length of all stems and branches of chokecherry and the length of black knot galls on the stems in each miniplot and expressing diseased tissue as a percentage of total stem length. Because of the rhizomatous, spreading growth habit of the chokecherry plant and difficulty of determining boundaries of a single plant, all stems and branches within the 2 x 2 m subplots were measured and considered as a single plant.

Correlation analyses, regression analyses, analysis of variance, and chi-square analysis were used to analyze the data. Regression and correlation coefficients were tested for significance with the t-test (Snedecor and Cochran 1967). To determine if elevation affected incidence of black knot, the plots were divided into three elevational categories with six plots in each category designated. Low elevation was 1524–2012 m. Midelevation was 2073–2256 m. High elevation was 2256–2463 m.

Results

Black knot disease was observed on plots between 1840 and 2444 m. The 18 random plots ranged in elevation from 1524 to 2463 m (5,000–8,000 ft) above sea level (Table 1). A chi-square analysis showed no significant difference in incidence of disease in high, middle, and low elevational categories.

The data obtained for the 12 factors on the 18 sites are shown in Table 1. A correlation analysis relating the incidence of black knot with all quantified site factors was determined. The correlation coefficients for the analyses are shown in Table 2. The correlation analyses indicate that black knot disease tended to occur more frequently on sites with lower soil temperatures, deeper soils, more acid soils, and lower plant moisture stress. Of these, soil temperature and plant moisture stress were most closely correlated with incidence of the disease. Both plant moisture stress and soil temperature were negatively correlated with disease incidence. The probability of the null hypothesis being true for plant moisture stress was .065; for soil temperature probability was .055.

Using severity of black knot as the dependent variable, linear regressions were determined with plant moisture stress or soil temperature as independent variables. Figures 3 and 4 show the results of those regression analyses. As plant moisture stress increased, severity of black knot decreased. Similarly, as soil temperature increased, incidence of black knot again decreased.

Since plant moisture stress and soil temperature were not significantly correlated with each other and could conceivably interact to alter plant response to black knot disease,

TABLE 2. Linear correlation coefficients showing relationship of degree of development of black knot disease (cm of gall/cm of stem) to various factors.

Factors	Correlation coefficient	Significance level (p)
Soil temperature	-.440	.055
Plant moisture stress	-.439	.065
Soil pH	-.391	.085
Distance to surface H_2O	-.264	N.S.
Average age of stand	-.086	N.S.
Average height of stems	-.002	N.S.
Slope	.353	.080
Elevation	.287	N.S.
% composition from forbs	.215	N.S.
Soil depth	.151	N.S.
Exposure	.110	N.S.
Percent understory cover	.101	N.S.
% composition from grasses	.061	N.S.
% composition from shrubs	.033	N.S.

N.S. = Nonsignificant

these two factors were used as independent variables in a multiple regression analysis in which degree of severity was the dependent variable (Table 3). The analysis gave a multiple regression coefficient of -.411 (p .05). The regression equation takes the form: y = 24.7 - .717 (moisture stress - 1.38 [soil temperature]).

Discussion and Conclusion

Koch (1935) and Smith (1970) found ascospore and conidia ejection occurred during rainfall, when the temperature was 10–15 C. Germination occurred when the relative humidity was 76%–90% and the temperature was between 12–30 C. Optimal germination occurred at 24 C. There is no information available on the environmental conditions necessary to maintain and increase fungal growth in vivo, although in vitro studies indicate 22–24 C as optimal for growth (Koch 1935). The environmental site factors found to be most closely correlated with disease incidence in this study were plant moisture stress and soil temperature. Low plant moisture stress reflects high moisture availability for both the plant and for the fungus. Soil temperature can exert strong influences on available soil moisture. Those sites with lower soil temperature and less plant moisture stress are probably the sites that receive and hold more spring moisture, which in turn would provide a more favorable site for infection. The results would suggest that the pathogen infects over the same range of elevation as chokecherry grows. Further studies are needed to establish the influence of the site factors we measured on those environmental factors that are necessary for fungal sporulation, dispersal, infection, and growth under field conditions.

TABLE 3. Linear correlation coefficient values for percent black knot disease (cm of gall/cm of stem) relative to independent environmental site factors.

Exposure	.110
Elevation	.287
Slope	.353
Soil pH	-.391
Soil depth	.151
Distance to surface H_2O	-.264
Plant moisture	-.439 (p = .065)
Soil temperature	-.440 (p = .055)
Percent understory cover	.101
Percent composition:	
a. Forbs	.215
b. Grasses	.061
c. Shrubs	.033
Average age of stand	-.086
Average height	-.002

Black knot is a disfiguring and debilitating disease on chokecherries. Knowledge of those site characteristics associated with high incidence of black knot can be useful in making management decisions concerning revegetation with chokecherry plants.

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