The Disease Disposition of Tuber Crops as Compared to other Annual Crops

Author: R. Delhey, Departamento de Ciencias Agrarias, Universidad Nacional del Sur, 8000 Bahía Blanca, Argentina.

ABSTRACT

The Pathological Index (PI) is introduced as a measure for the overall disease incidence of a crop species. PI is calculated according to the formula:

$$PI = \frac{\text{No. of publications in Rev. Pl. Pathol.}}{\text{No. of publications in Pl. Breed. Abs.}} \times 100.$$

Similarly, partial PI values referring to fungal, bacterial, and virus disease incidence (PI_F, PI_B, PI_V) can be calculated.

The PI values of 45 annual crops have been determined, including 5 tuber crops. The overall disease incidence is high in yam, aroids, and potato, and moderate in cassava and sweet potato. Also, virus disease incidence is higher in the three former species. Cassava is unique in having relatively low PI_F and high PI_B values.

Tuber crops as a whole have a very high disease incidence as compared to cereals, medicinal fiber crops, and legumes. This is especially true with respect to bacterial and virus diseases. Vegetative propagation is accompanied by a higher disease incidence than propagation by true seed; this tendency is more pronounced with virus and bacterial than with fungal diseases.

Crops differ in their disposition to contract diseases and suffer from them. To express those differences quantitatively the term Pathological Index (PI) is introduced which is considered as an intrinsic character of a given crop species. This index is calculated according to formula 1:

$$PI = \frac{\text{No. of publications in Rev. Pl. Pathol.}}{\text{No. of publications in Pl. Breed. Abs.}} \times 100. \qquad (1)$$

Similarly, partial PI values, referring to fungal, bacterial and virus diseases (PI_F, PI_B, PI_V, respectively) can be calculated. As formula 2 indicates, PI is the sum of these partial indices.

$$PI = PI_F + PI_B + PI_V \qquad (2)$$

This pattern makes up the Pathological Profile of a crop.

Formula 1 is based on the number of phytopathological (in the case of partial indices of mycological, bacteriological and virological) publications dedicated to each crop as included in Review of Plant Pathology. This figure is divided by the number of publications reviewed in Plant Breeding Abstracts, in order to eliminate the influence of factors which are not related to phytopathology, such as the acreage of the crop, the attention it has received in research, and others.

Results and Discussion

The PI values of 45 annual crops have been determined according to formula 1, in base of Review of Plant Pathology, vols. 55-59, and Plant Breeding Abstracts, vols. 46-50, corresponding to the years 1976 to 1980. The values obtained show a wide variation from 9.8 (foxtail millet, *Setaria italica*) to 157.7 (pineapple, *Ananas comosus*). Those of five tuber crops are shown in Table 1. In some crops, which include inter alia yams and aroids, the numerical base for the calculation of PI is very small; this permits only to establish certain trends in such cases.

As a rule, the PI_F values are higher than those of PI_V or PI_B, indicating that fungal diseases are more important in most crops than viruses or bacterioses. There are a few exceptions, however; one of them is cassava (Table 1).

Agronomic Characters

The disease impact suffered by a species as expressed by its PI value may be influenced by various determinants. To identify these determinants, crops were grouped according to their agronomic characters, including intensity, climatic zone, type of propagation and plant parts harvested. The results of these comparisons can only be summarized here.

It could be demonstrated that the level of cropping intensity is positively correlated with the PI values; this is true for fungal, bacterial and virus diseases.

There are various factors responsible for this tendency. Firstly, in extensive agriculture many diseases can be tolerated, or pass even unnoticed, because under such circumstances the yield reductions produced do not justify major efforts in research and control. The margin of tolerance is much smaller in crops with high investments in capital and/or labor per unit area (Heitefuss, 1975).

In most of the intensively cultivated crops (fruits, vegetables, tobacco) product quality is of much more significance than in extensive crops like cereals or oil seeds. Therefore, diseases which affect quality, aspect, storage ability and commerciability have to be considered more in the former than in the latter species.

Finally, intensive agriculture is often associated with factors which tend to favor the development of epidemics: protected cultivation, irrigation and dense stands create a special microclimate favorable for many pathogens; a permanent occupation of the soil, extension of the growing season, overlapping cultures, small plots and the proximity of related species which share the same pathogens (e.g. solanaceae, cucurbitaceae) guarantee the presence of disease inoculum and vectors.

Table 1. Pathological Indices and number of pathogens recorded in tuber crops (in base of Review of Plant Pathology and Plant Breeding Abstracts, 1976-1980).

Crop	No. of publications 1976-1980					Pathological Indices				No. of pathogens		
	P.B.A.	R.P.P.										
		Total	Fungi	Bact.	Virus	PI	PI_F	PI_B	PI_V	Fungi	Bact.	Virus
Aroids	25	17	7	0	10	68.0	28.0	0.0	40.0	3	0	3
Yams	37	33	18	3	12	89.1	48.6	8.1	32.4	18	2	8
Cassava	198	92	28	34	30	46.5	14.1	17.2	15.2	19	2	8
Sweet potato	156	62	38	6	18	39.7	24.4	3.8	11.5	13	6	7
Potato	2,106	1,470	680	248	542	69.8	32.3	11.8	25.7	51	8	30

When the crops are grouped according to the climatic zone they belong to (tropical, subtropical, warm temperate, cool temperate), the average disease impact is highest with the lower latitudes, decreasing towards the higher latitudes. This tendency is more pronounced with fungal and bacterial than with virus diseases.

To some degree, the temperature and humidity conditions of the tropics and subtropics might favor directly the development of many fungi and bacteria. Possibly of more importance for the abundance of inoculum and vectors is the year-round cultivation and/or presence of natural vegetation, in contrast to cool temperate and mediterranean zones, where cold or dry seasons interrupt the epidemic cycles. According to Levin (1975), in tropical climax communities the pressures of herbivores and pathogens are higher than in other communities; this might have its influence also on the crops cultivated in these regions.

A very important influence on the PI values is exerted by the kind of reproduction. The average PI of seed propagated species is much lower than that of vegetatively propagated ones. This is especially true for PI_B and PI_V, and less so for PI_F. However, whereas all the asexually multiplied crops suffer considerably from virus diseases, some are nearly free from bacterial diseases, e.g. aroids, garlic, hops and strawberry. This indicates that vegetative reproduction is not necessarily associated with bacterial diseases.

The greater vulnerability of crops which are multiplied asexually can be explained in part by their genetic uniformity and their impossibility to adapt themselves to changing populations of pathogens. Another important factor is the transmissibility of many fungi, bacteria and especially viruses, via the planting material, as compared to the relatively small number of pathogens transmitted by true seed.

This has considerable epidemiological implications. Diseases of seed multiplied plants, in most cases, have their primary sources of inoculum outside the crop; therefore their spread is often delayed and plants become infected late in the season with less dramatic effects on yield. However, in the case of vegetatively transmitted diseases, the sources of inoculum are ideally distributed within the crop, which enables a rapid and efficient dissemination leading to early infections which considerably affect the yield. Moreover, late infections are of great significance because of the contamination of propagating material obtained from these plants.

Crop species were also arranged according to the plant parts harvested. The group of dry grains showed the lowest disease incidence; crops with subterranean products (roots, tubers, bulbs) and those where stems and leaves are utilized occupy an intermediate position, whereas crops with soft fruits have the highest PI values. Apparently, the more tender and delicate the organ, the more vulnerable it is to fungal and bacterial diseases.

The cereals are the least affected crops, with an average PI of 28.7, followed by pulses (38.9) and oil and fibre crops (39.0). The other groups, miscellaneous crops (58.5), tuber crops (62.6) and vegetables and fruits (67.3) show much higher PI values. These three groups are characterized by their sensibility to bacteria and viruses. Vegetables and fruits, in addition, are extremely vulnerable to fungal diseases.

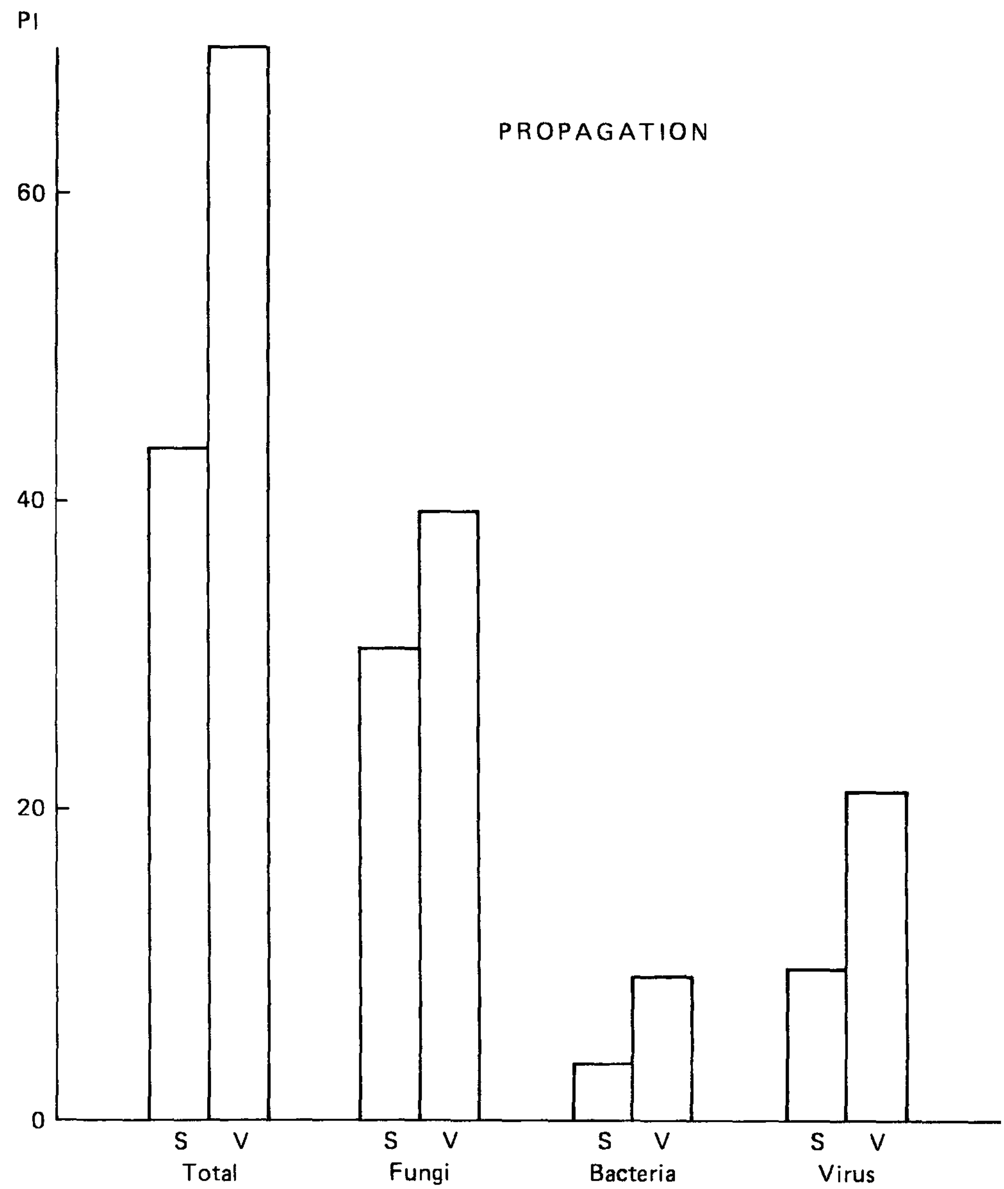

Figure 1. Average Pathological Indices of seed (S) and vegetatively (V) propagated crops.

It is evident that the differences in cropping intensity, climatic zone, propagation and plant parts harvested contribute to this pattern, as previously pointed out. With respect to tuber crops, the Study Group 4 of the International Symposium on Tropical Root Crops, in St. Augustine, Trinidad, identified four main factors responsible for the high disease impact in tropical tubers: the planting material of these vegetatively propagated species harbors viruses and other pathogens; the economic parts of the plants are exposed to the direct attack of soil pathogens; the wounds produced during harvesting provide avenues for infections which cause storage diseases; and the long growing season together with the humid tropical environment enhance the disease incidence (Martin et al., 1967).

Tuber Crops

Within the group of tuber crops, the highest PI values are found in yams, potato and aroids; cassava and sweet potato are less affected (Table 1). Also with respect to virus diseases, sweet potato and cassava have relatively low PI_V values, those of potato, yams and aroids being considerably higher. The highest PI_F is found in yams and the lowest in cassava, with intermediate values in sweet potato, aroids and potato. There are great differences also with respect to bacterial diseases, cassava being extremely vulnerable and sweet potato and aroids highly resistant to these pathogens. Bacteria are quite important also in potato (Table 1).

The marked differences in the Pathological Profiles are difficult to interpret. With the exception of potato, the tuber crops included here are predominantly of tropical regions. There are differences in cropping intensity, with the lowest level probably in cassava, an intermediate one in sweet potato and potato, and the highest level in yams and aroids. This factor may explain the Pathological Profiles of these species, at least partially.

From Table 1, it may be concluded that the number of pathogens recorded for each crop in the five volumes of Review of Plant Pathology indicated is of little significance in the PI values. Rather it reflects how much attention has been paid to each species. However, a closer look to the most important pathogens might be helpful to identify the main disease problems of each crop.

In aroids, *Phytophthora colocasiae* and dasheen mosaic virus are the most frequently mentioned disease agents, whereas none of the 28 pathogens cited for yams seems to play a dominant part. The most frequently named pathogen of sweet potato is *Ceratocystis fimbriata*, followed by the virus complex feathery mottle-russet crack-internal cork and *Fusarium oxysporum*.

The high incidence of bacterial diseases in cassava is due nearly exclusively to *Xanthomonas manihotis* which is the most important pathogen of this crop. The African mosaic virus complex is the next most important cassava disease.

The highest number of pathogens has been recorded for potato. By far the most important one is *Phytophthora infestans*, followed by *Erwinia carotovora*, virus X, virus Y, virus leafroll, *Synchytrium endobioticum* and *Rhizoctonia solani*.

The paramount importance of vegetative propagation for the high PI values of tuber crops is underlined by the fact that nearly all the pathogens mentioned are transmitted by the planting material. This should encourage the attempts to shift from vegetative to seed propagation, as has been initiated recently with potato (Accatino and Malagamba, 1982) and yams (Okoli, 1981).

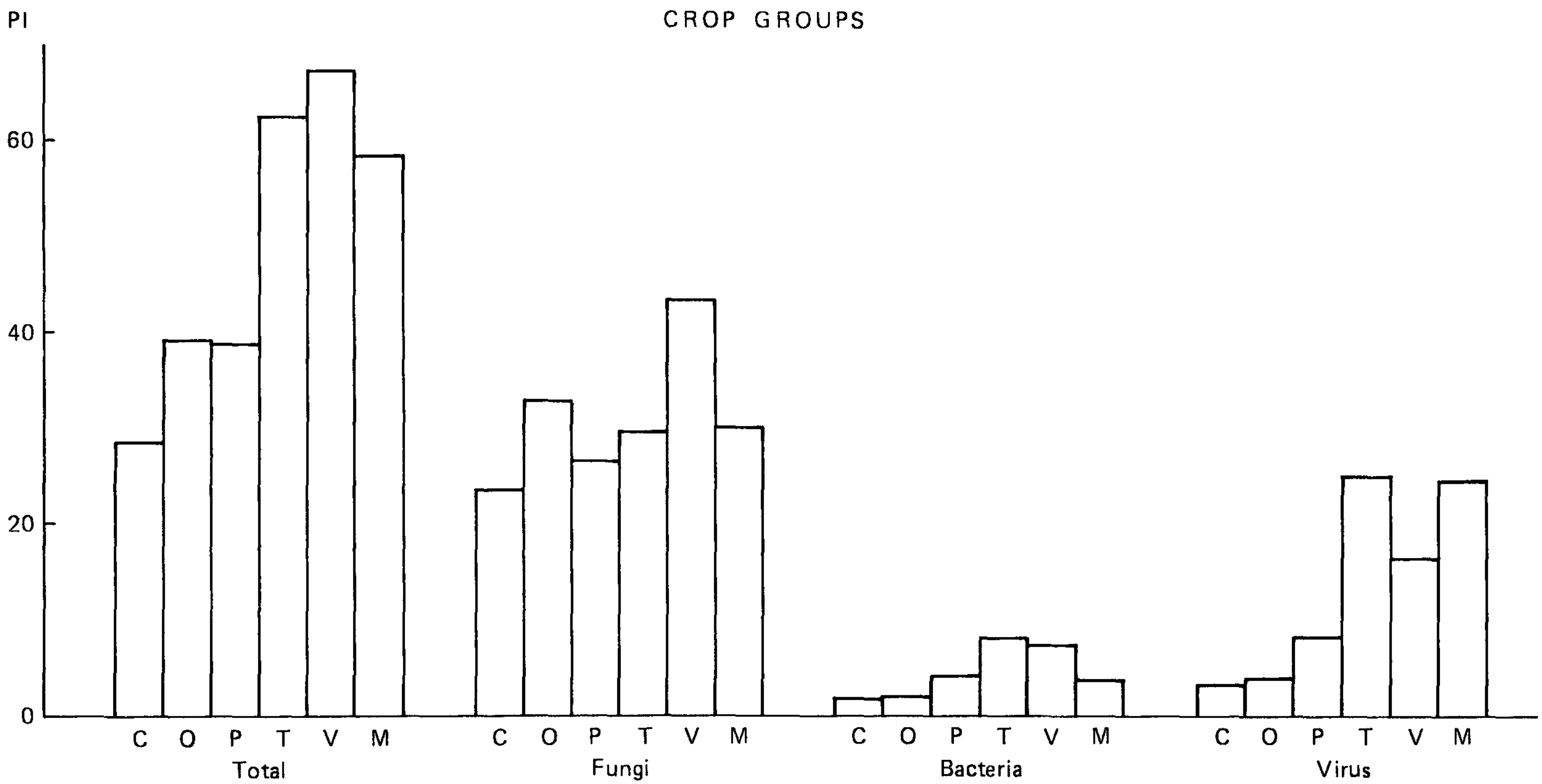

Figure 2. Average Pathological Indices of cereals (C), oil and fibre crops (O), pulses (P), tuber crops (T), vegetables and fruits (V) and miscellaneous crops (M).

Conclusions

The Pathological Index and the Pathological Profile, introduced here, give a new insight into the disease problems of a species. This may pave the way towards a Comparative Pathology of crops, which can help to identify weak points of a crop species or crop group, and to develop a strategy in order to overcome these problems. In the case of tuber crops as a whole, the impact of diseases, as reflected in the high PI values, at least partly accounts for their inferior role in world agriculture as compared to cereals, which probably have a lower production potential than tubers, but are less affected by diseases.

Literature

Accatino, P. and P. Malagamba. 1982. Potato production from true seed. International Potato Center. Lima, Peru.

Heitefuss, R. 1975. Pflanzenschutz. Grundlagen der praktischen Phytomedizin. Georg Thieme Verlag, Stuttgart.

Levin, D.A. 1975. Pest pressure and recombination systems in plants. The American Naturalist 109, 437-451.

Martin, W.J., R. Barrow, R. Galichet, E. Iton, E. Jones, J. Mills, S. Parasram, R. Pierre, and E.E. Trujillo. 1967. Identification of areas needing further elucidation in disease occurrence on tropical root crops. Proc. Intern. Symp. Trop. Root Crops, St. Augustine, Trinidad, 2-8 April, 1967. Pp XII-XIII.

Okoli, O.O. 1981. Parameters for selecting parents for yam hybridization. In: E.R. Terry, K.A. Oduro, and F. Caveness (eds.): Tropical root crops: research strategies for the 1980s. International Development Research Centre, Ottawa. Pp. 163-165.

Plant Breeding Abstracts, vols. 46-50 (1976-1980).

Review of Plant Pathology, vols. 55-59 (1976-1980).