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TRADITIONAL PEST MANAGEMENT IN MAIZE IN NICARAGUA: A SURVEY

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1. INTRODUCTION

One of the main problems of the developing countries is to assure an adequate food supply. Generally an attempt is made to meet the increased food demand by increasing food production rather than food imports and dependance on external food sources (CORBET, 1970; PEARSE, 1977). The rate of increase of the crop production has to be higher than the population increase to eliminate starvation and malnutrition. The policy in Latin America should be to raise food production by increasing the yield from the existing arable land instead of reclaiming new land, which is a high cost alternative.

To achieve this, agricultural research stations have developed 'technological packages' (main components: high yielding varieties, fertilizers and pesticides). In order that these programmes achieve their aim, credit, technical assistance, supplies and crop insurance are also included. However when the package was promoted (e.g. by demonstration) the farmers were generally only inclined to accept parts of it (BIGGS, 1980; CIMMYT, 1974). Several reasons have been put forward to explain this behaviour. Firstly, the physical conditions (soil types, the slope of the fields, water supply) in the target area varied greatly between the many different farms and although the package was developed in the region, it was composed under optimal conditions. Secondly, it was erroneously assumed that economic, social and political infrastructure can and will automatically adjust to the requirements of new technology (ZANDSTRA and MOTOOKA, 1978). Thirdly, the profit concept is often irrelevant for small farmers, who cannot risk production losses. The realization that farmers have different risk preferences explains and justifies what was formerly considered economically irrational behaviour (RAJAGOPALAN and VARADARAJAN, 1978). In farm management research, risk aversion is now often included in models as a small farmers' objection function (HARDAKER, 1979).

Pests are a definite risk for small farmers. What this risk is or how it should be minimized (by which control measures) often depends on physical, institutional and technological constraints facing the farmer (OECD, 1977; HASKELL, 1977). Physical constraints dealt with by land reform institutes are the land tenure system, the quality and quantity of land and the physical accessibility. Institutional constraints are health, education and production services. Technical assistance, credit and input delivery systems are often poor, also the small farmer lacks access to remunerative and stable markets. Political constraints are the dualistic economic structure. For example on the one hand there may be a small number of large farmers, who produce export crops at a high technological level on the most fertile soils, on the other hand there are many small farmers producing for the domestic market on marginal soils. The entrepreneurial success of the first often depends on the poverty and impotency of the second (PEARSE, 1977; MARCHETTI, 1981) who lack organization and political influence. Technological constraints apply to the traditional technology which keeps yields at a low level. Traditional agriculture however is very resilient under unfavourable conditions. This is the result of a selection process which incorporates many buffers and safeguards to prevent catastrophic system failure (PUTTER, 1978). To break the above mentioned constraints comprehensive field action programmes have now been designed (MATHUR, 1976).

Processes for the development of agricultural technology should start by studying the peasant's way of farming with the view of identifying his real needs and constraints (for farm technology in general see WAUGH, 1975; HILDEBRAND, 1976; WHYTE, 1977; PEARSE, 1977; for pest management technology see MORAN, 1978; GOODELL et al., 1981; LITSINGER et al., 1980; PERRIN, 1977; OECD, 1977). The technology to be designed should be compatible with the physical, ecological and socio-economical conditions of the farmers. This 'appropriate technology' (see also DAVIS, 1978) can be developed either by improving the traditional technology or by adjusting transferable technology (in general see HERRERA, 1979; NWOSU, 1975; as to pest management see BRADER, 1980).

The present study concentrates on the first part of the development process: a survey of traditional maize farming and pest management in Nicaragua[1]. Socio-economic factors, physical inputs, cultural practices, risk perception, pest recognition, cultural and chemical control have been analysed for differences between production regions and for trends according to farm size.

Four production regions in Nicaragua are compared: the Pacific North, the Pacific Central, the Interior Central and the Interior South (fig. 1, table 1). The Pacific North consists of fertile lowlands interrupted by a chain of active vulcanoes. Cotton and sugarcane are grown in the lowlands, while most of the foodgrain crops are produced on the slopes of the vulcanoes. The Pacific Central consists for the greater part of densely populated highlands, the main crops being coffee, foodgrains and upland rice. In the lowland between the lakes cotton and paddy are the main crops. The interior regions can be referred to as the Central Highlands. The Interior North and Interior Central are more elevated than the Interior South. Important export products are coffee in the Interior Central and beef in the Interior South. The Interior South is sparsely populated. All Interior regions, particularly the Interior Central, are important for foodgrain production. The Caribbean regions are covered by practically uninhabited forests.

Referring to farm size, land in Nicaragua is owned by a very limited number of producers as in many other countries in Latin America. In 1971, according to a census, half of all farms were concentrated on slightly more than 3% of the farm land and half of all the farm land area was occupied by 2–3% of all farms (WARNKEN, 1975). This skewed land distribution is shown in table 1.

[1] In developing countries the information on traditional pest management is still very limited. LITSINGER et al. (1980) have proposed a questionnaire on this subject to be used for Asian rice farmers.

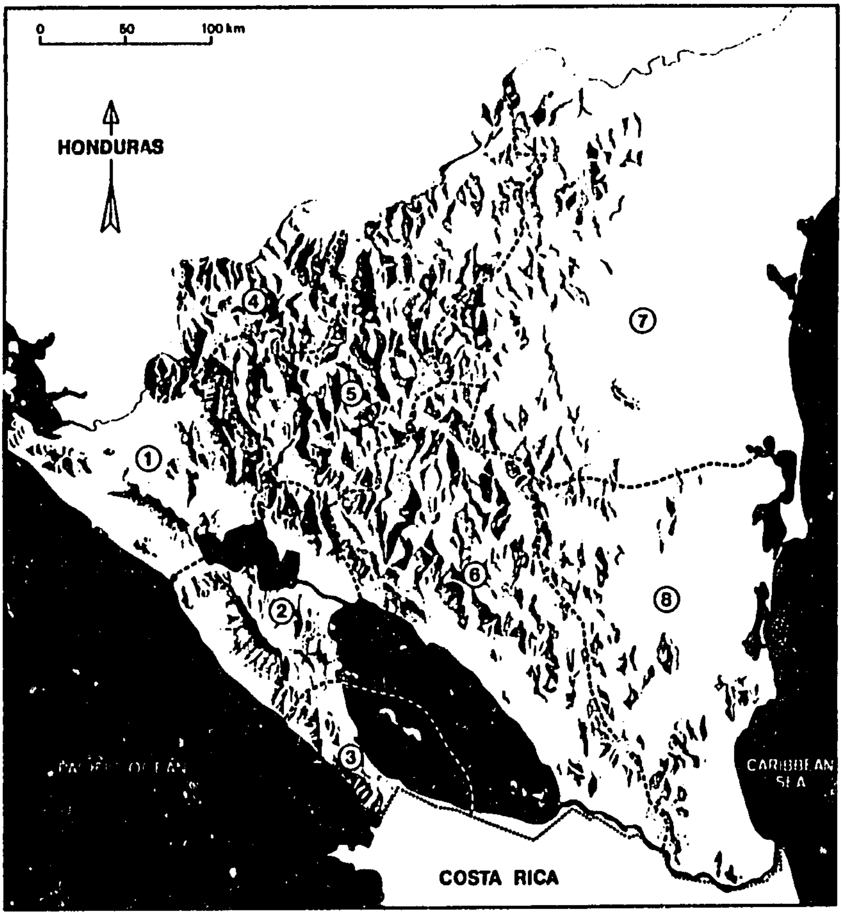


Fig. 1. Map of Nicaragua: production regions (see also table 1)

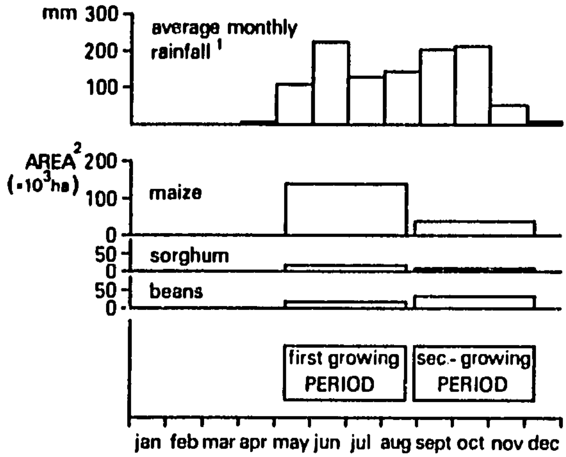
1. Pacific North
2. Pacific Central
3. Pacific South
4. Interior North
5. Interior Central
6. Interior South
7. Caribbean North
8. Caribbean South

Nicaragua has an estimated population of 2.3 million inhabitants, 48% of whom live in rural areas (BCN, 1978). The 'ladino' (Hispanicized) culture is shared by approximately 90 per cent of the population. In the Pacific and Interior regions the ethnic and cultural mixing of Spanish and Indian had virtually been completed by the beginning of the 18th century. In the Caribbean regions, where the British dominated until the mid-19th century, there are groups with distinctive non-European cultural patterns (Indian, Negroes and Indian-Negroes).

TABLE 1. Percentage of the total number of farms and the total area of farm land of export crops, foodgrains and pastures per production region in Nicaragua and per farm size class.

	Export crops						Foodgrains[3]								Pas-ture[2] area
	Cotton[1]		Coffee[2]		Sugarcane[2]		Maize		Sorghum		Beans		Upland rice[4]		
	Farms	Area	Farms	Area	Farms	Area	Farms	Area	Farms	Area	Farms	Area	Farms	Area	
Production regions															
Pacific North	95	84	1	1	13	62	13	12	15	16	3	2	5	2	15
Central	5	15	23	33	8	19	21	15	19	31	20	15	41	52	13
South	0	0	1	1	5	9	6	4	3	1	7	6	25	30	7
Interior North	0	0	23	16	18	1	11	10	19	9	15	16	2	0	8
Central	0	1	41	43	39	8	29	29	31	32	41	47	9	2	21
South	0	0	11	6	17	1	20	30	13	11	14	14	18	14	36
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Farm size classes (ha)															
<.7	–	–	19	2	1	0	19	6	12	3	18	15	8	2	0
.7–3.5	22	1	54	13	7	0	42	28	43	18	39	32	42	27	0
3.5–7	22	3	11	9	7	1	9	10	14	8	11	12	11	16	1
7–14	19	5	7	10	9	1	8	8	10	7	8	10	5	14	2
14–35	14	8	5	16	26	3	10	14	12	10	12	14	13	10	8
>35	23	83	4	50	50	95	12	34	9	54	12	17	21	31	89
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Average farm size (ha)	50.0		5.9		8.5		1.8		1.6		.94		1.3		–
Number of farms (× 10³)	4.1		17.7		3.8		102.5		16.5		57.4		2.4		2,075[6]
Total farm land area (× 10³ ha)	204.6		104.8		32.4		181.0		26.9		54.0		3.1		2,000
Yield (kg ha⁻¹)[5]	707		523		58,305		863		993		742		1,220[3]		–

[1] Source: CONAL (1978).
[2] Source: Warnken (1975).
[3] Source: DIPSA. Encuesta Nacional de Granos Básicos (1973/74).
[4] Another 115 farms produce paddy on 15.8 × 10³ ha with an average yield of 2,642 kg ha⁻¹; source: DIPSA. Encuesta Nacional de Granos Básicos (1973/74).
[5] Average of 1971/72 to 1976/77: BNN (1977)
[6] Cattle number (× 10³).



[1] Las Mercedes, Managua (1958-1977). Source: Servicio Meteorológico Nacional, Ministerio de Defensa, Managua.
[2] Source: DIPSA, Encuesta Nacional de Granos Básicos 1973/1974.

Fig. 2. Average monthly rainfall and area sown with foodgrains per growing period in Nicaragua.

Cotton and maize are the dominant crops, about 200,000 ha each. Maize is produced throughout the Pacific and Interior regions (table 1, figure 1). Since 1960 maize yields have remained almost constant (950 to 1000 kg ha^{-1}; VAN HUIS, 1981). Cotton is grown chiefly in the Pacific North.

The rainy season extends from mid-May to early November, during which maize, beans and sorghum are sown in two successive periods (fig. 2). The maize area in the first growing period is 155,000 ha and in the second 45,000 ha, the acreage of sorghum and beans is much smaller. Beans are usually sown in the second half of the rainy season as harvesting is safer because there is less danger of rot as November and December are relatively dry. The rain available in this second growing period is often not sufficient for maize; therefore beans, vegetables (shorter crop cycle) or sorghum (more drought-resistant) are sown, or the land is left fallow.

2. MATERIAL AND METHODS

The survey, based on interviews, was carried out among 192 maize farmers during the dry season from January until May 1978. Ten interviews were considered unreliable and therefore omitted in all analyses. The distribution of the farms surveyed in the production regions over farm size classes is given in table 2. The criterium for the selection of farm size was the area under maize in the

TABLE 2. Distribution of farms surveyed in Nicaragua over farm size class and production region. Between brackets the number of farmers intended to be interviewed according to the sampling plan.

Production regions		Farm size classes[1] (ha)						Total	%
		<.7	.7–3.5	3.5–7	7–14	14–35	>35		
Pacific	North	5(7)	14(14)	8(7)	6(7)	3(7)	9(7)	45(48)	25
	Central	5(7)	16(14)	12(7)	6(7)	4(7)	4(7)	47(48)	26
Interior	Central	4(7)	13(14)	6(7)	6(7)	10(7)	4(7)	43(48)	23
	South	6(7)	15(14)	8(7)	8(7)	7(7)	3(7)	47(48)	26
Total		20(28)	58(56)	34(28)	26(28)	24(28)	20(28)	182(192)[2]	100
%		11	32	19	14	13	11	100	

Note: Raw Chi square = 12.75 (P = .62) Cramer's V = .15.
[1] Concerns the foodgrain area in the first growing period.
[2] The answers from ten questionnaires were considered unreliable and therefore omitted in all analyses.

first growing period. In the analyses however farm size class is based on the area sown with foodgrains (maize, sorghum and beans) in the first growing period. The difference between the maize and foodgrain area is only small (table 4B). As foodgrain crops are easily interchanged, a foodgrain farmer was considered a better indication than a maize farmer. The number of farmers interviewed in the farm size class .7 to 3.5 ha was twice the number in the other classes (table 2). This class covers the largest maize area (28%) and represents a considerable number of maize farms (42%) (table 1). The number of farmers interviewed in each production region was the same. The orthogonal design allows for comparisons within farm size classes and production regions. The survey was not intended as being representative for the whole of Nicaragua.

The municipalities were selected by proportional random sampling: those with a large maize area had a greater chance of being included in the sample. The number of farmers to be interviewed in one municipality was (a multiple of) four. There was a practical reason for this; there was only one vehicle and 2 interviewers (the two junior authors, students of the Agricultural University of Wageningen, the Netherlands, who both speak fluent Spanish). The size class of farms to be sampled in each municipality had been drawn at random. Maps of the municipalities, where sampling sectors had been indicated, were supplied by the Agricultural Planning Institute DIPSA (Dirección Nacional de Planificación Sectorial Agropecuaria). During the survey it was often difficult to find farmers with farms of the agreed size in these sectors. This was particularly so in the larger farm size classes. Therefore adjustments were made (sampling in other sectors or interchanging farm size classes between municipalities; table 2). A questionnaire was used, all relevant remarks by the respondents were noted. These have been used where appropriate.

The recognition of insect pests was verified by asking the farmer to identify

TABLE 3. Species of maize insects shown to farmers for recognition.

Insect species	Injury to	Insect stage[1]	Photograph
Spodoptera frugiperda (J. E. Smith) Lepid.: Noctuidae)	whorl	L	+
Mocis latipes (Guen.) Lepid.: Noctuidae)	foliage	L	+
Heliothis zea (Boddie) (Lepid.: Noctuidae)	ear	L	+
Diatraea lineolata (Wlk.) (Lepid.: Pyralidae)	stem	L	–
Elasmopalpus lignosellus (Zeller) (Lepid.: Phycitidae)	lower stem	–	+
Estigmene acrea (Drury) (Lepid.: Arctiidae)	styles	L	+
Agrotis sp. (cutworms) (Lepid.: Noctuidae)	roots	L	–
Feltia subterranea (F.) (cutworms) (Lepid.: Noctuidae)	roots	L	–
Phyllophaga spp. (white grubs) (Coleop.: Scarabeidae)	roots	L	–
Aeolus sp. (wireworms) (Coleop.: Elateridae)	roots	L	–
Colaspis sp. (Coleop.: Chrysomelidae)	foliage	A	–
Diabrotica spp. (Coleop.: Chrysomelidae	foliage	A	
Cerotoma spp. (Coleop.: Chrysomelidae)	foliage	A	
Dalbulus maidis (Delong & Walcott) (Homopt.: Cicadellidae)	whole plant[2]	A	–

[1] L = fullgrown larvae in tube with alcohol, A = adult pinned.
[2] The cicadellid transmits the spiroplasma corn stunt, a serious plant disease in the Pacific regions.

photographed or prepared insects (adults pinned, larvae preserved in alcohol[2]) in the stage that they cause damage (table 3) and to provide the local name of the insect as well as a description of the injury caused. The farmers were also asked whether they knew any other damaging agents (insects, diseases, birds, mammals). Diseased insect larvae were described by the interviewer and it was noted whether or not the farmer recognized it.

The effect of the production region (a nominal[3] variable) on ordinal[4] and nominal variables was tested by the Chi-square test. The Chi-square test shows whether a relationship exists between two variables. How strongly the variables are related is shown by Cramer's V, which adjusts the Chi-square for sample size and table size. In tables the value of Cramer's V is given with the statistical significance of the Chi-square test.

The effect of farm size class (an ordinal[4] variable; rank numbers 1 for the lowest and 6 for the highest were given) on other ordinal variables (dichotomies[5] are considered ordinal) was tested with Kendall's Tau-c (T_c), which measures the level of association between two ordinal-level variables in rectangular tables.

[2] The size of larvae preserved in alcohol in tubes may be distorted and look bigger than they really are. This may reduce the farmers' ability to recognize the pest.
[3] In nominal-level measurements no assumption is made about the values being assigned to the categories (e.g. cities, religion).
[4] In ordinal-level measurements all of the categories can be rank-ordered to some criterion (e.g. social class, education).
[5] Variables with only 2 possible values or categories (e.g. sex: male, female; or recognition of a pest: yes, no).

In tables the value and significance of T_c is given. For nominal variables the Chi-square test and Cramer's V was used.

In dichotomies the negative answers have been omitted in the tables. In the analyses they were lined above the affirmative answers and in this way determined the sign of Kendall's Tau-c.

The effect of production regions as well as farm size classes on interval[6]-level variables was tested by one-way analysis of variance (Var). To detect trends with farm size, a test of linearity (Lin) was performed on farm size classes.

The symbols +, *, **, ***, and NS relate to effects in analyses of variance and the tests of Chi-square and Kendall's Tau-c.

*** very highly significant (P (= probability level) ≤ .001)
** highly significant (P ≤ .01)
* significant (P ≤ .05)
+ weakly significant (P ≤ .10)
NS not significant

No test has been performed when no values or symbols are indicated. Missing values have been defined and are excluded from the tables and the statistics.

The analyses have been carried out by means of the SPSS computer programme (Statistical Package for the Social Sciences; Nie et al., 1975).

3. GENERAL DESCRIPTION OF THE FARMS

Production regions

The total farm size, the area sown with annual crops, foodgrains or maize are not significantly different between regions (table 4A and 4B). The Pacific regions differ from the Interior regions, particularly the Interior South, in most other respects.

Besides growing maize, animal husbandry is an important activity of the farmers in the Interior. This is shown by the area with pastures (table 4B) and the farmer's occupation (table 4H); in the Pacific North cotton is grown by about 40% of the farmers (table 4H, see also table 1). As the number of insecticide applications in cotton is high (from 1971 to 1976: 19–22[7]) an impact on the insect pest incidence in maize may be expected (see chapter 6).

Farmers in the Pacific regions grow sorghum more and beans less often than in the Interior (table 4B). In the Pacific regions the drought-resistant sorghum is probably favoured because of the low rainfall, besides beans suffer more from diseases in the lowlands than in the highlands. Maize is often intercropped with sorghum, particularly in the Pacific regions (table 4B). This intercropping system

[6] In interval-level measurements, in addition to ordering, the categories are defined in terms of fixed and equal units (e.g. farm size, age).

[7] Source: Comisión Nacional del Algodón (CONAL), Memorias 1971/76.

Table 4. Characteristics of maize producing farms in Nicaragua, four production regions and six farm size classes.

Farm characteristics	Production regions: Pacific N	Pacific C	Interior C	Interior S	Test	Farm size classes (ha): 0 –	.7 –	3.5 –	7 –	14 –	35 – x
	ha					ha					
A. Farm size: total	64.	33.	84.	74.	NS	1.35	11.	25.	49.	180	227
B. Land use											
pastures	21.	8.0	43.	42.	Var*	.42	6.0	14.	10.	100	57.
annual crops	39.	24.	28.	10.	NS	.49	1.9	3.7	13.	48.	144
foodgrains	20.	11.	16.	11.	NS	.70	2.3	5.1	10.	23.	69.
maize[1]	20.	11.	15.	9.7	NS	.70	1.9	4.4	9.0	20.	55.
Foodgrains sown	% of farmers					% of farmers					
maize (2nd period)	33	30	44	38	V=.11	15	29	44	39	58	35
sorghum[2]	51	51	21	2	V=.45***	25	40	38	23	13	35
beans[2]	16	43	77	68	V=.47***	45	60	53	54	46	25
multiple cropping[2,3]	24	30	16	2	V=.27**	15	28	27	12	0	10
C. Field conditions											
inclined	29	23	44	68	V=.27**	40	48	56	38	25	20
stones	38	32	60	66	V=.24**	50	62	53	42	42	20
infertile	18	13	21	28	V=.14	15	31	21	23	8	0
irrigated	18	4	9	0	V=.25**	0	2	0	0	8	55
D. Tenancy											
landowner[4]	44	43	58	68	V=.28**	20	41	56	69	75	70
tenant[4]	47	53	26	21		80	53	38	15	8	5
	ha (%)					ha (%)					
land owned	84	44	95	95		20	46	55	75	88	87
	US$/ha					US$/ha					
E. Rental value land	114	76	76	40	Var***	47	71	94	83	106	127
	kg/ha (× 10)					kg/ha (× 10)					
F. Maize yield (1977)	189	100	141	97.	Var**	74.	105	102	109	154	252
	% of harvest					% of harvest					
G. Own consumption	54	66	56	78	Var*	100	87	69	59	21	11
H. Other occupations[5]	% of farmers					% of farmers					
Total	64	64	39	63	V=.21	70	48	56	52	67	81
Partly occupied with											
- hired field work	31	32	38	21		85	48	26	0	0	0
- cotton	42	14	25	0	V=.46***	0	11	11	23	36	46
- animal husbandry	0	4	25	72		0	8	32	54	50	31
- outside agriculture	27	50	12	7		15	33	31	23	14	23
I. Education											
read and write (literate)	44	55	30	40	V=.18	25	35	44	46	54	65
J. Age of farmer	43	47	46	45	NS	40	47	44	50	46	40

[1] First growing period.
[2] Total for both growing periods. While sorghum is sown by more than half of this total in the 2nd period, beans are sown predominantly ([illegible] of the total) in the 2nd period.
[3] Maize-sorghum and maize-bean intercropping (in the Pacific North only maize-sorghum).
[4] Does not always add up to 100 because of other forms of land tenure (statistics concern only the presented categories).
[5] Besides foodgrains.

Inputs and production services	Production region: Pacific N	Pacific C	Interior C	Interior S	Cramer's V	Farm size classes (ha): 0 – .7	.7 – 3.5	3.5 – 7	7 – 14	14 – 35	35 – x	Test
A. Cultivars												
Inland varieties												
never used	25	40	30	6		0	17	20	27	33	70	
occasionally	24	24	30	17	.25***	25	28	18	19	33	15	T_c = –.31***
always	51	36	40	77		75	55	62	54	34	15	
Improved O.P.[2] varieties												
never used	85	70	67	94		80	76	82	77	79	85	
occasionally	13	28	28	6	.19*	20	22	18	23	17	5	T_c = –.01
always	2	2	5	0		0	2	0	0	4	10	
Hybrids												
never used	49	43	44	79		95	62	62	35	42	15	
occasionally	35	36	42	15	.22**	5	28	21	46	42	60	T_c = .33***
always	16	21	14	6		0	10	17	19	16	25	
B. Fertilizer												
never used	18	19	35	82		50	37	47	39	38	16	
occasionally	24	28	35	7	.40***	25	33	12	7	12	47	T_c = .10*
always	58	53	30	11		25	30	41	54	50	37	
C. Insecticides												
never used	5	2	23	79		35	29	26	31	25	15	
occasionally	33	28	33	17	.51***	35	28	27	15	25	40	T_c = .07+
always	62	70	44	4		30	43	47	54	50	45	
D. Herbicides[3]	16	11	33	4	.29**	0	3	3	15	42	55	T_c = .37***
E. Credit												
foodcrops	44	51	52	30	.26***	15	33	35	56	74	75	V = .39***
other crops	24	2	7	4		0	3	9	24	9	20	
F. Technical assistance	51	48	51	13	.33***	15	35	38	50	48	68	T_c = .29***
obtained through:												
– visits extensionists	44	47	35	13	.29**	15	29	32	50	29	60	T_c = .22**
– field days	4	11	0	0	.23*	5	3	6	4	4	0	T_c = –.01
– demonstration plots	9	15	9	0	.20+	0	10	9	15	8	0	T_c = .00
– folders (bulletins)	29	6	2	0	.39***	10	7	12	4	13	15	T_c = .03
– broadcasting programmes	16	11	7	6	.12	20	7	9	19	8	0	T_c = –.05
– neighbours	44	55	40	60	.16	65	53	65	42	29	35	T_c = –.22**
– selling agents[4]	31	23	37	6	.27**	15	21	18	19	46	35	T_c = .16**
– own experience	16	15	21	32	.17	15	21	24	23	21	20	T_c = .03
Listening to agricultural broadcasting programmes	63	64	78	67	.12	60	81	56	92	57	35	T_c = –.14*

[1] From 1972 to 1977 never (0 years), occasionally (1 to 4 years) and always (5 years) used.
[2] Open pollinating.
[3] This includes farmers who used herbicides incidentally or regularly.
[4] Technicians from chemical companies, who recommend fertilizers and pesticides to the farmer.

seems to spread risk, especially in dry years (sorghum is usually used for stock and chicken food, but if the maize crop fails it is also used as human food) and distributes the labour and the harvest (ANDERSON and WILLIAMS, 1954). The intercropping of maize with beans has many agronomic advantages and lowers the infestation of *Spodoptera frugiperda*, the main pest of maize in Nicaragua (VAN HUIS, 1981). The effect of intercropping maize with sorghum on the incidence of *S. frugiperda* is not known (in this system the moth oviposits more on maize than on sorghum; VAN HUIS, 1981). Other intercropping systems such as maize-cotton and maize-sesame were found mainly in the Pacific North.

Most of the fertile land in the densely populated Pacific regions is occupied by large landowners who grow cotton, coffee and sugarcane. This is probably the main reason that in these regions the number of tenants is highest (50% of the farmers) as well as the percentage of land rented, particularly in the Pacific Central (table 4D). Small farmers often borrow from big farmers. When debts become excessive the land is impounded and the farmer usually becomes a hired labourer of the large landowner, who grows export crops.

Land rent is highest in the Pacific North, the cotton region, and lowest in the Interior South where the infrastructure is poor (table 4E). Farm land in the Interior regions is also less valuable because it slopes more, is less fertile (not significantly) and has more stones than in the Pacific regions (table 4C).

Maize yields in 1977 were highest in the technically highly developed Pacific North (1.9 metric tons) and lowest in the Pacific Central and Interior South (1.0 metric tons) (table 4F). In the Interior South more of the total maize production is used for home consumption (78%) than in the other regions (about 60%) (table 4G). About 50% of the farmers in the two Pacific regions can read or write compared to 30 to 40% in the Interior, the difference however is not significant (table 4I). In the Pacific North and Pacific Central 27% and 50% of the farmers respectively have incomes from outside agriculture, in the Interior only about 10% (table 4H).

In the Interior South as contrasted with the other regions, maize is grown with very low levels of inputs: hybrids, improved varieties, fertilizers and insecticides are never or only occasionally used (table 5A, 5B and 5C). In the Pacific North and Central fertilizers and insecticides are most frequently used (50–70% of the farmers use these each growing season). In the Interior South there is less credit and technical assistance than in the other regions (table 5E and 5F).

Farm size class

The total average farm size is considerably larger than the area with foodgrains on which the farm size class is based (table 4A and 4B). The remaining land is used for annual crops (e.g. cotton), pastures and perennial crops (e.g. fruit trees, coffee, sisal) or is uncultivated. In the largest farm size class beans are grown less than in the other classes; smallholders more often than large landowners intercrop the maize with sorghum and beans (table 4B). In the Pacific North larger maize farmers often grow cotton and in the Interior South they often keep cattle (table 4H).

The number of tenants decreases from 80% in the lowest farm size class to about 10% in the farm size classes above 7 ha; these figures are in accordance with the percentage of untitled land (table 4D). Eighty-five to 26 per cent of the small farmers in the farm size classes up to 7 ha (table 4H) also work as farm labourers on the larger farms. The number of farmers, who are able to read and write increased from 25% in the lowest farm size class to 65% in the highest (table 4J).

The maize yield triples from the lowest to the highest farm size class (table 4F). This is propably due to the fact that larger farms:

1. are situated on better farm lands (less sloping, fewer stones, more fertile, see table 4C; the cost of land, which reflects the suitability for agriculture, tripled from the lowest to the highest farm size class, table 4E).
2. use more new inputs such as irrigation (table 4C), hybrid maize, otherwise improved varieties and herbicides (table 5A and 5D); fertilizer and insecticides only tend to be used more often on larger farms (table 5B and 5C).
3. receive more credit and technical assistance (about 70% of the farmers in the highest farm size class against 15% in the lowest, table 5E and 5F).

The average age of the farmers was 40 to 50 years (table 4J). Farmers' ages were not significantly different between the regions, but they are between the farm size classes (the linear component however is not significant).

4. INPUTS, CREDIT AND TECHNICAL ASSISTANCE

Questions referring to the use of inland varieties and the non-use of fertilizer and insecticides refer especially to the Interior South region, from where most of the low-input farmers originate.

Varieties

About 75% of the farmers interviewed use inland varieties (table 5A), mainly because they believe that these varieties involve less risk (37% of these farmers) and because the farmers do not know the high yielding varieties (34%) (table 6). Other reasons are the high price of the new varieties and a preference to consume inland varieties. Farmers who did not use or rarely used the new varieties were asked whether they expected that these varieties would increase yields. In the Pacific more than 40% of the farmers expect a high increase, in the Interior only about 10% (table 7). Over 40% of the farmers in the Interior Central do expect a small increase, in the Interior South most of the farmers (67%) have no opinion.

The farmers were asked whether they knew cultivars resistant to pests. Inland varieties were mentioned by 34% of all farmers (76% of these farmers live in the Interior, where the use of these varieties is common). The pests against which

TABLE 6. Reasons for the use of inland varieties and the non-use of the inputs fertilizer or insecticides in Nicaragua (in percentage of the farmers who do so).

Inland varieties		Fertilizer		Insecticides	
Less risk	37	Too expensive	34	No serious pests	57
Better quality	12	Not necessary	33	Too expensive	24
Better yield	5	No experience	18	No experience	22
New cultivars are		Difficult to obtain	3		
– unknown	34	Other reasons	6	Other reasons	14
– too expensive	13				
– difficult to obtain	2				
Other reasons	18				
Number of farmers involved	134 (74%)		95 (52%)		76 (42%)

TABLE 7. Anticipated yield increases per production region in Nicaragua when new inputs are adopted (in percentage of farmers not using these inputs).

Anticipated level of yield increase	HY[1] Varieties Pac. N	Pac. C	Int. C	Int. S		Fertilizer Pac. N	Pac. C	Int. C	Int. S		Insecticides Pac. N	Pac. C	Int. C	Int. S	
nothing	21	35	14	8		0	37	28	40		0	50	36	27	
a little	16	6	43	17		0	27	11	20		50	0	9	37	
much	47	41	14	8		75	36	50	18		50	50	27	8	
does not know	16	18	29	67		25	0	11	22		0	0	27	27	
Number of farmers involved	19	17	14	36	86 (47%)	8	11	18	40	77 (42%)	2	4	11	37	54 (30%)

[1] High Yielding

they are supposed to be resistant are storage insects (73%), pests in general (14%), *Spodoptera frugiperda* (7%) and diseases (6%). The resistance against storage insects is mostly associated with the inland variety Tuza Morada; the husk of this variety covers the ear very tightly and completely. The resistance against pathogens is applicable to the yellow endosperm varieties (in Nicaragua white endosperm varieties are predominantly sown) which are known to be less susceptible to corn stunt, a spiroplasm transmitted by the cicadellid *Dalbulus maidis*. Several farmers were confident that their own inland varieties were the best adapted for the area, even better than other inland varieties. In the largest farm size class, 40% of the farmers, mainly in the Pacific North, believed that hybrids (X-105-A and B-666) were resistant to corn stunt (they are not!). Many farmers (27%) in the Pacific North expected not only that hybrids and improved varieties

TABLE 8. The relative importance of the media that recommend the use of new inputs (in percentage of the farmers who use these inputs).

Recommendations obtained from	High yielding varieties	Fertilizer	Insecticides
Agricultural services	54	51	37
Selling agents[1]	12	9	22
Neighbours	22	19	26
Own experience	0	15	0
Others	8	6	6
Not known	4	0	9
Number of farmers involved	111 (61%)	106 (58%)	131 (72%)

[1] Technicians from chemical companies, who recommend fertilizer and pesticides to the farmer.

would be more resistant to corn stunt, but also to drought and pests in general. Some added that these cultivars were bred for resistance.

The inland varieties were the most popular followed by the hybrid X-105-A and the improved, open-pollinating variety SALCO. Half of the farmers obtained the recommendations regarding the use of the new varieties from the agricultural services, the other half from neighbours and selling agents (table 8).

Fertilizer

The farmers abstain from the use of fertilizers because these are: expensive (34% of the farmers), unnecessary (33%) or unknown (18%) (table 6). Most of these farmers are from the Interior South (table 5B). The farmers in this region expected fertilizer to increase the yield much less than farmers in other regions, 40% of the farmers expected no increase in yield at all (table 7).

The use of fertilizer and insecticides during the last five years were heavily correlated (Pearson correlation coefficient is .75 ($P \leq .001$)), also after eliminating the effect of production regions and farm size on this relationship (partial correlation coefficients are .62 and .70 respectively). There could be two reasons. Firstly fertilizer stimulates the attack of the whorl feeder *Spodoptera frugiperda* and the stalk borer *Diatraea lineolata* (VAN HUIS, 1981). Secondly fertilizer hardly increases the yield when *S. frugiperda* is not controlled (VAN HUIS, 1981). The last explanation is only valid when *S. frugiperda* is a serious pest, this is questionable with regard to the Interior South, a region where foliar applications are few (see chapter 6). Besides this the farm land in this region is often kept fallow for 2-3 years (the farmers say that 'the soil needs resting'), this practice makes fertilizers unnecessary.

Five farmers told the interviewers that urea maintains the humidity of the soil (probably because of its hygroscopical nature). Fourteen farmers believed that urea (4 farmers), NPK fertilizer (6) and lime (4) control soil pests (wireworms, cutworms and white grubs). In the Interior South 3 farmers used fertilizer to prevent diseases. The idea of fertilizer controlling soil pests or diseases may be easier understood as a mechanism of obtaining a fast growing green looking plant than the concept of supplying nutrients to the plant. The relation between a green plant with the use of fertilizer and a yellowish plant with diseases is understandable (local names for diseases often include the word for yellow).

Half of the farmers that use fertilizer have been advised to do so by the agricultural services, the others by neighbours and selling agents or they use it on their own initiative (table 8). Big farmers have been advised mostly by the National Bank, small farmers by neighbours (confirmed by table 5F).

Pesticides

About 70% of the farmers who do not use insecticides live in the Interior South and 20% in the Interior Central (table 5C). Farmers abstain from the use of insecticides because the pests are not considered serious (57% of the farmers), the insecticide is too expensive (24%) or the farmers lack experience (22%) (table 6). In the Interior a big yield increase as a result of the use of insecticide was expected by a small percentage of the farmers (table 7). Most of these farmers (75%) would apply insecticides and 53% would also try to get technical assistance in case of a severe pest outbreak. The insecticide would be obtained from selling agents (41% of the farmers), agricultural services (28%) or neighbours (8%), the remainder did not know from whom they would get the insecticide. The agricultural services are less important for the recommendation of insecticides than for high yielding varieties or fertilizers, selling agents are more important. Neighbours also play an important role in recommending insecticides (table 8).

From 1974 to 1978 only 2% of the farmers ever used fungicides in foodgrains. Herbicides are used on about 50% of the farms larger than 14 ha, on smaller farms they are rarely used. The farmers object to the use of herbicides because these do not control grasses (important weeds), are phytotoxic and expensive. A method of herbicide use and supplementary weeding, appropriate for smallholders and dealing with the above mentioned objections, is given by VERSTEEG and MALDONADO (1978).

Credit

Many small farmers do not want to have credit (see table 5E), because the risk of a bad harvest in the rainfed agriculture is too high (from 1960 to 1978 eight years had an annual rainfall less than 1000 mm, these can be considered as dry years). The 'fear of a bad harvest' objection was mentioned by 88% of the farmers in the Interior South not using credit, and by 30–40% in the other regions. The farmers furthermore do not ask for credit because they do not want to compromise, are unable to find a guarantor, still have outstanding debts, fear that the farm land or farm animals may be impounded or confiscated, do not need a loan, do not own the land and believe that 'credit is only for the rich'.

TABLE 9. Opinions of farmers (%) concerning the main limiting factors of maize production (A and B) and concerning the climate and maize pests of the growing season of 1977 (C and D) in four production regions of Nicaragua and six farm size classes.

Opinions		Production regions: Pacific N	Pacific C	Interior C	Interior S	Cramer's V	Farm size classes (ha): 0 - .7	.7 - 3.5	3.5 - 7	7 - 14	14 - 35	35 - ∞	Tau_c
A. Main limiting factors[1] in maize production:	drought	44	75	42	34	.31***	55	49	56	42	52	35	-.08
	insects	22	13	21	17	.10	5	14	21	12	35	30	.17**
	no means[2]	27	23	12	6	.22**	15	29	15	15	4	5	-.16**
	no land	20	15	26	19	.09	55	31	12	8	4	0	-.36***
B. Most damaging to your crop in the 1st and 2nd place:													
Drought	first	60	84	44	45		55	66	71	65	46	30	
	second	27	12	12	10	.32***	20	17	9	16	17	10	.15**
	no problem	13	4	44	45		25	17	20	19	37	60	
Insects	first	36	16	28	17		25	22	21	11	29	45	
	second	58	82	39	36	.35***	55	61	62	58	42	30	.01
	no problem	6	2	33	47		20	17	17	31	29	25	
C. Climate in first growing period of 1977:	good	5	0	30	63		25	27	12	31	31	22	
	regular	16	6	26	11	.46***	15	10	14	23	17	11	-.03
	bad	79	94	44	26		60	63	74	46	48	67	
D. Appraisal of insect pest problems in 1977:	none	5	2	20	41		11	16	18	22	18	21	
	little	18	15	51	37	.43***	37	29	27	35	32	21	-.04
	serious	77	83	29	22		52	55	55	44	50	58	

[1] Do not add up to 100 per cent as farmers may mention more than one factor or none at all.
[2] No means of subsistence.

Technical assistance (table 5F).

Extension service personnel and selling agents provide a great deal of the technical assistance, particularly to the bigger farmers. The information received by small farmers is usually provided by neighbours. Folders and bulletins are frequently used in the Pacific North, probably as a result of the intensive technical assistance in cotton by the National Bank.

In the Interior South the technical assistance from extension activities (visits by extensionists and selling agents, demonstration plots and field days) is the least. Most of the farmers, especially the smaller ones, listen to agricultural broadcasts, however only about 10% considered that they had benefitted from them.

5. FACTORS LIMITING PRODUCTION

The main factor limiting maize production (as remarked by the farmer in an open question) is drought, followed by insect pests, no means of subsistence and lack of farm land (table 9A). No means of subsistence is mentioned mostly in the Pacific and especially by small farmers. The lack of farm land is felt as a severe handicap by farmers with less than 3.5 ha. Insect pests are more often a limiting factor for farmers with more than 14 ha than for small farmers.

In general, drought is found most damaging to the maize crop, especially in the Pacific and particularly in the Pacific Central (table 9A and 9B). Droughts often occur, the farmers considered 1977 to be a bad year (equal in all farm size classes) with regard to weather conditions for maize growing. The low maize yield in the Pacific Central (table 4F) in spite of the relative advanced technology (table 5) may be attributed to the severe drought. Big farmers consider drought less a problem than small farmers (table 9A and 9B), probably because they farm on better soils (with a higher moisture-retaining capacity) and are more often able to irrigate (table 4C). A small farmer's very existence is threatened if a crop fails whereas a big farmer is not so vulnerable.

Differences in the farmer's evaluation of the severity of the insect pests in 1977, occurred only between regions and not between farm size classes (table 9D, see also 9B). Insect pests rank as the second cause of damage to maize (table 9B). In the Interior, in particular the Interior South, pest problems are considered less severe. Pest problems in the year 1977–1978 were experienced as serious by about 80% of the farmers in the Pacific regions compared to about 25% in the Interior (table 9D). It is not clear whether the difference in evaluation of insect pests between regions should be attributed to an actual existing or a conceptual difference. This aspect is discussed in the following chapter.

	Production regions				
	Pacific		Interior		Cramer's
	N	C	C	S	V
	Spodoptera frugiperda				
Recognition	96	100	100	96	.15
Considered important	92	91	90	69	–
Using insecticides	80	79	70	15	–
	Diatraea lineolata				
Recognition	67	75	56	38	.28**
Considered important	15	17	12	6	–
Using insecticides	4	11	5	0	–
	Dalbulus maidis				
Recognition	44	55	5	6	.50***
Considered important	9	15	0	3	–
Using insecticides	7	2	0	0	–
	cutworms				
Recognition	53	66	35	4	.48***
Considered important	4	2	7	0	–
Using insecticides	4	0	2	0	–
	storage insects				
Identification[2]	29	45	77	70	.39***
Considered important	0	0	32	40	–
Using insecticides	0	0	18	29	–
	mammals				
Identification[2]	9	13	21	26	.18
Considered important	2	0	0	2	–
Using insecticides	0	0	0	0	–

	Production regions				
	Pacific		Interior		Cramer's
	N	C	C	S	V
	Mocis latipes				
Recognition	87	92	67	53	.36***
Considered important	36	45	27	19	–
Using insecticides	31	42	19	11	–
	Estigmene acrea				
Recognition	44	32	23	34	.16
Considered important	0	4	0	0	–
Using insecticides	0	2	0	0	–
	Bemisia tabaci				
Recognition	53	66	7	2	.60***
Considered important	9	19	0	0	–
Using insecticides	2	9	0	0	–
	wireworms				
Recognition	71	77	37	13	.53***
Considered important	42	28	3	0	–
Using insecticides	18	13	0	0	–
	diseases				
Identification[2]	47	40	56	60	.15
Considered important	0	0	5	32	–
Using insecticides	0	0	0	0	–
	birds				
Identification[2]	47	57	28	45	.21*
Considered important	2	4	0	7	–
Using insecticides	0	0	0	0	–

	Production regions				
	Pacific		Interior		Cramer's
	N	C	C	S	V
	Heliothis zea				
Recognition	64	75	74	47	.24*
Considered important	17	6	28	9	–
Using insecticides	9	4	16	0	–
	Spodoptera spp.				
Recognition	64	53	16	9	.50***
Considered important	9	13	0	0	–
Using insecticides	9	9	0	0	–
	white grubs				
Recognition	89	96	61	47	.46***
Considered important	29	38	29	15	–
Using insecticides	5	0	2	2	–
	Elasmopalpus lignosellus				
Recognition	33	19	7	2	.33***
Considered important	18	3	3	0	–
Using insecticides	2	0	0	0	–
	rats and mice				
Identification[2]	40	29	12	68	.42***
Considered important	0	0	0	38	–
Using insecticides	0	0	0	11	–
	diseased insects				
Identification[2]	7	19	0	0	.32***
Considered important	–	–	–	–	–
Using insecticides	–	–	–	–	–

[1] Name and correct description of injury.
[2] Identified as damaging the crop (it was asked if other items, apart from those shown, damaged the maize crop or harvest).
[3] The farmers mentioning the pest as the first, second or third most important.
[4] Those farmers indicated by note 2 who use insecticides to control that particular pest.

6. PEST RECOGNITION, RISK PERCEPTION AND INSECTICIDE USE.

The importance of a pest to the farmer was measured by asking him the following questions (table 10): 1. which of the prepared and photographed insects do you recognize (name of the pest and description of injury to the plant), list possible other items damaging your maize crop or harvest; 2. rank the three most damaging pests in order of importance; 3. how do you control these three pests? Only the control by insecticides is discussed in this chapter (cultural control measures are extensively discussed in chapter 8). All data on chemical control measures in 1977 were also noted.

Spodoptera frugiperda

S. frugiperda is recognized by almost all farmers (table 10). However, the evaluation of *S. frugiperda* as a pest in the two Pacific regions as well as in the Interior Central is different from the Interior South. In the first three regions 90% of the farmers consider *S. frugiperda* as an important pest and 60% as the most important pest, in the Interior South these figures are 70 and 30% respectively. In the two Pacific regions and Interior Central 70–90% of the farmers, who consider *S. frugiperda* important, use insecticides to control this pest, while in the Interior South only 15% (table 10). *S. frugiperda* is mainly responsible for the use of foliar applications (table 11). In both Pacific regions and the Interior Central, where 70 to 90% of all farmers use foliar applications (table 12), 50 to 60% of these applications are exclusively aimed at *S. frugiperda*, while in another 20 or 30% of the applications *S. frugiperda* is among the targets (table 11). In the Interior South only 8 farmers (17%) use foliar applications (table 12), of which half are directed against *S. frugiperda* (table 11).

Why do farmers in the Interior South consider *S. frugiperda* of less importance and apply considerably less insecticides than in the other regions? The physical infrastructure in the Interior South is poor, only a small number of farmers obtain credit and technical assistance, new inputs (high yielding varieties, fertilizer and insecticides) are scarcely used (table 5). The farmers' lack of experience in relation to chemical control may cause the damage of *S. frugiperda* to be considered inevitable and therefore less relevant.

Another explanation is that the incidence of *S. frugiperda* in the Interior South is actually lower, an impression arising from frequent observations that maize fields, in this region only, are relatively free from *S. frugiperda* attack. A lower incidence of *S. frugiperda* in the Interior South could be due to unknown effects of a different climate and/or vegetation, more frequent use of inland varieties and less use of fertilizer (the application of NPK fertilizer stimulates the attack by *S. frugiperda*; VAN HUIS, 1981). However it is most likely that the natural mortality by parasites and predators had not yet been disrupted by the fact that insecticides were previously used extensively (see VAN HUIS, 1981). This is contrasted with the Pacific regions where the intensive use of insecticides prob-

TABLE 11. The relative importance of insect pests measured by the number of applications (in percentage[1] of the total number of applications) aimed at specific insect pests in four production regions of Nicaragua. Between brackets: the percentage of the total number of applications exclusively aimed at controlling one pest species.

Target pests	Production regions			
	Pacific		Interior	
	North	Central	Central	South
A. Foliar insecticides				
Spodoptera frugiperda	84 (64)	73 (52)	85 (61)	54 (42)
Mocis latipes	14 (1)	18 (3)	12 (3)	46
Diatraea lineolata	2	0	4	0
Heliothis zea	3	6 (1)	4	0
Spodoptera spp.	2	8 (5)	0	0
Dalbulus maidis	2 (1)	5 (3)	0	0
Bemisia tabaci	2 (1)	4 (3)	0	0
chrysomelids	0	0	0	31
all pests[2]	14	9	7	15
Total number of applications	188	203	64	26
B. Soil insecticides				
white grubs	29 (6)	11 (11)	50 (33)	0
wireworms	35 (12)	45 (45)	17 (17)	0
cutworms	12	0	33 (33)	0
Elasmopalpus lignosellus	12	0	0	0
ants and termites	6 (6)	11 (11)	0	50 (50)
Dalbulus maidis[3]	6	0	0	0
Bemisia tabaci[3]	6	0	0	0
all pests[2]	47	33	17	50
Total number of applications	17	9	6	2

[1] The sum of the percentages for one production region surpasses 100 as one application is often intended to control more than one pest.
[2] Non-specific applications.
[3] Controlled by systemic insecticides.

ably made their use in the future inevitable.

Other *Spodoptera* species are identified by about 60% of the farmers in the Pacific regions (table 10). About 10% of the farmers consider these pests important and apply insecticides. It is however possible that these larvae are *S. frugiperda*, which have been confused with other *Spodoptera* spp., known from cotton or beans, such as *S. exigua* (HÜBNER) (most likely), *S. latisfacia* (WALK.), *S. eridiana* (CRAMER) and *S. dolichos* (F.). Under crowded conditions *S. frugiperda* larvae have a greenish and striped appearance and feeding is not restricted to the whorl, but extends to the outer leaves (VAN HUIS, 1981).

Table 12. The use of insecticides in maize in four production regions of Nicaragua and in six farm size classes.

Insecticide use	Production regions					Farm size classes (ha)						
	Pacific		Interior		Analysis of Variance	0 – .7	– 3.5	– 7	– 14	– 35	– ∞	Tau_c
	N	C	C	S								
Insecticide use	% of farmers					% of farmers						
– foliar	91	92	70	17	.65***	60	67	65	62	71	80	.08
– soil	34	19	14	24	.28**	10	9	12	23	21	50	.23***
– against storage insects	13	2	40	38	.38***	10	24	24	27	29	20	.06
– against rats and mice	2	0	0	13	.28**	0	3	6	8	0	5	.02
Foliar applications	number per crop cycle					number per crop cycle						
– per farmer	4.2	4.3	1.5	.6	Var***	1.5	2.4	2.5	2.6	3.1	4.2	L**
– per applying farmer	4.6	4.7	2.1	3.3	Var***	2.5	3.6	3.8	4.3	4.4	5.2	L**
Way of applying	% of applications					% of applications						
– by hand	62	73	51	46		58	66	57	76	60	67	
– by knapsack sprayer	29	24	40	54	–	42	34	43	22	35	6	–
– by tractor	6	1	9	0		0	0	0	0	0	23	
– by aeroplane	3	2	0	0		0	0	0	2	5	4	

Other pests

After *S. frugiperda*, the foliage feeder *Mocis latipes* is the most important insect in maize provoking insecticide applications: 12 to 18% of the foliar applications in the Pacific regions and the Interior Central are directed against *M. latipes* (table 11). In the Pacific *M. latipes* is recognized by about 90% of the farmers, 40% consider the pest important (about 15% most important) and almost all of these farmers control the pest with insecticides (table 10). In the Interior *M. latipes* is not recognized as easily as in the Pacific (by 50 to 70% of the farmers), 20 to 30% of the farmers consider the pest important and half of them control it by means of insecticides.

The ear feeder *Heliothis zea* and the stalk borer *Diatraea lineolata* are recognized by about 70% of the farmers in the Pacific regions and in the Interior Central and by about 40% in the Interior South (table 10). Only 15% of the farmers consider these pests important (occasionally as of prime importance). These pests are hardly controlled chemically (table 10 and 11). VAN HUIS (1981) made a first crop loss assessment for *D. lineolata*. He concluded that chemical control is not justified and that other control methods such as stalk and stubble burning in the dry season need to be emphasized. *D. lineolata* is not known as a stalk borer but by the damage the insect causes by tunneling the ear shank and ear centre; this is because the larvae appear when the cobs are picked or the husks removed.

By the time the maize is to be harvested *H. zea* is no longer present in the ear. Some inland varieties (e.g. Tuza Morada) are highly resistant against this ear feeder as the husk tightly and completely covers the ear.

Estigmene acrea, a style ('silk') feeder of maize, is better known by the farmer as a pest in beans. The insect is not considered of any importance and does not stimulate insecticide applications (table 10 and 11).

The cicadellid *Dalbulus maidis*, a vector of corn stunt, is mainly a lowland pest. In the Pacific half of the farmers recognize the pest, 10 to 15% consider it important and only a few apply insecticides (table 10). Foliar applications and soil applications of systemic insecticides are used in the Pacific, particularly late in the growing season, when the incidence of corn stunt is normally high (table 11). For this reason the growing of maize in the second growing period in the Pacific is generally discouraged.

White fly, *Bemisia tabaci* is a pest of cotton and beans in the Pacific regions, primarily as a virus transmitter. This may be the reason why 10 and 20% of the farmers in both regions consider it an important pest of maize and are even prepared to use insecticides (table 10 and 11).

In the Pacific regions soil insects seem rather important. White grubs are recognized by almost all farmers, wireworms by more than 70%, cutworms by 60% and *Elasmopalpus lignosellus* only by 20–35% of the farmers (table 10). White grubs and wireworms are considered about equally important by 30–40% of the farmers. Control of wireworms by insecticides is more usual than of white grubs (table 10 and 11), probably because the white grub can also be controlled physically during ploughing (see chapter 8). In the Interior regions white grubs are recognized by 50 and 60% of the farmers and considered important by 15 and 30%; insecticides are hardly used (table 10 and 11). Wireworms and cutworms are recognized by one third of the farmers in the Interior Central but not considered important.

In the second growing period fungi are an important mortality factor for Lepidopterous larvae (VAN HUIS, 1981). Only in the Pacific did farmers (7–19%) confirm the appearance of these larvae (table 10).

Storage insect pests are mentioned as a problem by about 75% of the farmers in the Interior against 30 and 45% in the Pacific regions (table 10). Only farmers in the Interior (30 and 40%) mention storage insects among the three most important pests, and insecticides are more often used to prevent damage than in the Pacific regions (table 10 and 12). This is probably because storage is used more extensively in the Interior (as the distance to markets is larger) and there are less public storage facilities.

Diseases, rats and mice are considered as main pests of maize only in the Interior South (table 10). Diseases have a large variety of local names which make the identification extremely difficult.

Mammalian and reptilian pests are most often mentioned in the Interior. The racoon is by far the most important, followed by the squirrel, deer (only in the Interior South), rabbit, armadillo, coati, skunk, agouti, wild boar and the iguana. Some birds uproot young seedlings, viz. the grackle (*Cassidix* spp., only in the Pacific regions) and the pigeon (mostly in the Pacific regions). Other birds pick the ripening seeds from the ear, especially parakeets (*Aratinga* spp.), followed by parrots and jays (*Cyanocitta* spp.). Other birds mentioned are the tanager (*Ramphocelus passerinii*), quails and woodpeckers. Woodpeckers drill holes in the internode and the ear shank. Usually the farmer and his children frighten the birds off the crop.

The number of insect pests recognized in the Interior is significantly lower than in the Pacific. Between farm size classes there are no significant differences (table 13), except for some specific pests. *D. maidis* (which requires sophisticated control techniques), wireworms and *Spodoptera* spp. (both pests of cotton) are best known by bigger farmers. *M. latipes* on the contrary is better known by smaller farmers (probably because bigger farmers weed more often, table 16D).

The importance of checking the pest list with the farmer can be demonstrated from an example in beans. Many farmers consider the meloid *Pyrota decorata* (L.) a serious pest, which needs control by insecticides. The agricultural services were not aware of this problem.

One pest in a single region sometimes has more than five names. Different pests may also be called the same in distinct regions. The onomatic problem can be illustrated by white grubs. They are called: 'gallina ciega' (most common name; mainly Pacific North), 'chogote' (mainly Pacific Central), 'chicharra' (mainly Interior Central) and 'tecorón' (mainly Interior South), and even more names were mentioned. Knowledge of the local names for any particular pest is important for any extension program of pest management.

Table 13. Recognition (R) of insect pests (prepared or photographed) and identification (I) of other damaging agents of maize (in number of insect species and agents) in four production regions of Nicaragua and six farm size classes.

Pests	Production regions					Farm size classes (ha)						
	Pacific		Interior		Analysis of Variance	0 – .7	– 3.5	– 7	– 14	– 35	– ∞	Tau_c
	N	C	C	S								
Soil insect pests[1] (R)	2.5	2.6	1.4	1.7	***	1.5	1.9	1.8	1.7	1.5	2.2	NS
Most important maize pests[2] (R)	3.6	4.0	3.0	2.4	***	2.9	3.4	3.5	3.0	3.3	3.2	NS
All maize insect pests[3] (R)	8.4	8.4	5.1	3.7	***	5.6	6.7	6.7	5.7	5.9	7.1	NS
All maize pests[4] (R+I)	11.3	11.4	7.6	6.9	***	8.5	9.5	9.9	8.4	9.1	10.1	NS

[1] Cutworms, wireworms, *Phyllophaga* spp. and *E. lignosellus*.
[2] *S. frugiperda*, *D. lineolata*, *H. zea*, *M. latipes* and *D. maidis*.
[3] Insects of note 1 and 2 plus termites, ants, chrysomelids, *E. acrea*, *Spodoptera* spp. and *B. tabaci*.
[4] Insects of note 3 plus storage insects, diseases, birds, rodents and mammals.

7. INSECT PEST CONTROL BY INSECTICIDES

Number of foliar applications

The number of foliar applications of insecticides per growing period (1977) per farmer was 4.2 in the Pacific and .6 to 1.5 in the Interior (Interior South and Interior Central respectively) (table 12). The number of applications increases with farm size. The smallest farmers use an average of 1.5 applications per crop cycle and the biggest farmers 4.2.

Taking into consideration only the farmers who applied foliar insecticides the figures were 2.5 and 5.2 respectively. Twenty farmers applied foliar insecticides more than 5 and 6 farmers more than 10 times per growing period.

VAN HUIS (1981) reported that young maize plants (first 2–3 weeks) proved to be almost insensitive to whorl injury by *S. frugiperda*. The reason for loss of yield during this stage of development is, that plants are eliminated by larvae of *S. frugiperda* feeding on the meristematic tissue of the bud. This loss can be compensated by sowing at higher densities and thinning the infested and least vigorous plants 2–3 weeks after plant emergence. Insecticide applications at or after tasseling are generally unnecessary: *Heliothis zea* is hardly a problem, ear feeding by *S. frugiperda* is prevented by pesticide applications in the late whorl stage and chemical control of *D. lineolata* is generally not justified (low field losses, cumbersome pest scouting, ineffective applications (VAN HUIS, 1981).

Judging by these criteria about 50 to 60% of the farmers in the Pacific apply pesticides unnecessarily and of another 30% it is doubtful if the use is effective (table 14). In the Interior regions these percentages are somewhat lower, but still considerable. Particularly for the biggest farmers it is questionable if it is necessary to apply pesticides so often. This evaluation has been based only on the timing of the applications (too early or too late) and not on economic thresholds. Also applying these criteria in the evaluation will probably show still more clearly the need for the introduction of a supervised control strategy.

Insecticide formulations and mode of application

A large variety of different insecticides is used. Insecticides most frequently used against *S. frugiperda* are: trichlorphon (Dipterex SP 80 or 5%G) (28% of all foliar applications); chlorpyrifos (Lorsban 480E or 5%WP) (22%); a mixture (3:15 active ingredients (a.i.)) of parathion-methyl (45%EC) and DDT (7%); parathion-methyl (48%EC) (6%); DDT (5%); monocrotophos (Azodrin 600 SC) (4%); and a mixture (4:2:1 a.i.). of camphechlor (Toxaphene), DDT and parathion-methyl (48%EC) (4%). Another 12 insecticides are applied in percentages of 3 or less of all applications. The high number of applications and the large variety of insecticides used in maize in the Pacific is probably caused by the large-scale use of insecticides in cotton.

About two third of the farmers in the Pacific regions apply insecticides by hand, a quarter by knapsack sprayer and the rest by tractor or aeroplane (table

TABLE 14. Percentage of farmers, who made foliar insecticide applications which are unnecessary or doubtful in four production regions of Nicaragua and six farm size classes.

Timing of applications	Production regions				Farm size classes (ha)					
	Pacific		Interior		0 – .7	– 3.5	– 7	– 14	– 35	– ∞
	N	C	C	S						
Early applications: unnecessary[1]	40	33	14	14	10	26	20	42	21	67
doubtful[2]	26	22	27	29	40	20	25	16	50	6
Total	66	55	41	43	50	46	45	58	71	73
Late applications: unnecessary[3]	23	45	18	29	10	40	15	25	36	47
doubtful[4]	8	12	37	14	20	6	15	17	35	29
Total	31	57	55	43	30	46	30	42	71	67
All applications: unnecessary[5]	54	60	32	43	20	54	30	50	50	93
doubtful[6]	26	28	45	14	50	20	35	33	50	7
Total	80	88	77	57	70	74	65	83	100	100
Number of farmers stating times of applications	35	42	22	7	10	35	20	12	14	15

[1] First application at ≤ 10 days after plant emergence.
[2] First application at 15 days after plant emergence.
[3] Application at ≥ 50 days after plant emergence (after emergence of tassel).
[4] Application at ≥ 45 days after plant emergence (at tasseling).
[5] note 1 + note 3.
[6] note 2 + note 4.

12). Applications by hand and knapsack sprayer are equally important in the Interior. In general, applications by hand are preferred, even by big farmers, as it saves a considerable amount of insecticide (most applications are used against *S. frugiperda* and need therefore be directed only at the whorl). Some small farmers only treat the injured whorls, saving even more insecticide (VAN HUIS, 1981). Ten farmers followed the extension services' recommendations, to mix chlorpyrifos (Lorsban 480E) with sawdust and water; 9 of these farmers were from the largest farm size class.

To protect the whorl, dusts and granular insecticides are applied by means of bottles, bags and socks; liquid insecticides are applied by bottles.

Soil is often mixed with insecticide powder in the Pacific (12 farmers). Also lime (3 farmers) or ash from the stove (1 farmer) are used for this purpose. These are thought to have a synergistic effect. Eight percent of all farmers applied soil to the whorl to control *S. frugiperda*. Another 17% of the farmers were aware of this practice, most of them in the Pacific North. This may have to do with soil properties (vulcanic ashes) (in this region *S. frugiperda* is also often controlled by mixing soil with insecticides). Applying soil to the whorl is considered a typical control method of the poor (the rich use insecticides). The larvae are supposed to suffocate or leave the plant. Some farmers believe that wet soil (by rain) suffocates the larvae, while others believe that dry soil, as hot dust, kills the larvae. Inert powders are known to damage insects (see EBELING, 1971; he does not however refer to lepidopterous larvae). Several farmers expect the application to be most effective when applied very early in the morning. VAN HUIS (1981) could not confirm that soil applied to the whorl controlled *S. frugiperda*. In the Interior South the practice was mentioned by 3 farmers to prevent damage by deer.

Supposed insecticidal effects of fertilizer on soil pests are discussed in chapter 4.

Prediction of insecticide use

By discriminant analysis it was tried to identify a set of variables that discriminate best between farmers who use and do not use insecticides. The discriminating variables which entered the analyses are: production regions (4 variables), farm size (total size, foodgrain and maize area), field conditions (3 variables: see table 4C), education (years), farmer's age, credit and several aspects of technical assistance (see table 5F). The farmers were selected according to the number of years they had used insecticide during the last five years and to the number of foliar insecticide applications during the first growing period of 1977.

In the first analysis (selection criterium: years of insecticide use) the farmers are divided in a group that never used insecticides (50 farmers) and a group that always used insecticides (82 farmers). In the stepwise selection procedure only 2 variables remained with sufficient discriminating power: the Interior Central and the Interior South, the last region being the most important. Based on these variables the classification routine correctly identified 89% of the farmers as members of the group to which they actually belong.

In the second analysis (selection criterium: the number of foliar application) the farmers are divided in a group that did not apply (60 farmers) and a group that applied 3 times or more (57 farmers). In the stepwise selection procedure 7 discriminating variables remain. The Interior regions, particularly the Interior South, are by far the most important. The other variables concern technical assistance, ranked in order of importance: 1. selling agents, 2. agricultural broadcasting programmes, 3. ever received technical assistance, 4. visits to demonstration plots and 5. own experience (no technical assistance received). Only 1, 3 and 4 positively correlate with the number of the applications. The classification routine correctly identified 89% of the farmers as members of the group to which they actually belong.

These analyses show that the insecticide use (number of years and of applications per crop cycle) can largely be predicted from the production regions. The number of applications per growing period can further be predicted from several components of technical assistance of which the visits by selling agents (technicians of chemical companies) are the most important.

TABLE 15. Percentage of farmers knowing the meaning of pest management terms in four production regions of Nicaragua and six farm size classes.

Pest management terms	Production regions					Farm size classes (ha)						
	Pacific		Interior		Cramer's	0 –	.7 –	3.5 –	7 –	14 –	35 – ∞	Tau_c
	N	C	C	S	V							
Integrated pest control	13	6	2	0	.22*	0	0	3	0	4	40	.16***
Biological control	33	13	7	0	.37***	0	3	15	4	17	60	.28***
Beneficial insects	47	21	12	4	.39***	0	10	21	15	33	65	.35***

Knowledge of pest management terms

The meaning of pest management terms such as 'integrated pest control', 'biological control' and 'beneficial insects' is only known by the biggest farmers, especially by those of the cotton region, the Pacific North (table 15). This is probably due to the intensive campaign for integrated pest management in cotton by the project of technical assistance of the National Bank of Nicaragua.

8. CULTURAL PRACTICES AND PEST CONTROL

The role of cultural practices in pest control was assessed by asking the farmers firstly, whether and how these are carried out and secondly, whether they affect pest incidence.

Destruction of maize remnants in dry season (table 16A and 17A)

The destruction of stalks and stubbles of maize and sorghum in the dry season may reduce the incidence of diapausing *D. lineolata* larvae and consequently the size of the borer population in the next growing season. Usually the cattle feed on these remnants, more often in the Pacific regions (on about 80% of the farms) than in the Interior Central and Interior South (60 and 20% respectively). This is probably because there are less pastures in the Pacific regions (table 4B). About 50% of the farmers, particularly the small farmers, burn the remnants. In the Pacific the stalks are collected into heaps and burned, in the Interior it is burned without collecting. This last practice has less effect, because even with strong winds it is difficult to burn a field completely. A few big farmers plough in the remnants, which also reduces the borer population.

Farmers in the Pacific have the most confidence in controlling pests by burning the remnants. Most however fail to answer which pest. Only four farmers mentioned white grubs and only one the stalk borer *D. lineolata*. Most refer to pests in general, eggs (12 farmers) or microbes ('desinfects the soil', 6 farmers). It seems that the farmers are unaware that the stalk borers survive the dry season as larvae in the stalks and stubbles of maize and sorghum (they do know the larvae as tunnelling the ear, see page 22). We discovered such ignorance several times when sampling maize and sorghum remnants during the dry season in farmers' fields in several parts of Nicaragua. The farmer would probably be more motivated to thoroughly destroy the remnants if he were told that these contain the larvae of the stalk borer, of which the next generation infests his future crop.

Ploughing and sowing (table 16B, 16C and 17B).

Most farmers in the Interior South (more than 80%) sow maize by plantstick without soil preparation. In the other regions the land is plowed predominantly by oxen, and the maize is sown simultaneously by hand, in the furrow. Plowing

TABLE 16. Percentage of farmers using certain cultural practices [illegible]

Cultural practices	Production regions: Pacific N	Pacific C	Interior C	Interior S	Cramer's V	Farm size classes (ha): 0 – .7	.7 – 3.5	3.5 – 7	7 – 14	14 – 35	35 – ∞	Test
A. Stalk and stubble destruction												
Burning	23	9	35	27	.23*	33	33	21	17	14	6	T_c=–.21**
Burning in heaps	43	45	15	4	.40***	28	28	33	25	14	8	T_c=–.11+
Total (both)	67	58	50	31	.27**	65	63	52	42	20	18	T_c=–.32***
Ploughing under	3	15	5	2	.22+	0	4	3	9	20	15	T_c= .12**
Cattle feeding	81	85	60	20	.53***	68	58	71	54	64	53	T_c=–.04
B. Soil preparation (ploughing)												
none	7	2	17	82		26	28	27	36	29	16	
by oxen	61	55	60	18	.53***	74	67	52	32	19	11	T_c= .28***
by tractor	32	43	23	0		0	5	21	32	52	74	
C. Sowing												
by hand: – planting stick (1)	4	2	30	83		25	33	35	38	25	15	
– ploughing (ox) (2)	58	68	35	6		65	55	53	27	13	15	
– both 1 and 2	7	0	14	9	.45***	10	10	6	8	4	0	V = .34***
by tractor (3)	22	26	14	2		0	2	0	19	46	60	
Other combinations of 1, 2 and 3	9	4	7	0		0	0	6	8	12	10	
D. Weeding (frequency)												
none	2	2	0	0		6	0	3	0	0	0	
once	18	29	27	26	.22**	24	27	27	20	37	10	T_c= .11*
twice	46	55	71	67		53	63	64	76	42	45	
three or more	34	14	2	7		17	10	6	4	21	45	
E. Thinning out plants	38	40	14	4	.36***	5	14	15	27	42	65	T_c= .36***
F. Earthing up	93	85	63	13	.66***	65	66	67	60	70	85	T_c= .15*
G. Doubling stalk	91	66	46	9	.61***	35	47	55	52	61	70	T_c= .19**

TABLE 17. Percentage of farmers who expected an effect from cultural practices and climatological factors on pest incidence (none = no effect, less = lower pest incidence, more = higher pest incidence) in four production regions of Nicaragua and six farm size classes.

Cultural practices and climatological factors		Production regions: Pacific N	Pacific C	Interior C	Interior S	Cramer's V	Farm size classes (ha): 0 – .7	.7 – 3.5	3.5 – 7	7 – 14	14 – 35	35 – ∞	Tau_c
Cultural Practices													
A. Burning stalk and stubbles	none	47	39	60	67	.22*	60	58	44	40	50	45	.09
	less	53	61	40	33		40	42	56	60	50	55	
B. Ploughing	none	44	48	53	92	.39***	60	68	62	73	38	40	.18*
	less	56	52	47	8		40	32	38	27	62	60	
C. Thorough weeding	none	40	26	70	79	.44***	47	60	48	65	54	35	.06
	less	60	74	30	21		53	40	52	35	46	65	
D. Sowing early	more	9	2	0	7		5	4	0	0	4	20	
	none	52	60	69	83	.22**	70	66	73	63	67	50	–.01
	less	39	38	31	10		25	30	27	37	29	30	
E. Sowing in second growing period	more	47	62	47	42		70	50	35	69	38	40	
	none	35	29	44	47	.13	30	35	47	31	38	60	.08
	less	18	9	9	11		0	15	18	0	25	0	
Climatological factors													
F. Wet season	more	7	2	12	6		5	3	9	8	13	5	
	none	9	2	14	24	.20*	26	16	3	4	4	25	.01
	less	84	96	74	70		69	81	88	88	83	70	
G. Heavy rainfall	none	13	11	50	51	.42***	30	30	35	31	33	25	.00
	less	87	89	50	49		70	70	65	69	67	75	
H. New moon (young moon)	more	87	83	79	66	.19+	90	90	83	77	58	55	.27***
	none	13	17	21	34		10	10	17	23	42	45	

nd sowing by tractor is chiefly limited to farms larger than 7 ha.

In the Pacific and Interior Central half of the farmers (among them relatively most of the big farmers) expect ploughing to reduce pest incidence; in the Interior South, where only a fifth of the farmers plough, this holds only for 8%. Similar to burning, farmers (14) believe that ploughing kills the eggs of pests. In the Pacific many farmers (20) expect that cutworms, wireworms, white grubs and soil pests in general are controlled by ploughing. In the Interior Central only white grubs were mentioned. To control white grubs ploughing should be done according to many farmers when the soil is dry (in the dry season), because then the larvae are killed by the heat-rays of the sun. Some mentioned birds eating the larvae. Farmers or children walking behind the plough also collect the larvae of white grubs by hand.

Weeding ((table 16D and 17C)

In all regions about 25% of all farmers weed only once during a crop cycle. About 50% of the farmers in the Pacific and about 70% in the Interior weed twice. More frequent weeding is done on the larger farms, mainly in the Pacific and particularly in the Pacific North.

More farmers in the Pacific than in the Interior believe that weeding reduces pest incidence; opinions were not significantly different between farm size classes. It was often said that 'weeds produce pests', Only in the Pacific regions some weeds and pests were mentioned specifically. Many farmers knew that *Portulacca oleracea* L. is a host for *Spodoptera* spp., some also mentioned *Amaranthus spinosus* L. and *Boerhavia erecta* L. (For a discussion of the effect of weeds, mainly the grasses *Eleusine indica* (L.) and *Digitaria* sp., on the incidence of *S. frugiperda* see VAN HUIS, 1981.). The incidence of *Mocis latipes* (Guenée), a feeder of many grass species, was expected to be high if the weeds were not well controlled. Farmers in the Interior South reported a higher mice population when weeds were abundant.

Sowing early (table 17D)

In the Pacific and the Interior Central 30 to 40% of the farmers said that early sowing reduces pest incidence, while in the Interior South only 10%. Many farmers in the Interior sow at the end of the dry season in the dry soil. Several farmers however found when they used this method that ants ate the seeds, therefore they sow after the first rains. In the Interior South some expect early sowing to reduce disease problems. It was often remarked in the Interior that early sowing favors plant growth because the soil is still warm (end of the dry season).

Sowing in the second growing period (table 17E)

About 50% of the farmers expect that pest problems are more severe after sowing in the second growing period, especially corn stunt and *Dalbulus maidis* in the Pacific North, *Bemisia tabaci* in both Pacific regions, white grubs and *S. frugiperda* in both Interior regions and diseases in the Interior South.

Thinning and earthing up (table 16E and 16F)

Dense sowing and thinning out injured and least vigorous plants should be able to compensate the plant losses caused by soil insects, *S. frugiperda* and *D. lineolata* (VAN HUIS, 1981; see also page 25). Thinning is frequently practised only in the Pacific regions, especially on the larger farms. The more general application of this practice can reduce the excessive use of early insecticide applications (table 14). Several farmers in the Interior South however commented that, when sown by plant stick, sowing more plants per hole would not compensate for the damage, as white grubs destroy all plants in a planting hole.

Earthing up after about 3 weeks is generally practised in the Pacific regions, in the Interior Central it is less common (60% of the farms) and in the Interior South uncommon (10% of the farms).

Doubling the stalk (table 16G)

Doubling means that the stalk is broken downwards just below the ear shank. It is done when the grain is mature but not completely dry (moisture content about 30%). The main reason is to control the humidity of the grains (rain cannot enter the cob and prevents ear rot). The farmer only harvests after the humidity of the grains is sufficiently low. In extension bulletins this practice is discouraged as it allows more damage by rodents, birds, insects and fungi; artificial drying is recommended (BNN/INCEI/IAN/MAG, 1974). In one experiment in Nicaragua doubling did not increase the incidence of storage pests (LEON and GYLES, 1976). The practice is very common in all regions, except the Interior South. There it is also less relevant, as predominantly inland varieties are used, which have a very complete ear coverage. In Belize doubling is practised to prevent parrot damage in areas where farmers suffer extensive losses from these birds (BERNSTEN and HERDT, 1977).

Other control measures

One farmer in the Pacific used light traps which he placed at each corner of the maize field. The trap consisted of the lower-one-third-part of a barrel filled with water, above which a paraffin lamp burned. The trap caught many moths during each night, for the farmer sufficient proof of its effectiveness.

In the Interior South three farmers told the interviewers under the heading of 'secrets' that they knew a practice to counter diseases and pests: a cross of diseased leaves or a cross drawn in the soil in which 6 larvae are distributed (called 'a suncross') are made in each corner of a maize field. One farmer in this region said that he controlled the bean pest *Pyrota decorata* L., a meloid, by throwing a bottle with 7 adults into the river. Another farmer in the Interior South expected a control of chrysomelids in beans by strewing the leaves of two species of trees (only local names available) in his bean field.

9. RAINFALL, LUNAR CYCLE AND PEST INCIDENCE

Rainfall (table 17F and 17G)

In general the farmers, particularly those in the Pacific, believe that a dry growing season increases the incidence of insect pests, especially the Lepidoptera *S. frugiperda, M. latipes, H. zea* and *D. lineolata*. During a wet growing season many farmers (26) most in the Interior (21) expect a higher incidence of diseases.

In general heavy rain is supposed to reduce pest incidence. This view holds strongest in the Pacific (90% of the farmers). The pest most referred to is *S. frugiperda* (39 times), followed by *M. latipes* (17 times); some mentioned *H. zea* and *D. lineolata*. Farmers described that when the whorl fills up with water, the larvae of *S. frugiperda* leave the whorl, drown or are washed off the whorl onto the ground and carried away by the stream. Eggs and small larvae in general (to which many farmers in the Pacific refer) would be 'knocked off the plant' or 'washed away'. VAN HUIS (1981) proved in an experiment inspired by these opinions, that heavy rain significantly reduces the infestations of young larvae of *S. frugiperda*.

Lunar cycle (table 17H)

The lunar cycle seems to be important in the management of the maize crop in Nicaragua. A large percentage of the farmers, in the Interior South somewhat less than in the other regions, expect more insect pests during young moon (i.e. new moon plus several days). This view is held more by small farmers than by big farmers.

Almost all farmers believe that the storage insects are more abundant, if harvesting takes place at young moon. Other cultural practices that should not be carried out at this moon phase are sowing, doubling the stalk (only in the Pacific, because only here doubling is a common practice) and cutting. Sowing at this moon phase would result in a tall plant with small ears easily prone to breaking and lodging (said particularly by farmers in the Interior regions, 44 and 14% in the Interior South and Interior Central respectively). Several farmers explained that the maize should not be touched at the young moon phase as long as the plant is in connection with the earth. Some commercially minded farmers only harvest at young moon if the grains are to be sold. Several farmers in the Interior said that wood for construction should not be cut at young moon, because such wood would rot easily.

Farmers in Belize believe that maize sown at full moon (in contrast to new moon) grows shorter and develops a stronger root system, which makes the plant more resistant to lodging, while storage insects would cause less damage (BERNSTEN and HERDT, 1977). In Nicaragua however they believe that harvesting and not sowing affects the incidence of storage insects. In Belize they also harvest by moon phase (from 3–4 days after new moon to 3–4 days before full moon) but the reason is not given. BERNSTEN and HERDT (1977) assumed a mythological cause for the supposed effects of the lunar cycle: 'Mopan Mayans traditionally believe that when the moon is full all living things are mature and strong; during the new moon most trees and plants are believed to be weak like new born babies'.

There are no references – as far as we know – to the effect of the lunar cycle on the incidence or the flight activity of storage pests. Several lepidopterous species (*Heliothis* spp., *Agrotis* sp.) lay more eggs at new moon (BOWDEN 1973; PERSSON, 1974; see also EL-SAADANY and ABD-EL-FATTAH, 1975). The ear feeder *Heliothis zea* provides an entrance for storage insects. Therefore a possible effect of the moon phase on the incidence of storage insects (via *H. zea*) should not be excluded. (Much more is known about the effect of the lunar cycle on the flight activity of many insect species, but this will not be considered here). Fourty per cent of the farmers in the largest farm size class expected an effect of the moon phase on the oviposition by lepidopterous moths. These farmers were probably told of this by the extension programme in cotton (BNN, 1974 and 1975; see also FALCON and DAXL, 1978).

10. PEST MANAGEMENT STRATEGY (A SUMMARY)

Small farmers face a number of socio-economical, physical, institutional, technological and political constraints to raise their standard of living. The success of any pest management programme will greatly depend on the national and regional efforts to break these constraints. Therefore pest management should be integrated in plans for rural development.

Drought and insect pests are among the main factors limiting maize production. Minimizing risks is a main objective for the farmer. His production system has evolved during many years and is very well adapted to the harsh local conditions. An evaluation of the traditional way of farming should therefore be carried out with the aim of improving the traditional practices and adapting new techniques. The contribution of the ecologic, agronomic and socio-economic disciplines is thereby indispensable. For example in the agronomic and socio-economic rehabilitation of the maize-bean intercropping system in Latin America (FRANCIS et al., 1978), VAN HUIS (1981) demonstrated that the incidence of the key pest, *Spodoptera frugiperda*, decreased in maize when intercropped with beans.

New inputs such as insecticides and fertilizer draw heavily on the scarce resources of the farmer and constitute a high risk because of the insecure harvest (e.g. drought). Therefore before promoting these inputs to the farmer their effect should be carefully assessed. This will be illustrated by the following examples. The control of *S. frugiperda* by insecticides under drought conditions is useless as yield does not increase (VAN HUIS, 1981). PERRIN (1977) and BROL et al. (1976) reported from Mexico and Guatemala respectively that fertilizer has low adoption rates. They demonstrated that fertilizer did not increase yields under small farmers' conditions (on sloping fields this can be expected). VAN HUIS (1981) proved that the use of NPK fertilizer stimulated the attack of *S. frugiperda* and *D. lineolata* and increased yields only after the whorl had been chemically protected. These examples show that a sufficient water-supply and the use of modern inputs should not be considered as a matter of course. If pest damage is not assessed and control methods are not designed for small farmer conditions, the farmer often corrects the usually too academic investigator and adapts the technological packages to his specific conditions by rejecting it or parts of it (BIGGS, 1980).

Between and within production regions several names are used for the same pest or one name is used for different pests. Therefore national names should be agreed upon and introduced (e.g. through pest management guidelines and/or by providing extension agencies with boxes demonstrating prepared insect specimens). The damage potential of pests is not always clear to the farmer. Many farmers are not aware that *D. lineolata* causes damage as a stalk borer and diapauses as a larva in the stalks and stubbles of maize and sorghum during the dry season. Such knowledge may motivate them to thoroughly destroy the remnants.

Farmers consider *S. frugiperda* as the most important pest in maize. In various experiments VAN HUIS (1981) found yield reductions by this whorl defoliator between 30 and 60 per cent. This pest was responsible for about 80% of the foliar insecticide applications in maize. In the Pacific farmers applied foliar insecticides more than four times per growing period, big farmers more than small farmers. Considering the timing of the applications, about 80% of the farmers use unnecessary or doubtful applications. Probably farmers are readily inclined to control *S. frugiperda* chemically as they are able to see within a few days the dead larvae and the termination of whorl injury. Other surveys too showed that farmers expect too much from the result of insecticide use (MUMFORD, 1977). This hampers the introduction by the extension service of the economic threshold concept to the farmer, which often even proves difficult for extensionists themselves. For instance 80 per cent of the number of insecticide applications recommended by extensionists in Nicaragua during 1978 were unnecessary (survey among extensionists; VAN HUIS, unpublished data). This indicates the necessity to train adequately extension personnel in integrated pest management.

Insecticide use, especially for the small farmer, may have severe implications concerning: 1. health (poisoning due to inexperience, lack of storage places and a higher sensitivity due to malnutrition), 2. socio-economics (high risk of a bad harvest, ineffective use of pesticides). 3. agro-ecology (disruption of mortality by parasites and predators, pest resistance, hazards to wildlife species, etc.).

In the Pacific a strategy of supervised control of *S. frugiperda* should be a first priority. Special attention should be given to susceptible plant stages, economic thresholds and selective applications (VAN HUIS, 1981). In the Interior efforts should concentrate on a rational use of insecticides (preventing unnecessary applications) making full use of cultural, varietal and biological control (VAN HUIS, 1981).

Other pests considered of importance were: *Mocis latipes* (most in both Pacific regions); the soil pests white grubs (in all regions), wireworms (only in the Pacific regions) and *Elasmopalpus lignosellus* (only in the Pacific North); storage insects (only in the Interior); diseases and rodents (only in the Interior South). This shows that there are considerable differences in pest risk perception between regions. Also physical infrastructure, use of inputs (among which the use of insecticides), agricultural services (credit, technical assistance and marketing), field conditions, climate, and farmer's side-occupations are different between regions; mainly the Pacific versus the Interior and in particular the Interior South. Therefore different strategies of research, training and extension are required for each region.

Traditional pest control practices need full consideration. Several have shown to be promising (the application of granules or insecticide baits only to injured whorls saves a considerable amount of insecticide; VAN HUIS, 1981); others seem appropriate (the physical control of white grubs by ploughing, the hand collecting of the striking red *Estigmene acrea* larvae in beans). A practice may also turn out to be ineffective (the control of *S. frugiperda* by applying soil to the whorl: VAN HUIS, 1981) or seem irrational (to omit harvesting at new moon to prevent a high incidence of storage insects). Unprejudiced research however should evaluate these peculiar supposed causal relationships (e.g. covariation may be involved). The farmers' concept of pest control may be correct (the mortality of young *S. frugiperda* larvae by heavy rain, VAN HUIS, 1981) or incorrect (fertilizers acting as soil insecticides).

Farmers' technology and approaches should be identified by extension and evaluated by research. The improvements and innovations should be directed so that they are adopted by the farmer; this depends on perceptible advantage, easy implementation, socio-economic risks and cultural factors (beliefs). The adoption by the farmer of the proposed techniques is the best criterion for their appraisal. A feed-back mechanism from the farm to the research should be ascertained through the extension service. In that manner investigation and extension should be complementary and respond to the real needs of the farmer.

ABSTRACT

In 1978, 182 maize farmers, stratified in six farm size classes in four production regions, the Pacific North and Central and the Interior Central and South, which cover most of Nicaragua, were interviewed. Farm characteristics, physical inputs, credit, technical assistance, risk perception, pest recognition, cultural practices and chemical control have been analysed for differences between production regions and for trends according to farm size. Farmers consider drought and insect pests the main factors limiting maize production. In both Pacific regions insecticides are applied more than four times per growing period. In the Interior regions, where less use is made of new inputs and production services (credit and technical assistance), only one application is made. About eighty per cent of all applications are directed against the whorl-feeding larvae of *Spodoptera frugiperda*, which farmers correctly consider the main pest in maize. Most of these applications seem unnecessary. The expected effects of cultural practices, rainfall and lunar cycle on pest incidence have been analyzed. Most of the traditional pest control methods used in Nicaragua proved to be very appropriate, indicating that such inventarizations and evaluations can be of great value.

RESUMEN

En 1978 fueron entrevistados 182 agricultores maiceros, estratificados en seis clases de tamaño de fincas, en cuatro regiones productoras: El Pacífico Norte y Central y el Interior Central y Sur, las cuales cubren la mayor parte de Nicaragua. Las características productivas, insumos, créditos, asistencia técnica, percepción de riesgos, reconocimiento de plagas, prácticas culturales y control químico, fueron analizados con el fin de establecer diferencias entre las regiones de producción y tendencias en relación al tamaño de la unidad productiva. Según los productores la producción de maíz es limitada principalmente por la carencia de agua y plagas. En ambas regiones del Pacífico fueron aplicadas insecticidas más de cuatro veces en el período de crecimiento. En las regiones del Interior, donde se utilizan menos nuevos insumos y servicios de producción (crédito, asistencia técnica), se realiza sólo una aplicación. Alrededor del 80% de todas las aplicaciones son dirigidas contra las larvas del 'cogollero', *Spodoptera frugiperda*, al cual los agricultores consideran correctamente la principal plaga en el maíz. La mayor parte de estas aplicaciones parecen innecesarias. Han sido analizados los efectos esperados de las prácticas culturales, caída de lluvia y ciclo lunar sobre la incidencia de plagas. La mayor parte de los métodos tradicionales usados en Nicaragua para el control de plagas han probado ser muy apropiados indicando que una inventarización y evaluación de tales métodos pueden ser de gran valor.

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