Biological and Economic Factors Influencing Farmer Acceptance of Pest Management Practices

H. WALKER KIRBY and C. E. MAIN, Department of Plant Pathology, and G. A. CARLSON, Department of Economics and Business, North Carolina State University, Raleigh 27650

ABSTRACT

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Personal interviews were conducted with a randomly selected group of 84 tobacco farmers in four eastern North Carolina tobacco-producing counties to determine factors influencing adoption of pest management practices. Results of this study indicate that most tobacco farmers apply pesticides routinely instead of using crop scouting or monitoring methods to determine actual need for such pesticides.

Additional key words: crop rotation, insecticides, IPM, nematicides

Integrated pest management (IPM) programs for flue-cured tobacco (*Nicotiana tabacum* L.) in North Carolina emphasize use of multiple tactics and strategies to monitor and contain pest populations. IPM programs stress selected cultural practices, soil sampling for nematodes and fertility, insect scouting, and disease surveying before selective application of pesticides based on proven need. Procedures were designed to reduce pest populations in the current crop as well as the level of overwintering pests. State extension specialists and county extension personnel are available to assist tobacco growers in developing countywide as well as individual farm programs.

One widely accepted IPM program for tobacco in North Carolina (8) stresses several complementary practices to control disease and nematode problems based on results of soil samples and disease surveys. Growers select pesticides, tobacco varieties, and rotation schemes after using monitoring and sampling techniques rather than depending on intuition or "insurance" applications of pesticides. Pesticides, however, still remain the preferred method for dealing with real and "potential" pests in tobacco. Although insecticide use has been reduced through extension IPM programs (H. W. Kirby, *unpublished*), nematicide use has increased dramatically during the past decade in North Carolina (5,9). Expenditures for all types of nematicides totaled $2.3 million in 1974 and increased to $25 million by 1979. Because of stalk and root destruction programs plus routine use of nematicides, however, these increases occurred at a time when the actual need for nematicides had declined. A survey of tobacco fields during 1969–1976 (2) showed that the number of fields infested with high populations of root-knot nematodes (*Meloidogyne* spp.), which can be extremely damaging to tobacco (5,9), declined from 78% in 1969 to 58% in 1976. Root-knot nematode larvae recovered from soil showed a similar declining trend, ie, from an average of 1,000 larvae per 500 cm^3 soil in 1969 to 600 larvae per 500 cm^3 soil in 1976 (2).

Even with this declining trend, growers still prefer to rely on traditional methods of disease and/or nematode control, primarily chemical, rather than using predictive methods to reduce dependence on pesticides. Except within organized county IPM programs, soil assay procedures and related advisory services are not widely accepted among tobacco growers because of pesticide reliability, anticipated high returns on investment in pesticides, lack of confidence in predictive methods, and a historical adherence to proven control methods.

The objectives of this study were to 1) determine the adoption rates of selected pest management practices among a randomly selected group of eastern North Carolina tobacco farmers, 2) develop sampling and interview methods to assess factors influencing the decision-making process related to pest control, 3) establish a data base of currently accepted practices for comparison with on-farm IPM research plots, 4) determine if patterns of pesticide use occur within sampling areas, 5) determine the effectiveness of soil-sampling and state advisory services for nematode management, and 6) assess the monetary expectations of tobacco growers with respect to nematicide use and predictive soil sampling.

MATERIALS AND METHODS

Chatham, Franklin, Lenoir, and Moore counties in eastern North Carolina were selected during 1980 for detailed confidential surveys of tobacco crop management practices with emphasis on nematode management. Counties selected also had tobacco IPM research plots during the same year. County extension personnel assisted in locating the respondent subjects but did not participate in the interviews. Respondents were selected by a systematic survey of county townships from current tobacco warehouse sales designation lists located in the respective county Agricultural Stabilization and Conservation Service (ASCS) offices. Final selections were based on a previously described sampling procedure (6) that yielded about three times as many names as were actually interviewed (Table 1). This permitted substitutions if the primary respondent could not be located after three trips to the farm.

All interviews were conducted by a trained enumerator who visited with each respondent on the farm. Growers were asked to select a tobacco field representative of their 1980 tobacco crop and were asked about crop management activities for that field during the past 3 yr.

A set of detailed questions was designed that included multiple choice, single answer based on personal judg-

Table 1. Number of tobacco growers interviewed (Na), number selected as potential respondents (Nb), and percentage of total tobacco growers per county interviewed (N%)[a]

County	Na	Nb	N%[b]
Chatham	16	48	7.76
Franklin	26	78	2.08
Lenoir	21	63	1.88
Moore	20	60	4.70

[a] Number of farmers to be selected in each county determined by the following formula: $Na = \sqrt{\text{Total tobacco farms having allotments}} \times 0.5$, $Nb = Na \times 3$.

[b] Percentage of farms planting tobacco in 1980 that were sampled within each county.

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ment, ordering by importance, and dichotomous selection types. All survey questions were pretested to remove interview biases and biases from misunderstood questions.

Table 2. Frequency of soil sampling in tobacco fields by survey growers for nematode assay purposes during 1978–1980

	Percent sampling[a]	
Frequency	MP users	Non-MP users
Yearly	12	2
Every 2–3 yr	38	22
Seldom	19	19
Never	31	56

[a] MP users refers to tobacco growers who applied multipurpose fumigant materials and non-MP users refers to all other growers in the survey.

Table 3. Frequency of observing yield losses in tobacco attributed by survey growers to nematodes

	Percent observing[a]	
Frequency	MP users	Non-MP users
Yearly	7	12
About one-half of tobacco crops	0	2
Less than one-half of tobacco crops	0	9
Very seldom	33	21
Never	60	56

[a] MP users refers to tobacco growers who applied multipurpose fumigant materials and non-MP users refers to all other growers in the survey.

Table 4. Expected additional returns per hectare in tobacco fields from application of a chemical soil treatment by survey growers

	Percent expecting returns[a]	
Expected returns per hectare	MP users	Non-MP users
$25.00–$625.00	31	52
$625.00–$1,250.00	25	30
$1,250.00–$1,875.00	6	11
$1,875.00–$2,500.00	18	6
$2,500.00 and higher	18	0

[a] MP users refers to tobacco growers who applied multipurpose fumigant materials and non-MP users refers to all others in the survey.

Table 5. Savings needed per hectare on chemical costs before a yearly soil sample for nematode assay purposes would be submitted by tobacco growers

	Percent of total[a]	
Amount needed	MP users	Non-MP users
$0.00–$25.00	25	13
$26.50–$62.50	37	24
$65.00–$125.00	19	26
$127.50–$250.00	12	20
$250.00 or more	6	16

[a] MP users refers to tobacco growers who applied multipurpose fumigant materials and non-MP users refers to all other growers in the survey.

Statistical Analysis System (SAS) programs (3) available at North Carolina State University were used for the data analysis. Computations included response means, frequency distributions, regression analysis, and logit analysis (4,7).

A regression model was developed to identify factors that significantly influenced the level of nematicide expenditures among the respondents. This model contained a variable for frequency of observing yield losses attributable to nematodes (yearly, half of the crops, less than half of the crops, seldom, or never), based on the best judgment of the respondent. Other variables included in the model were given as a function of nematicide expenditures as follows: nematicide expenditures = f (soil sampling frequency expected, returns on investment in nematicides, submitted soil sample for nematode assay in 1979 for tobacco crop, planted root-knot nematode-resistant tobacco variety, years of past three that selected field was planted to tobacco, hectares of land in other crops, hectares of land in tobacco, years of experience with tobacco crops, and years of formal education).

Two logit models also were developed from a modified program (4,7) to identify factors that influenced the planting of tobacco varieties with resistance to the common southern root-knot nematode (*Meloidogyne incognita* (Kofoid & White) Chitwood). Logit analysis replaced regression analysis because of use of jointly dependent qualitative variables. Logit models contained either a variable for submitting a soil sample for nematode assay during 1979 for the 1980 tobacco crop or for the soil-sampling frequency expected, two variables that appeared to be closely correlated. Other variables used in the model were as follows: use of root-knot nematode-resistant tobacco variety = f (frequency of observing yield losses due to nematodes, expected returns on investment in nematicides, nematicide expenditures, years of past three that selected field was planted in tobacco, hectares of land in other crops, hectares of land in tobacco, years of experience with tobacco crops, and years of formal education).

RESULTS

Grouping of growers. Growers in this survey could be grouped according to the type of pesticide used. Growers applying multipurpose (MP) soil fumigants to control both nematodes and soilborne diseases operated larger (>80 ha) tobacco farms than those applying nonfumigant materials or not treating. Also, a majority of those using MP materials did so for control of soilborne diseases rather than for nematode control. A majority (63%) of MP users applied these materials even though they indicated that they had never observed yield losses attributable to nematodes in their tobacco fields. A smaller percentage (41%) of non-MP users applied nematicides even though they indicated that they had never observed yield losses attributable to nematodes.

Biographical information. Growers using MP materials had a mean age of 50.9 yr compared with 49 yr for non-MP users. Formal education had a mean of 11.7 yr for MP users and 10.8 yr for non-MP users. Farming experience with tobacco crops had a mean of 28 yr for MP users and 24.8 yr for non-MP users.

Farm size was greater for MP users, with a mean of 87.4 ha of cropland consisting of 9.7 ha of tobacco allotment owned, 10 ha of tobacco allotment leased, and 67.7 ha of land containing other commercial crops (primarily corn and soybeans). Farm size for non-MP users had a mean of 50.6 ha of cropland consisting of 3.1 ha of tobacco allotment owned, 7.8 ha of tobacco allotment leased, and 36.6 ha of land containing other commercial crops.

The amount of land leased as additional allotment, expressed as a percentage of the total allotment, was about the same for both MP users (67.3%) and non-MP users (64.1%). A majority of both groups leased an additional allotment each year from 1978 to 1980.

Use of state advisory services. MP users used state nematode advisory services to assist with nematode management more frequently than did non-MP users (Table 2). Soil samples were submitted more frequently by MP users than by non-MP users. A larger percentage of MP users submitted soil samples in 1979 for the 1980 tobacco crop than did non-MP users (27% compared with 9%, respectively).

Neither group considered yield losses due to nematodes a significant problem, reporting that these losses occurred either very seldom or never (Table 3). Distribution frequencies for occurrence of yield losses was about the same for both groups.

Monetary expectations. MP users expected to receive much higher returns on investment in pesticides than did non-MP users during the 1980 crop season (Table 4). MP users, however, did not require as high a level of savings in terms of chemical costs before collecting and submitting soil samples for nematode assay purposes on a yearly basis (Table 5). MP users required a mean savings of $62.50/ha, whereas non-MP users required $125.00/ha before submitting yearly soil samples.

Factors influencing nematicide expenditures. Four factors significantly influenced the level of nematicide expenditures when all growers were included in the model (Table 6). If MP users were deleted from the model, only use of a root-knot nematode-resistant variety and the expected returns from use of a nematicide were significant.

Use of root-knot nematode-resistant tobacco varieties and crop rotation. MP users did not use root-knot nematode-resistant varieties to the same extent as non-MP users did. Only 33% of the MP users planted a resistant variety during 1980 compared with 69% of the non-MP users.

Planting of a root-knot nematode-resistant variety served as a suitable pesticide substitute for growers in both groups. If all growers are included in the model, the level of nematicide expenditures was reduced by about $15 when a root-knot nematode-resistant tobacco variety was planted (Table 7). If MP users are deleted from the model, the level of nematicide expenditures decreases by about $12. This represents a reduction in expenditure level of about 25–28%.

Crop rotation patterns were similar for both groups during the past 3 hr (Table 8). A majority of growers in both groups practiced crop rotation consisting of 1 yr or more of alternate crops in their tobacco fields rather than continuous planting of tobacco.

Ranking for selection of chemical soil treatments. Both grower groups ranked performance in previous crops as the main reason for selecting a particular chemical soil treatment (Table 9). MP users felt, however, that a second major reason would be results of a soil assay for nematodes, whereas the non-MP users rated cost and ease of application as equally important second reasons. Both groups ranked performance on a neighbor's farm as least important.

Sources of agricultural information. Local county extension personnel were the primary individuals contacted for all types of agricultural information for growers in both groups (Table 9). Local farm supply dealers were listed as a second choice, friends and neighbors as a third choice, and representatives of agricultural products companies were given as a fourth source of agricultural information.

Factors influencing planting of a root-knot nematode-resistant tobacco variety. Logit analysis (4,7) indicated that tobacco crop size had no significant influence on growers in either group concerning the decision to plant a root-knot nematode-resistant tobacco variety (Table 7). Both groups were influenced by the level of expenditures for nematicides and the frequency of observing yield losses attributable to nematodes. The level of expenditures for nematicides had a negative effect on the planting of a root-knot nematode-resistant variety, ie, growers considered pesticides a suitable substitute for a resistant variety, with the use of resistant varieties decreasing as the level of nematicide expenditures increased.

Frequency of observing yield losses attributable to nematodes had a positive effect on the use of root-knot nematode-resistant varieties for both groups, indicating complementary practices. No other factors were significant for non-MP users. When all growers were included in the model, crop rotation had a positive influence on the use of root-knot nematode-resistant varieties.

Other crop management practices. All growers preferred to apply insecticides

Table 6. Factors influencing nematicide expenditures among tobacco growers in survey with variable for observation of yield losses from nematodes in 1979 tobacco crop[a]

Variable	Parameter estimate: All growers	Non-MP users[b]
Intercept	19.38	34.38*[c]
Frequency of soil sampling	30.75*[c]	11.93
Submitted soil sample in 1979 for 1980 tobacco crop	13.75	2.54
Expected returns from the use of a nematicide	0.05**	0.06**
Planted a root-knot nematode-resistant variety	−14.92*	−11.87*
Crop rotation for tobacco (years out of 3 that a field will be planted to tobacco)	2.52	0.63
Hectares of other crops	−0.002	−0.01
Hectares of tobacco	0.09*	0.05
Years of formal education	0.48	−0.19
Years of experience with tobacco	0.04	−0.19
Observed yield losses from nematodes in 1979 crop	9.54	4.92

[a] All growers, $R^2 = 0.46$, adjusted $R^2 = 0.39$, $\overline{Y} = 54.23$, $n = 83$. Non-MP users, $R^2 = 0.46$, adjusted $R^2 = 0.37$, $\overline{Y} = 41.35$, $n = 68$.
[b] Non-MP users refers to growers who did not apply nematicides or multipurpose materials.
[c] * Indicates significant at $P = 0.10$, ** indicates significant at $P = 0.05$.

Table 7. Logit analysis of factors influencing planting of a root-knot nematode-resistant tobacco variety by survey growers[a]

Variable	Final coefficients[a]: All growers	Non-MP users
Constant	−2.45	−2.32
Frequency of observing yield losses from nematodes	0.48*[b]	0.63**[b]
Soil samples submitted in 1979 for nematode assay	0.48	1.67
Expected returns from nematicide	−0.001	0.002
Nematicide expenditures	−0.02**	−0.04**
Crop rotation for tobacco	0.74**	0.57
Observed yield losses from nematodes in 1979 crop	0.32	1.74
Hectares of other crops	0.03	0.01
Hectares of tobacco	−0.09	−0.01
Years of formal education	0.05	0.03
Years of tobacco farming experience	−0.01	0.01

[a] Non-MP users refers to growers who did not apply nematicides or multipurpose materials.
[b] * Indicates significant at $P = 0.10$, ** indicates significant at $P = 0.05$.

Table 8. Crop rotation patterns among tobacco growers in survey during 1978–1980

Pattern of crop rotation	Percent utilizing[a]: MP users	Non-MP users
1 yr of tobacco	13	25
2 yr of tobacco	56	34
Continuous tobacco	31	41

[a] MP users refers to tobacco growers who applied multipurpose fumigant materials and non-MP users refers to all other growers in the survey.

Table 9. Rankings by tobacco growers in survey for selection of chemical soil tratment and sources of agricultural information[a]

Reason	Ranking[b]: MP users	Non-MP users
Performance in previous crops	1	1
Result of a nematode assay	2	3
Cost of material	3	2
East of application	4	2
Performance on a neighbor's farm	5	4
Source		
Farm supply dealer	2	2
County extension agent	1	1
Friends and neighbors	3	3
Chemical company representative	4	4

[a] MP users refers to tobacco growers who applied multipurpose fumigant materials and non-MP users refers to all other growers in the survey.
[b] 1 = Most frequently selected reason or source. 5 = Least frequently selected reason or source.

based upon observed damage or the presence of pest insects rather than using a routine scouting program. No growers applied insecticides based on a calendar or crop-growth schedule or weather patterns.

Mean insecticide applications were 2.1 per season, with an initial application made early in the season (2–4 wk after transplanting) to control tobacco budworms (*Heliothis virescens*) and a second application made late in the season, primarily to control tobacco hornworms (*Manduca sexta*) or green peach aphids (*Myzus persicae*). No other insects were mentioned as consistent pests during the 1980 season.

More than 90% of the survey growers indicated that they did not tank-mix insecticides with growth-regulating materials used to retard development of axillary shoots ("suckers") after tops of plants were removed as a normal cultural practice. Growers indicated that they made one or more applications of a fatty alcohol material as a contact sucker control agent followed 10–14 days later by the recommended rate of maleic hydrazide, a systemic growth regulator. Removal of plant tops was carried out in the button to early flower stage by most growers. Fewer than 1% waited until full flower to remove tops.

Adoption of the Systems Plan. Most of the respondents indicated that they had used one or more of the seven disease management strategies of the Systems Plan (8). Sixty-nine percent of the growers used this approach to manage tobacco disease problems. The remaining 31% of the respondents did not practice crop rotation, an essential component of the Systems Plan.

DISCUSSION

Every attempt was made not to select growers based on any selection characteristic or categorical variable. Sampling methods used should have precluded any bias within the sample population. Any differences found in this survey are therefore considered representative of the true differences among tobacco farmers.

Biographical information for growers in this survey is consistent with data reported for North Carolina in the 1974 *Census of Agriculture* (1). The mean age of growers in that census was 52.9 yr, which compares favorably with the mean ages reported in this survey. The mean total crop land per tobacco farm was slightly higher in this survey than that reported in the 1974 census, but this may be due to random selection of one or more larger than average tobacco farms and the limited size of the sample population.

Nematode management. Users of MP materials were either more progressive or more risk averse when dealing with real and/or potential nematode problems. These growers generally had more formal education, ownership of tobacco allotments, and total amount of land in other commercial crops and they also submitted soil samples more frequently for nematode-assay purposes. Because larger farms require more capital investment, especially for a specialized crop such as tobacco, these growers may be sampling more frequently for better monitoring of nematode populations. Because 69% of the MP users had never experienced yield losses attributable to nematodes, however, it appears that sampling may actually be the method of assessing the effectiveness of the MP materials used rather than as a means of determining the need to treat based upon a known threshold (8,10). Although soil sampling for nematode assay purposes was used more frequently by MP users, with only 6% of non-MP users submitting samples, they were not using the results to determine the need for a nematicide.

Growers using MP materials also were influenced significantly by the size of their tobacco crop when determining the level of nematicide expenditures, whereas non-MP users were not influenced by tobacco crop size (Table 6). This implies that MP materials are often used as routine crop management tools to ensure a successful crop and protect the large investments required for this type of crop. These routine applications may also account for the low frequency of yield losses attributable to nematodes.

Users of MP materials also expected much higher returns on investment in nematicides than did growers not using MP materials (Table 4). These higher expected returns may be due to observation of field tests conducted by the agricultural extension service (9) in fields known to have moderate to high nematode population levels and/or soilborne disease levels. Under these conditions, Todd (9) has reported consistently higher yields and returns where nematicides and/or MP materials are applied compared with untreated plots. Net gains of $1,250/ha occur in fields containing high pathogen or nematode population levels, but Kirby et al (*unpublished*) found net gains far below this figure in fields with low populations of nematodes and soilborne diseases. Growers treating fields where there have never been observed yield losses to nematodes may be anticipating unrealistically high returns based upon incorrect interpretation of extension tests.

Although R^2 values for the regression model (Table 6) account for less than half of the observed variation from our survey results, we think this may be due to factors influencing growers when determining a level for nematicide expenditures not included in our model, ie, waiting period for nematicides, advice received from sources not listed in our survey, availability of tobacco transplants when needed, infrequent pest problems, and weather conditions. More important than R^2, however, is the fact that four variables were found to be statistically significant in explaining the differences in nematicide use among tobacco growers (Table 6).

Resistant varieties. Growers in this survey appeared to use root-knot nematode-resistant tobacco varieties as part of their nematode management plans. Regression coefficients indicated that both MP users and non-MP users would be willing to reduce nematicide expenditures by $14.92 and $11.87, respectively, when planting a root-knot nematode-resistant variety. This indicates that a resistant variety serves as an acceptable substitute for part of the nematicide expenditures. Many MP users, however, still favor use of pesticides because only 33% of the MP users planted root-knot-resistant varieties compared with 69% of all other growers.

Logit models (4,7) revealed that as the frequency of observing yield losses attributable to nematodes increased, use of root-knot nematode-resistant varieties also increased (Table 7). Logit models also indicated that as the level of nematicide expenditures increased, use of root-knot nematode-resistant varieties decreased. This agrees with the regression models (Table 6), which indicated a similar inverse relationship between nematicide expenditures and planting of root-knot nematode-resistant tobacco varieties. This indicates that tobacco growers recognize the need for a management approach using several complementary practices rather than relying only on nematicides.

Although biographical factors did not significantly influence the decision-making process concerning chemical soil treatments or root-knot nematode-resistant varieties, they influence the frequency of soil sampling as evidenced by the differences in sampling frequency among MP users and all other survey growers (non-MP users). MP users had slightly higher levels of formal education and farming experience with tobacco crops. This may indicate that although these factors are not significant, they do play a role in the acceptance of soil sampling among tobacco growers.

Adoption of the Systems Plan (8) by most growers indicates that IPM programs have become a part of tobacco crop management. Because growers are willing to substitute resistant varieties for a portion of the nematicide expenditures, they are not relying upon a single method of controlling nematodes but have accepted the use of an integrated approach. The low use of soil sampling for monitoring nematode populations, however, seems to indicate an unwillingness on the part of tobacco growers to adopt predictive methods in an integrated management approach. At the time of this survey, North Carolina was charging only $1/nematode sample, so we believe that processing costs did not play a significant role in influencing the frequency of soil sampling.

Results of this survey emphasize the reliance that tobacco growers have on proven methods of disease and/or nematode control. Pesticides still remain the preferred method of dealing with all levels of known and potential pests. Although Kirby (*unpublished*) has shown that an IPM approach using scouting and surveying is an economical alternative to routine insecticide applications and can substantially reduce both the number of insecticide applications and costs, tobacco growers still seem unwilling to adopt these approaches for nematode management. There is a need for future surveys encompassing larger groups to increase information and to develop predictive models to further define the role of integrated pest management among tobacco farmers.

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