Black pepper yield prediction for the Transamazon Highway of Brazil*1/

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COMPENDIO

Se predicen los rendimientos que se esperan de la pimienta negra (Piper nigrum) *que se está plantando por los colonos cerca de Altamira a lo largo de la Carretera Transamazónica del Brasil, basándose en las relaciones entre rendimiento de la pimienta, y la fertilidad del suelo y el efecto del hongo* Fusarium solani *f.* piperi. *Esto, combinado con información sobre la calidad del suelo en la zona, los efectos de la fertilización y otros factores sobre la fertilidad del suelo, y la probabilidad de que los colonos usen fertilizantes, permite la construcción de una simulación de computadora de los rendimientos de pimienta en la zona. La simulación del rendimiento es una parte de un esfuerzo más grande de aplicación de modelos dirigido a estimar la capacidad del área en estudio para sustentar poblaciones humanas. El alto costo de los fertilizantes, unido a la baja prioridad asignada a la fertilización por los colonos, hace improbable el alcanzar las predicciones oficiales de rendimientos. La expansión actual de la enfermedad causada por* Fusarium *hace sumamente remota la posibilidad de obtener rendimientos sostenidos de pimienta negra.*

Introduction

BLACK pepper *(Piper nigrum* L.) has assumed a central place in government plans for encouraging perennial crops among colonists of the Transamazon Highway (2). Pepper, along with cacao, is one of the only crops for which the potential yields have a sufficiently high market value to justify the extremely high cost of fertilizer in the Amazon (1). Because of this, it is the focus of a major part of the extension efforts of EMBRATER (Brazilian Enterprise for Technical Assistance and Rural Extension, formerly ACAR-PARÁ: Association for Credit and Rural Assistance of Pará) in the Altamira Colonization Area. Unfortunately, black pepper is doomed as a long-term mainstay of colonist cash cropping due to its susceptibility to a number of devastating diseases. This will be documented in the discussion of black pepper diseases included in this paper.

Despite the higly probable demise of pepper growing in the Transamazon area, it is important to develop a model for predicting pepper yields for two reasons: a) black pepper is currently being planted by many colonists and therefore has been included in a computer simulation aimed at producing estimates of human carrying capacities for the area under a variety of assupmtions (9, 10), and b) great emphasis is being placed on pepper by agricultural planners and extension personnel as a means of obtaining high yields on poor soils.

Predicting pepper yields from soil fertility

Pepper is recognized as being highly demanding of fertile soil. Even in fertile areas it is necessary to use fertilizers two or three years after planting (8). Soil pH must be maintained in the range of 5.5 to 6.5 through liming if good yields are to be expected (6, p. 98).

Not enough pepper plantations were producing yet at mature plant levels during the principal period of fieldwork for this study (1974-1976) to be able to predict yields from soil samples and field data on actual colonist yields. Recourse had to be made to

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data available in the literature Such a relationship between pepper yield and soil fertility, when combined with the information obtained from field sampling on the Transamazon Highway on initial soil quality, soil fertility changes, land use allocation behavior, etc (10), allows the simulation of pepper production in the area.

No published study exists providing the necessary equations for making quantitative predictions of pepper yields based on the levels of soil nutrients, but such equations can be derived using published data on pepper fertilizer trials in Belém. The data come from a report by the Albuquerque and Condurú (6, p. 110) giving three years of field data for seven different combinations of fertilizers plus an unfertilized control. The yields had to be estimated from a bar graph of the results. The levels of the soil nutrients had to be estimated in a rather indirect way, since this information was apparently not gathered in the experiment. The soil nutrient levels in the control plot can be estimated from the nutrient levels in the control plot in another experiment which was being conducted at the same time on the same soil type in another part of IPEAN (Institute for Agriculture and Cattle Ranching Research of the North, now CPATU: Center for Research on Agriculture and Cattle Ranching in the Humid Tropics) compound in Belém. The control plot in this experiment (14, p 10) had a pH of 4 7, aluminum (Al^{+++}) of 1 2 meq/100 g, carbon of 0.94%, nitrogen of 0 07%, and exchangeable phosphorus of 4 ppm. The nutrient levels in the fertilized plots must also be deduced from nutrient levels in fertilized plots in other IPEAN experiments which received the same dosages One can be fairly safe in assuming that pH in the limed plots (444 kg/ha lime) was over the black pepper critical value of 5 5 (6, p 98), since limed plots in the other experiments exceeded this value (14, Fig. 6) Phosphorus in the fertilized (333 kg/ha phosphorus) plots was assumed to have a value of 10 ppm, since similarly fertilized plots in the other experiments (14, Fig 6) climbed at least to this level and 10 ppm is considered as a dividing line between low and high fertility for pepper by CPATU when making fertilization recommendations for farmers (3). A value of 2 0 per cent was estimated for the carbon level in the plots receiving manure, since large (2222 kg/ha) dressings of manure were applied and the initial carbon level of 0 94 per cent is relatively high Using an estimate of 2 per cent for the critical level of carbon above which no further response would occur in pepper is safely above the critical levels for most crops: the Brazilian Soil Testing Service for Minas Gerais, cited by the North Carolina State University Soil Science Department (13, p 149), classifies soils as high in organic matter if this exceeds 1.5 per cent (corresponding to a carbon level of about 0.87 per cent), and general references on Brazilian soil fertility evaluation classify soils as "high" in carbon if carbon levels exceed 1.2 per cent (4, p. 33). Pepper requirements are probably higher than most crops judging from the good responses to manuring obtained. A critical value for carbon as high as 2 per cent therefore seems prudent. Unfortunately, nitrogen and potassium effects could not be separated from phosphorus since all three of these elements were supplied together in the same proportions of NPK fertilizer in all of the plots receiving chemical fertilizer It was decided arbitrarily to use phosphorus of these three fertility indicators

The appropriate soil nutrient estimates were assigned to the plots reveiving the various combinations of lime, manure, and NPK fertilizer, yields were expressed as proportions of the maximum yield for the appropriate year in order to minimize year effects from weather and plant age, and a multiple regression was performed on the resulting 24 data points. A highly significant regression ($P<0.0001$) was obtained explaining 74 per cent of the variance in the pepper yields. The regression is summarized in Table 1, and the observed and predicted pepper yields, expressed as proportions of the maximum yield, are plotted in Figure 1 The result that higher yields are obtained with increasing soil fertility is nothing new, but the ability to predict pepper yields in a quantitative manner based on soil fertility is.

The yield results produced by the regression in Table 1 have to be scaled to reflect the maximum (fertilized) yields expected under the conditions of the Transamazon Highway. The official estimate for "mean" yield of mature fertilized pepper at the three meter by three meter spacing used in the Belém experiments (which is also the most common spacing on the Transamazon Highway) is 5500 kg/ha (8, p 26) It should be noted that this figure is fairly optimistic given that the highest yield obtained in the completely fertilized plot during the three years of observation in Belém corresponds to only 3913 kg/ha,

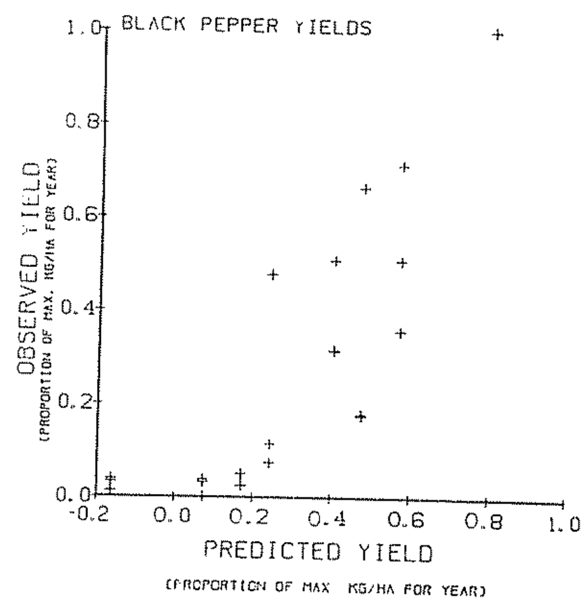

Fig 1 —*Observed vs predicted black pepper yields from soil fertility values.*

Table 1.—Multiple regression of black pepper yields on soil fertility

Regression	Y = −2.119	+ 0.292 A	+ 0.382 B	− 0.0552 C
Standard Errors	0.506	0.0952	0.0719	0.0127
t statistics	−4.185	3.065	5.320	4.351
Significance	<0.001	<0.01	<0.0001	<0.001
Partial Correlations		0.565	0.765	0.697
	R^2 = 0.74		F statistic = 18.88	
	N = 24		Multiple R = 0.86	
	P < 0.0001		Standard error = 0.187	

Abbreviations: Y = Pepper Yield (proportion of maximum yield for year)
A = pH
B = carbon (% dry weight)
C = phosphorus (ppm)

and the mean yield for the three years corresponds to 3592 kg/ha (6, p. 110), or 65 per cent of the official figure. The figure based on actual data of 3592 kg/ha for mean annual pepper yield under ideal conditions, with a standard deviation of 517 kg/ha, probably represents a more realistic value both for the average fertilized yield and the variability that can be expected from year to year. The critical importance of variability in yields has been emphasized throughout the carrying capacity modeling effort (9, 10).

Fertilization of black pepper

Probability of Fertilization

All government plans for pepper development assume that colonists will follow the advice of extension agents and fertilize their pepper plantations. Each colonist that receives financing for pepper also receives a schedule for fertilizer applications based on the results of a soil sample which must be submitted as a precondition for financing. Alvim (1) points out that fertilizing pepper always pays and that some pepper growers in Amazonia use almost double the officially recommended fertilizer dressings on their own initiative. This is undoubtedly true, but I would hazard the guess that the farmers Alvim was referring to were Japanese in origin. The same cultural differences which lead to markedly different behavior with respect to the use of fertilizer between Japanese and non-Japanese colonists in the case of cacao (11) also applies to pepper. Of seven colonists with pepper planted as of 1976 in the 177 colonist sample for the carrying capacity study, the only colonists I know of using any fertilizer were the two Japanese in the sample. Several of the non-Japanese colonists expressed the opinion that no fertilzation would be necessary, and that they did not intend to use fertilizers in the future. There were some cases of non-Japanese colonists acquiring fertilizer through bank credit and then re-selling it to Japanese colonists rather than using it on their own pepper. One colonist had several bags of financed fertilizer in a shed on his lot and had never bothered to put any on his pepper! In addition to the low priority placed on fertilizers, there was a notable lack of planning among colonists planting pepper as to where the money would come from which would be needed for the expensive fertilizer and chemical treatments recommended for this crop. Rather than plant a small area that could be maintained with the colonist's limited resources, he would plan on as large an area as possible.

In view of these facts, it is clear that the probability that a given colonist will fertilize his pepper is far less than the government-assumed probability of one. Both the assumed probability of one and more realistic values less than this can be used in runs of the carrying capacity simulation models to gauge the effects on pepper yields and on carrying capacity.

Soil Changes from Pepper Fertilization

The fertilizer dosage schedules which the colonists receive from EMBRATER at the time of financing are based on calculations made by the personnel in the CPATU soils laboratory in Belém based on the scheme presented in Table 2.

Equations have been developed for predicting the changes in soil nutrient levels per kilogram of fertilizer active ingredient applied (9, p. 548-558). These have been used in the carrying capacity simulation models to predict soil changes under fertilized pepper using the dosages given in Table 2. Equations representing

Table 2.—Government fertilizer recomendations for pepper

Initial Soil Analysis	Fertilizer Active Ingredient	Kg/ha active ingredient — pepper age (years) 1	2	3	4 or more
P $\leq$ 10 ppm	P_2O_5	70	100	150	300
P $\geq$ 10 ppm	P_2O_5	30	40	50	100
K $\leq$ 45 ppm	K_2O	60	80	100	200
K > 45 ppm	K_2O	0	0	25	50
N all levels	N	40	60	80	100
C all levels	Cotton cake*	2222	2222	2222	2222
$Al^{+++} \leq$ 0.3 meq/100 g and: Ca^{++} & Mg^{++} > 4 meq/100 g	dolomitic lime	0	0	140	280
$Al^{+++} \leq$ 0.3 meq/100 g and: Ca^{++} & Mg^{++} $\leq$ 4 meq/100 g	dolomitic lime	122	140	280	560
Al^{+++} > 0.3 meq/100 g	dolomitic lime	**	0	0	0

SOURCE: Brasil, Ministério de Agricultura, IPEAN (3)

* 5.71 kg manure is equivalent to 1 kg cotton cake (6, p. 110)

** 2000 kg/ha lime per unit of Al^{+++} expressed in meq/100 g

other soil changes under pepper, such as those resulting from erosion and from the combined effects of uptake and leaching are also derived and included in the simulation models (9, 10).

Pepper diseases

Disease susceptibilities

The ultimate fate of black pepper plantations on the Transamazon Highway appears to hinge on the susceptibility of pepper to a wide variety of diseases rather than the problems associated with the financial and cultural impediments to maintaining soil fertility with expensive fertilizers. All of the black pepper in the Brazilian Amazon comes from only two clones (5) and one of these accounts for most of it (8). Since the pepper is propagated from cuttings rather the seeds, all of the plants are genetically identical and all equally susceptible to the many different diseases which attack it. Despite continuous efforts since the late 1960's to breed a variety resistant to the main killer, the fungus *Fusarium solani* f. *piperi*, no such variety has been found to date.

No less than twelve different diseases are described in the EMBRATER manual on pepper growing (8). Two of these, *Fusarium* and the cucumber mosaic virus, have been increasing in frequency dramatically in Pará in recent years (6). *Fusarium* was first reported in 1960 (7) and the cucumber mosaic virus began in 1967. Both of these diseases lead inexorably to the death of the pepper plants. Chemical treatments can slow the progress of attack, but cannot stop it completely. Of all the pepper diseases it is *Fusarium* which has caused the most damage, and only this has been included in the carrying capacity simulation models for the Transamazon Highway study.

Modeling Fusarium Attack

The devastating power of the *Fusarium* fungus is immediately apparent to any visitor to Tomé-Açu, Pará, the Japanese colony where black pepper was first introduced from Singapore in 1933 (8), and where *Fusarium* got its start in Brazil in 1960 (7). When I visited Tomé-Açu in 1975 the area looked like nothing so much as a gigantic graveyard, with the bare posts on which the pepper had grown stretching out to the horizon. Some colonists had planted other crops such as pasture, cacao, passion fruit, or manioc in the devastated fields. Others on the edges of the pepper growing area were still trying to replace the pepper plants as they died and hoping for a couple of years of production before the disease ran its course again.

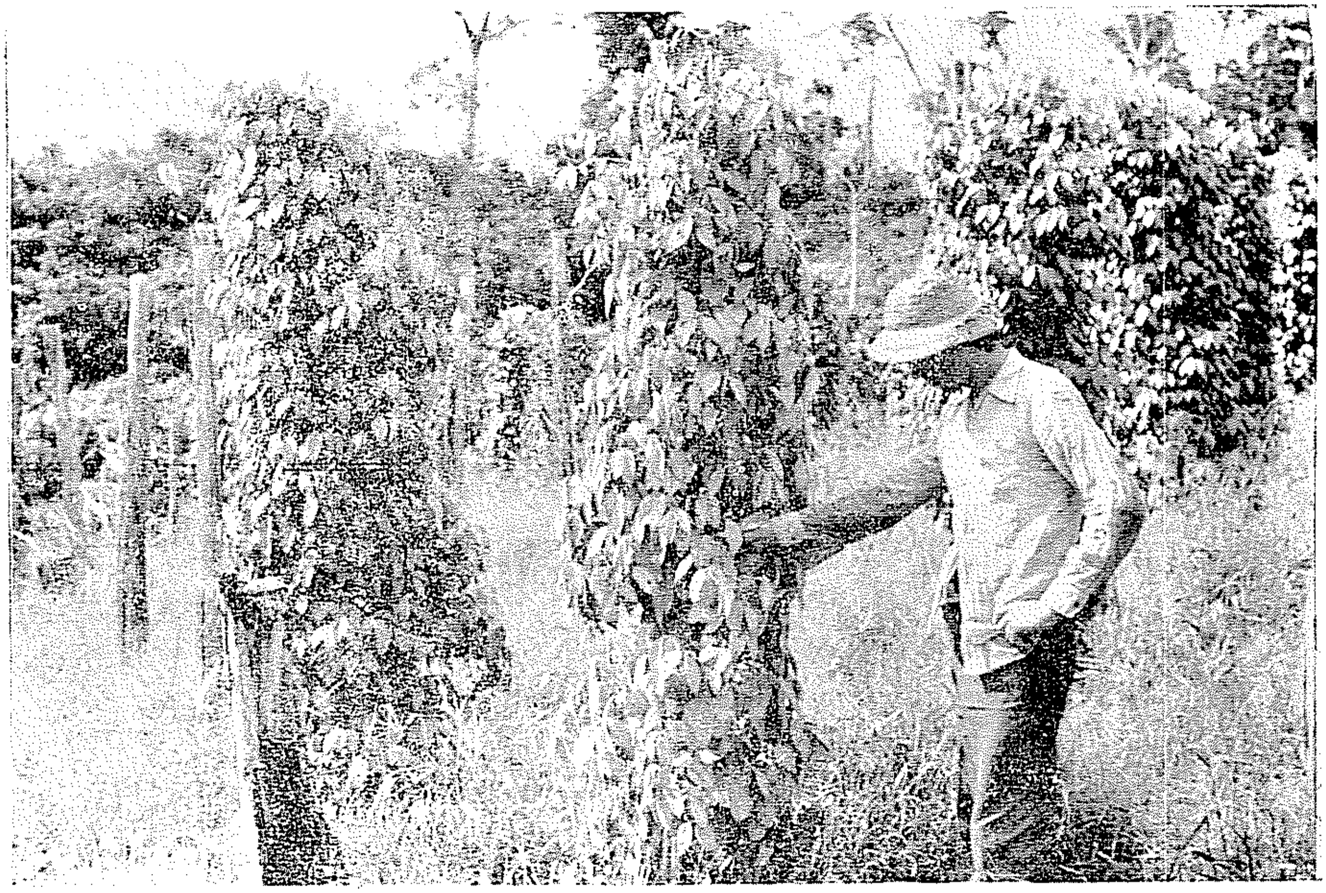

Fig. 2 —*Black pepper showing symptoms of* Fusarium *attack. Note the empty posts in the background where plants have died. This February 1975 photograph documents the arrival of the fungus in the Altamira Colonization Area (Gleba 15, Lot 28). There is no effective chemical treatment and no resistant pepper varieties exist to date.*

Colonists told of the losing battle that had been fought using fungicides, with several farmers suffering from chemical poisoning in the process.

Fusarium has now spread to other areas in Pará. The plantations near Castanhal on the Belém-Brasília Highway were dead or moribund, and the disease tapered off in intensity with distance from this center in the newer areas between the Belém-Brasília and Bragança when I visited these areas in late 1975. On the Transamazon Hihway a demostration pepper plot at a SAGRI (Pará State Agriculture Secretariat) agricultural station 35 km from Marabá had already lost ten of its 700 two-year-old pepper plants at the time of my first visit to the station in 1975, with many more plants moribund but not yet dead. In the Altamira Colonization Area 500 km further to the west, I found the first case of *Fusarium* attack within the colonization area (where the first pepper was planted in 1971) in February 1975. This is shown in Figure 2. An older plantation located outside of the colonization area on the outskirts of the town of Altamira had already had *Fusarium*-attacked plants for about two years previous to this. During 1975 and 1976 the disease spread in the infected pepper in the colonist's lot, destroying about half of his plants by May 1976. Between 1976 and 1978 the disease appeared in many other lots, as would be expected given the quick dispersal of the durable wind-dispersed *Fusarium* spores.

If *Fusarium* attack is to be modeled, probabilities must be estimated for: 1) the entry of the disease into a virgin area in any given year, 2) the attack of any given patch of healthy pepper within the area in any given year given that the disease has already entered the area, 3) the death of a patch of pepper in a given year given that it is diseased, and 4) the availability o fa new resistant variety given that the resistance of the current variety has been broken. The proportion of the healthy plant production expected from diseased plants must also be estimated.

The first of these probabilities —the probability of entry into a virgin area— can be estimated from the times needed for entry in the cases already discussed. The two year time in Marabá and the four year time in Altamira give a mean time to first appearance of three years. From this one can calculate the yearly probability from Equation 1 (11).

$$P = 1 - 0.5^{1/t} \quad \text{[Equation 1]}$$

Where:

P = the yearly probability of the disease entering a virgen area

t = the average number of years needed for the disease to make its first appearance

Te second probability, the probability that a given patch is attacked given that the disease has entered the area, will vary with how many other patches of pepper have been attacked. The average time for any given patch to be attacked throughout the course of a *Fusarium* epidemic must be very short. An estimate of two years seems reasonable given the quick dispersal of the disease, especially in the later years of an epidemic as in the plantations of Tomé-Açu and Castanhal.

The third probability, the probability of killing a patch given that it is diseased, also varies with time. Colonists interviewed in Tomé-Açu said that the time needed for *Fusarium* to kill a pepper patch has declined steadily since the disease first entered has area Judging from the speed with which the disease has spread in the infected lot in Altamira an estimate of three years seems within reason

The probability of a new disease-resistant variety becoming available seems very small indeed, given the difficulties in breeding pepper, the lack of success so far, and the number of other diseases that could easily kill pepper plants even if a *Fusarium*-resistant variety were found. The problem of disease organisms overcoming varietal resistance discussed with reference to witches' broom disease in cacao (11) also applies to the diseases attacking pepper.

The proportion of full production obtainable from diseased plants can be estimated to be approximately equal to 0.5, if one assumes that the pepper plants in a patch are killed at a constant rate during the course of an attack, and that the individual pepper plants die instantaneously. Actually the disease probably begins slowly at first, then spreads exponentially through the patch, and then approaches complete destruction asymptotically. This would give much the same result.

The estimated parameters for *Fusarium* attack are summarized in Table 3 These probabilities have been incorporated at decision points in the carrying capacity simulation models in the subroutine dealing with crop disease.

Age effects on pepper yields

In the years before a pepper plant reaches its full levels of production, a predictable fraction of the mature level of production can be expected. The values for age effects used in the simulation models have been calculated from the official production expectations given by de Albuquerque *et al.* (8, p. 26). Expressed as the proportion of the maximum (mature) yield expected, the values are 0.00, 0.40, 0.80, and 1.00 for years 1, 2, 3, and 4 or more respectively.

Table 3.—Probable parameters for *Fusarium* attack.

Item	Average years to occur	Probability per year
1) Establish in area given not in area	3	0.206
2) Attack patch given established in area	2	0.293
3) Kills patch given diseased	3	0.206
4) New resistant variety available given current resistance broken	∞	0
5) Proportion of healthy production if diseased = 0.5		

One would expect that as the pepper plants aged and approached their productive life expectancy of ten to fifteen years (12, p. 7.5), there would be a decline in yield due to senescence. Unfortunately, *Fusarium* attack may well prevent many of the plants from entering this age group. Senescence effects have not been included in the simulation models.

Modeling the pepper production system

The various aspects of the pepper production system discussed in the preceeding sections have been incorporated into the carrying capacity simulation models (9, 10), and can be simulated either as a part of the full KPROG2 model for estimating human carrying capacity, or as a part or the smaller AGRISIM model which permits individual parts of the agricultural system to be examined independently. In addition to the effects of soils on yields, disease effects, and the effects of fertilizers, leaching, uptake, and erosion on soils discussed, other parts of the model include the current pepper financing arrangements and the labor and fixed cost requirements both for installing and maintaning pepper.

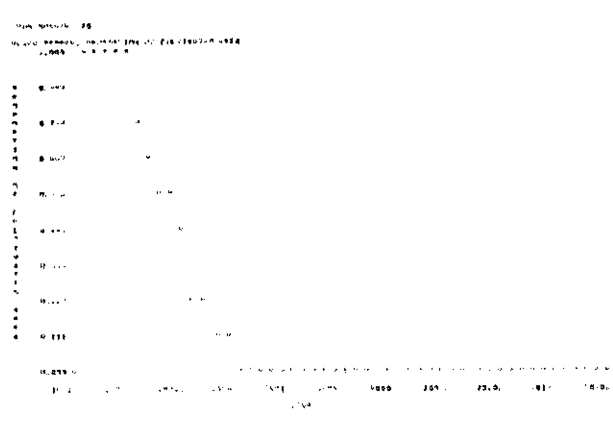

Fig. 3.—*Black pepper survival in stochastic AGRISIM run. The death of the pepper is due to* Fusarium *fungal attack.*

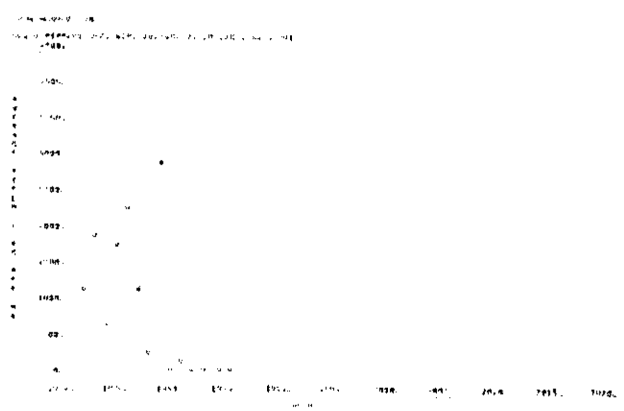

Fig. 4.—*Average black pepper yields in stochastic AGRISIM run*

Figure 3 shows the demise of a simulated area of pepper which results from the attack of *Fusarium* in a typical stochastic run of AGRISIM. It is essential to remember that the scale of years given on the simulation outputs is not intended to imply that the results constitute a projection for pepper survival or yields for particular years. The scale does serve to orient the reader with respect to the simulated time span, beginning with the start of the colonization project in the intensive study area in 1971. The fact that the simulated pepper fields last only a few years before being destroyed by *Fusarium* is the result in all of the stochastic runs, and does not bode well for the future of pepper in the area. The variability in yield during the few years that pepper lasts in the same AGRISIM run can be seen in Figure 4.

In conclusion, the prospects for pepper in the Transamazon Highway Colonization Area are bleak. Revenue from growing this very valuable crop cannot be counted on to appreciably raise the carrying capacity of the area on a sustained basis. Inclusion of the pepper production system in the carrying capacity models has nonetheless been indicated by the prominence of this crop in present plans. The high hopes placed on this crop by planners and colonists alike are due to its rare position as a crop which is sufficiently valuable to warrant being sustained on poor soils through the use of fertilizers. It is unlikely that these hopes will prove justified.

Summary

The yields to be expected from black pepper *(Piper nigrum)* being planted by colonists near Altamira on Brazil's Transamazon Highway are predicted based on relationships between pepper yields and soil fertility and the effect of the fungus *Fusarium solani* f. *piperi*. This, combined with information on soil quality in the area, effects of fertilization and other factors on soil fertility, and the probability of colonists using fertilizers, allows the construction of a computer simulation of pepper yields in the area. The pepper yield simulation is a part of larger modeling effort aimed at estimating the carrying capacity of the study area for human populations. The high cost of fertilizers, together with the low priority placed on fertilization by colonists, makes the attainment of official yield predictions unlikely. The current spread of disease caused by *Fusarium* in the area makes the chance of obtaining sustainable yields from black pepper extremely remote

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Notas y Comentarios

Premio Nobel de Química 1979

El premio Nobel de Química ha sido ganado en 1979 por Georg Wittig y Herbert Charles Brown por desarrollar el uso de compuestos que contienen fósforo y boro como reactivos importantes en la síntesis orgánica La profesión química ha celebrado este galardón como un triunfo por el esforzado trabajo de estos dos hombres, que han dedicado sus vidas a diseñar nuevas maneras de hacer productos químicos orgánicos Su labor dio lugar a métodos elegantes y eficientes para la producción de compuestos útiles, como productos farmacéuticos, colorantes, fertilizantes y productos para protección vegetal

Wittig, que tiene 82 años, y Brown, que tiene 67, están ambos formalmente retirados, pero todavía activos en investigación A comienzos de los novecientos cincuenta, Wittig obtuvo un compuesto inesperado de fósforo que contenía un nuevo tipo de ligazón que Wittig llamó "ylid" El nuevo compuesto, y otros en su clase, resultaron capaces de llevar a cabo un tipo de reacción muy útil en la síntesis orgánica: se combinan con compuestos que continen un grupo carbonil ($C=O$), en tal manera que forma un nuevo enlace carbón-carbón con doble ligazón ($C=C$)

La introducción de la doble ligazón en esta forma significó abrir una inmensa ruta química por el hecho de que muchísimos compuestos orgánicos importantes en la medicina tienen ligazones dobles Entre las más tempranas aplicaciones de la técnica estuvo la síntesis artificial de la Vitamina A. Las prostaglandinas, una gama de productos químicos similares a las hormonas con muchas aplicaciones como drogas, y los esteroides también usados en medicina, pueden ser hechos de la misma manera

Herbert Brown ha hecho dos contribuciones mayores a la química Como resultado de trabajos iniciados para mejorar la preparación del uranio para su uso en armas nucleares, se dio cuenta del potencial de los compuestos del boro en la síntesis orgánica Introdujo el borohidruro, un reactivo de significación fundamental También llegó a métodos simples de elaborar diborano, otro reactivo importante, e introdujo una nueva reacción, la hidroboración, que da lugar a compuestos orgánicos cuya conformación geométrica puede ser predicha con confianza Por ejemplo, las feromonas de los insectos (hormonas sexuales atrayentes), que se usan ahora ampliamente en el control de plagas, son compuestos que deben tener la configuración correcta para ser eficaces

Wittig y Brown, trabajando en la esfera teórica experimental, han creado un asombroso arsenal de reacciones originales que hoy se utilizan en la industria para sintetizar numerosos productos de interés económico y biológico De la creatividad y del rigor de estos científicos puros se han beneficiado desde la agricultura hasta la medicina Han abierto también un campo de investigación que ha representado una verdadera carrera para repetir en el laboratorio, cada vez con mayor seguridad, los caprichos que la naturaleza creía haber ocultado en la estructura de sus más complicadas sustancias químicas Esta carrera ha dado lugar a otros premios Nobel Así, por ejemplo, en la síntesis de las prostaglandinas, Corey, de Harvard aplicó el tris-amilborohidruro de litio, procedimiento creado por Brown, a una de estas síntesis, mientras que Woodward, también de Harvard, empleó la llamada reacción de Wittig en una de las etapas más avanzadas de otra El equipo que dirige Woodward ha logrado la síntesis de sustancias como quinina, cortisona, ácido lisérgico, reserpina, colchicina y clorofila, por lo que Woodward recibió el premio Nobel de Química 1965 (Cf *Turrialba*, 16:3).

Como dice el Dr Fernando Durán, uno de los vicerrectores de la Universidad de Costa Rica (*La Nación*, 28 de octubre 1979, p. 5C), la "Separación conceptual entre ciencia pura y la tecnología es, no imposible, improductiva . . El prejuicio de la aplicabilidad nos hace olvidar que la técnica depende de un fundamento que la precede: el conocimiento científico Estos dos científicos puros nos demuestran con su creatividad que, si la tecnología es una cara del progreso, la ciencia es su motor"

Mejorando el sabor de la proteína de soya

Aquellos que compran un sustituto de carne de vacuno o de ave a base de soya, encuentran que el sabor no responde a las expectativas del espíritu vegetariano. Los expertos en alimentos han encontrado que es muy difícil eliminar el sabor "frijoloso" de la proteína de soya antes de agregarle los deliciosos jugos que puedan simular los sabores a carne muy eficazmente Pero el futuro puede cambiar; un grupo de científicos japoneses parecen ahora haber superado el problema (*Agricultural and Biological Chemistry*, vol 43, p 1883)

H Chiba, N Takahashi y R Sasaki, del Departamento de Ciencias y Tecnología, en Kyoto, sabían que el sabor se origina de una familia de compuestos químicos, los aldehídos, en especial el *n* hexanal En consecuencia, trataron un extracto desengrasado de soya con la enzima aldehído dehidrogenasa, que convierte los aldehídos en los ácidos correspondientes Un panel adiestrado de 10 expertos en sabor de menestras, declararon que se había obtenido una gran reducción en el poco aceptable sabor Y no se detectó ninguna tendencia significativa de que el sabor retornaba al ser almacenado el producto Los ácidos formados por el tratamiento, también poseen el sabor extraño, pero felizmente se necesita un millón de veces más ácido que aldehído para que el sabor se note

Los aldehídos se encuentran en muchas clases de alimentos, de manera que este método de eliminación de sabor podría encontrar una amplia aplicación comercial; no reduce el contenido de proteína, a diferencia de otros métodos usados en la actualidad, y es más eficaz que estos métodos