CROPPING PATTERN AND SOIL MANAGEMENT INFLUENCE ON PLANT DISEASES: II. BEAN RUST EPIDEMIOLOGY[1]

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Resumen

La roya del frijol causada por Uromyces appendiculatus *(Pers.) Ung. afectó un mayor número de hojas (incidencia) y una mayor área foliar (severidad) en plantas de frijol (*Phaseolus vulgaris *L.) cultivadas en forma individual que en plantas de frijol asociado con maiz. Los valores promedio de la proporción de incremento diario de la incidencia y la severidad de la roya durante el total del periodo experimental siempre fueron más altos en el frijol en monocultivo que en el frijol cultivado en asocio con maiz. Al comienzo de la epidemia, se registraron diferencias entre la cantidad de roya que mostraban plantas de frijol que se habían cultivado con diferentes prácticas de manejo del suelo. Así, se produjo más roya en aquellos tratamientos del suelo que consistían en la eliminación de los residuos de la cosecha anterior y su posterior arada y pases de rotador que en aquellos tratamientos que consistían en labranza reducida o cero labranza.*

Introduction

Maize (*Zea mays* L.) and common beans (*Phaseolus vulgaris* L.) are important crop components in agroecosystems managed by Latin American small farmers. Different types of maize and beans are combined in cropping patterns such as association, relay cropping and double cropping. These cropping patterns are managed according to the ecological and socio-economic environment in which they are cultivated. Approximately 90% of beans in Colombia, 80% in Brazil, 73% in Guatemala and 40% in Mexico are produced in association mainly with maize (6). In spite of the importance of the maize-bean association only in recent years has information on this crop combination become available (2, 3, 4).

One of the advantages frequently pointed out to account for the popularity of maize-bean combination among small farmers is a possible reduction of the incidence and severity of diseases in this and several other crop combinations, as compared to monoculture (11), although the opposite has been reported (10).

Small farmers practise several methods of soil preparation for cultivation of maize and beans, ranging from conventional mechanical plowing to several types of minimum and no-tillage practices. The influence of soil management, particularly practices including crop residues such as mulch, on the onset of epidemics and further spread of plant pathogens has not been sufficiently studied under tropical conditions. A more uniform temperature and more diverse soil microflora than in temperate climates are factors frequently cited as influencing rapid degradation of crop residues and consequently reducing the availability of primary inoculum in the tropics (5).

Bean rust caused by *Uromyces appendiculatus* (Pers.) Ung. is an important air-borne bean pathogen that might limit production when virulent races of the fungus, susceptible cultivars of the host and favorable environment for disease development coincide.

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This research was conducted to quantify incidence and severity of bean rust in common beans in monoculture and associated with maize under four different soil management regimes.

Material and methods

A description of the treatments and sub-treatments; experimental design; crop varieties planted, plot size, fertilization and weed management of the field experiment from where data on bean rust epidemic were obtained was included in a previous paper (9).

Data on incidence (I) and severity (S) of bean rust were recorded weekly for five weeks beginning 61 days after planting. The concepts of I (number of leaves affected) and S (leaf area affected) are used as defined by James and Shih (7). Eighteen randomly selected bean plants from the center of each 48 m^2 plot were marked and used for each sampling period. Each bean plant was divided in four quadrants and data were always recorded from the same quarter of the plant. Each trifoliate leaf was considered for I values but S were recorded from only the center leaflet. A severity scale was used. The severity scale was calculated by measuring affected area with a planimeter.

To calculate I and S the following formulae were used:

$$I = \frac{t\,n\,i}{t\,n\,e}$$

$$S = \frac{0.01\,(n_1) + 0.05\,(n_2) + 0.1\,(n_3) + 0.2\,(n_4) + 0.5\,(n_5)}{t\,n\,e}$$

where:

t n i = total number of leaves affected

t n e = total number of leaves

$n_1 \ldots n_5$ = number of leaves with 0.01 . . . 0.5 of the leaf area affected.

The Van der Plank (12) formulae were used to calculate the rates of increase (r) of I and S.

Average values of I and S were used to calculate the general development of the bean rust epidemic. Transformation of data (arcsin $\sqrt{x}$) were used for calculations but percentages are used in tables. Significant differences ($P \leq 0.05$) were determined for I and S values using the least significant difference (LSD) test.

Meteorological data were obtained from hygrothermograph and rain gauge located at the center of the experimental field.

Results and discussion

In all treatments I and S values were significantly and positively correlated (R = 0.94). I and S of bean rust were positively correlated with oscillations (amplitude and frequency) of above average relative humidity (89.3%) during the experimental period. This indicated a more effective dissemination, penetration and development of pustules in conditions of high relative humidity as previously reported for this host-pathogen relationship (13). Crop age was positively correlated with high values of I and S. Possible explanations of this relationship are: increased host susceptibility with age, abundant secondary inoculum in later stages of plant development, more leaf area available for spore landing, a microenvironment favorable for plant infection or a combination of the above factors.

Uredosori were first seen 45 days after planting. During the first sampling (61 days after planting), a relatively high average value (24.3%) was registered for I, while S was only 0.6% (Table 1). Primary inoculum was probably abundant, penetrating several points but lesion size increase was slow. The epidemic increased for 66 days after planting, but there was a decrease in both I and S values after 73 days due to either a rapid increase in leaf area or to microenvironmental conditions not favorable for disease development or to both. Maximum I (82.8%) and maximum S (8.9%) occurred 79 days after planting. A slight decrease in disease amount was registered after 86 days due to a reduction of the total number of leaves in the plots that were more affected during the earlier stages of the disease development. Average daily rate of increase of I was relatively slow (r = 0.119) but S increased at a slower rate (r = 0.077).

INFLUENCE OF CROPPING PATTERN ON BEAN RUST EPIDEMIC

Rust pustules were observed 45 days after planting beans in monoculture and after 50 days in beans cultivated in association with maize.

Throughout the growing season the number of leaves and the leaf area affected by bean rust was higher in the monoculture than in the association. The analysis of variance of the I and S data from the five sampling periods indicated a statistically significant difference (0.05) between these cropping patterns (Table 1). Considering sampling periods individually, the values of I and S were significantly different between cropping patterns only after 61 and 66 days (Table 2). Inoculum dispersal across plots under different treatments or differences in leaf areas available for infection in later stages of the epidemic probably accounted for the lack of significance in the last three sampling periods

Table 1. Average values of incidence and severity of bean rust under four different soil managements, two bean cropping patterns, and five sampling periods. Turrialba, Costa Rica.

	Soil Managements[1]				Cropping Patterns[2]		Sampling periods[3]					Daily[4] rate of increase (r)
	CT	MT-1	MT-2	OT	B	B+M	61	66	73	79	88	
Incidence	64 5a[5]	56 6b	61 6a	57 3a	63 2a	56.8b	24.3b	64 3a	55.5ab	82 8a	73 3a	0 119
Severity	5 6a	3 9b	5 0a	3 9b	5 6a	3 8b	0 6a	3 9b	2 9b	8.9d	6 7c	0.077

1 CT = Conventional tillage; MT-1 = Minimum tillage-1; MT-2 = Minimum tillage-2; OT = No tillage.

2 B = Bean monoculture; B + M = Beans-maize association.

3 Days after planting.

4 r = Average daily rate of increase.

5 Figures followed by the same letters do not differ statistically to the least significant difference test, (LSD 0.05)

Table 2. Average values of incidence (I) and severity (S) of bean rust during five sampling periods, two bean cropping patterns and four soil managements. Turrialba, Costa Rica.

	Sampling periods (days after planting)									
	61		66		73		79		88	
	I	S	I	S	I	S	I	S	I	S
Cropping patterns										
Beans in monoculture	27.4a[1]	0 8a	70 6a	5 1a	57 6	3 1	86 2	11 6	74 9	7 5
Beans-maize association	21 2b	0 4b	57 9b	2 7b	53 4	2 7	79 8	6 2	71 8	6 0
Soil managements										
Conventional tillage	35 3a	1 0a	67 2	5 0	69 7	3 9a	88.9	12 4a	67 6	5 5b
Minimum tillage-1	19 7c	0.4c	62 8	4 0a	55 6	2.9b	83 9	7 2b	61 2	4 9b
Minimum tillage-2	23 3b	0 7b	68 4	4 1a	52 6	2.9b	85 1	10 2a	79 0	7 6ab
No tillage	19 0c	0 4c	58.5	2.4b	50 0	2.0c	74 1	5 7b	85 8	8.9a

1 Figures followed by the same letters do not differ significantly according to the least significant difference test, LSD (0.05)

Values of daily rate of increase in both I and S of bean rust between sampling periods and average daily rate of increase for the whole experimental period were always higher in bean monoculture than in beans cultivated in association with maize. The physical barrier imposed by the dominant component (maize) of the association probably slowed dispersion of wind borne rust spores. A loss of dispersing uredospores through their settling on the nonhost component of the intercrop (fly-paper effect) also has been suggested as the mechanism responsible for the slower increase of diseases in intercropping systems (8). Induced resistance has been suggested as another cause that retards the development of legume rusts in legume-cereal association. According to Allen (1) sporulation of bean rust can be delayed and reduced by inoculating beans with a mixture of maize rusts (*Puccinia sorghi* and *P. polysora*). Total biomass production of beans cultivated in simultaneous mixture with maize is usually less than the total biomass in monoculture (11), consequently there is probably a reduction in available leaf area for rust infection in the legumes intercropped as compared to legumes planted alone. Finally, the microenvironment created in the vecinity of bean plants by the dominant species (maize) may not favor the development of the disease and further spread of the pathogen.

It is more likely that several of these factors are acting together either simultaneously or sequentially.

Table 3. Daily rate of increase[1] of Incidence and Severity of bean rust in two bean cropping patterns and four different soil preparation practices. Turrialba, Costa Rica.

	Incidence	Severity
Cropping patterns		
Beans monoculture	0.123	0.069
Beans-maize association	0.115	0.068
Soil preparation practices		
Conventional tillage	0.107	0.054
Minimum tillage-1	0.098	0.049
Minimum tillage-2	0.139	0.081
No tillage	0.155	0.090

1 According to Van der Plank (12)

INFLUENCE OF SOIL MANAGEMENT ON BEAN RUST EPIDEMIC

Soil management practices influenced both I and S of bean rust, particularly at the onset of the epidemic, as shown at the first sampling period when more leaves were infected in the CT treatment (I = 35%) as compared to OT (I = 19%), MT–1 (I = 20%), and MT–2 (I = 23%) treatments. No statistically significant (0.05) difference in rust severity in beans cultivated under different soil management practices was registered throughout the whole period.

During the first four sampling periods, higher S values were registered for the CT treatment than for the reduced tillage treatments, while treatment OT always registered the lowest I and S values. During the final sampling period, early defoliation of bean plants under the CT treatment accounted for a decrease in I and S values. The continued increase in I and S values in treatment OT through this last sampling period may be explained by the fact that in this treatment, maize stalks from the previous crop provided a firm support for a vigorous growth, and leaf area duration was longer than average.

Mulch influences the development of bean rust epidemics either by reducing the impact of rain drops and subsequent splash of primary or secondary inoculum or by providing microclimatic conditions unfavorable to the further spread of rust spores.

Summary

The number of leaves (incidence) and the leaf area affected (severity) by bean rust (*Uromyces appendiculatus* (Pers.) Ung.) was higher in common bean (*Phaseolus vulgaris* L.) monoculture than in bean cultivated in association with maize. Average values of daily rate of increase of both incidence and severity of bean rust for the whole experimental period were always higher in bean monoculture than in bean cultivated in association with maize. Soil management influenced both incidence and severity of bean rust, particularly at the onset of the epidemic. More beans were infected in soil preparation treatments with mechanical plowing and rototilling than with the minimum tillage and no-tillage practices.

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Reseña de libros

HAGIN, J. y TUCKER, B. Fertilization of dryland and irrigated soils. Advances Series in Agricultural Sciences 12. Springer-Verlag Berlin, Heidelberg New York 1982, 188 p.

A pesar que la fertilización de los cultivos tiene una serie de características de manejo muy parecidos, estas prácticas generalizadas se pueden apartar cuando se trata de fertilización de cultivos creciendo en suelos bajo condiciones áridas y semiáridas bajo irrigación, donde la evapotranspiración excede la precipitación y de gran importancia actual y futura en la producción de alimentos en el mundo.

Bajo condiciones de stress de agua, que es una de las características principales de las regiones áridas y semiáridas; el manejo del uso racional de los fertilizantes, se ve afectado por esas condiciones especiales de poca disponibilidad de agua por los cultivos.

Hagin y Tucker los autores, con sus experiencias en el manejo de suelos áridos y semiáridos nos dan un excelente libro de texto de la famosa serie Advances Series in Agricultural Sciences (No. 12) Springer-Verlag Berlin Heidelberg New York. En este título ellos recopilan y nos dan un conjunto de conocimientos, para el estudio y manejo del uso racional de los fertilizantes bajo condiciones áridas y semiáridas del mundo.

El libro consta de 7 capítulos con 188 páginas e incluye 64 figuras. El capítulo 1 es una excelente introducción sobre el tema del título del libro, donde no sólo nos describe las áreas semiáridas y áridas del mundo, sino que también, toma en consideración los sistemas de producción agrícolas existentes en dichas regiones. Se incluye en este capítulo los conceptos básicos de la irrigación, relacionados con los nuevos problemas y ventajas que le ocurren a un suelo árido y semiárido cuando es irrigado y los cambios en el paso de un uso extensivo a un uso intensivo. Todo lo anterior trae consigo cambios en las prácticas de fertilización ocasionados con los cambios en el manejo de los sistemas de cultivos que se intensifican cuando las antiguas tierras secas se transforman en área de irrigación.

Los capítulos 2, 3, 4 y 5 nos aportan un conocimiento del porqué de la fertilización con Nitrógeno, Fósforo, Potasio, elementos secundarios y menores y su importancia en la agricultura de zonas áridas y semiáridas. Se discuten en cada uno de estos capítulos los factores que afectan la disponibilidad de esos nutrimentos por los cultivos, con el fin de aportar información para que el lector pueda seleccionar la mejor dósis, la mejor forma de aplicación y la mejor fuente del fertilizante. Se discuten además, las características de las diferentes fuentes de los fertilizantes nitrogenados, fosfóricos, potásicos y de los elementos menores y secundarios con especial énfasis en sus diferentes formas y/o cambios que ocurren en el suelo cuando se aplican a los cultivos.

El capítulo 6 sintetiza información presentada en los capítulos previos, pero expuesta en forma tal que da información práctica sobre el uso racional de fertilizantes con multinutrientes y sus características para sus formas sólidas y liquidas en la agricultura. Además, el lector se puede enterar de las modernas técnicas de aplicar los fertilizantes en el agua de riego y también la modalidad de la fertilización foliar y sus implicaciones para el futuro.

En vista que la mayoría de los suelos de las regiones áridas y semiáridas son suelos salinos y alcalinos, en el capítulo 6 se incluyen los especiales de fertilizantes a emplear en este tipo de suelos, que esté acorde con esas condiciones especiales de suelos.

El capítulo 7 es el más importante desde el punto de vista práctico, ya que nos explica las diferentes técnicas a utilizar, de cómo hacer las recomendaciones de fertilizantes, y nos da diferentes métodos para evaluar y diagnosticar deficiencias nutricionales y la disponibilidad de nutrimentos por los suelos. En este último tópico se hace énfasis en evaluar la fertilidad de suelos, por medio del uso de los análisis de suelos, tomando en consideración los aspectos más importantes, la calibración del análisis de los suelos y su interpretación. El libro termina con una reseña donde explica la manera práctica de evaluar el retorno económico del uso racional de los fertilizantes.

Como Profesor de Fertilidad de Suelos a nivel de pregrado y posgrado, recomiendo a mis estudiantes este texto como libro de consulta y mi recomendación puede ser extensiva para estudiantes que reciban otros cursos afines.

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