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New Directions in Integrated Pest Management Technology Transfer:

Research on Peanut Farmers, Attitudes, and Socioeconomic Impacts

PEANUT COLLABORATIVE RESEARCH SUPPORT PROGRAM

On the cover:

Pheromone traps in the field (left) monitor the buildup of beetles to predict outbreaks of southern corn rootworm. When the number of beetles collected (right) is 45 or less per week, chemical treatments may be eliminated due to low risk for rootworm damage.

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NEW DIRECTIONS IN INTEGRATED PEST MANAGEMENT (IPM) TECHNOLOGY TRANSFER: RESEARCH ON PEANUT FARMERS, ATTITUDES, AND SOCIOECONOMIC IMPACTS[1]

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Preface

Integrated pest management (IPM) can reduce the use of chemicals for insect control in peanut, which will reduce costs and potential damage to the environment.

The IPM study reported in this paper evaluates attitudes toward IPM adoption and socioeconomic impacts. The Study was supported by USAID, Grant No. DAN-1310-G-00-0045-00 to Michigan State University (MSU), Bean/Cowpea CRSP for impact studies by several CRSPs. A subsequent subgrant from MSU to The University of Georgia provided funds for a subgrant to North Carolina State University to conduct the IPM impact study.

We acknowledge the cooperation, support, and interest of the Department of Sociology and Anthropology at North Carolina State University in conducting the research reported. Also, the contributions of Dr. W. V. Campbell and students in the Department of Entomology, North Carolina State University for earlier research basic to the development of the IPM strategies for southern corn rootworm control and present research continued by Dr. R. L. Brandenburg to refine the strategies are acknowledged. The research of Drs. Campbell and Brandenburg was supported by the Peanut CRSP Grants DAN-4048-G-SS-2065-00, and DAN-4048-G-00-0041-00, and the North Carolina State Agricultural Research Service and Agricultural Extension Service. Appreciation is also extended to Dr. Brandenburg for review of the manuscript.

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ABSTRACT

Integrated Pest Management (IPM) involves a set of practices aimed at agricultural pest control and profitability, while simultaneously increasing protection of the environment and the health of individuals. One trend in IPM research has been directed toward farm and farmer characteristics. The literature review indicates for example that age, education, and income of the farmer and size of farm are positively associated with IPM acceptance. However, the decision to adopt new technology is made through obtaining and trusting the utility of new technological information, a process of communication and social interaction. Growers' attitudes and perceptions will also influence the process. The following social and social psychological influences are discussed in this report: (1) the perception of effectiveness of pesticide uses, (2) attitude toward protecting the environment, and (3) supporting attitude of growers' family and social network. Research is urgently needed on the three latter topics in order to improve technology transfer efforts.

The review of the literature on IPM related to peanut growers indicates the following key findings, which are discussed in detail in this report: (a) One of the most profitable crops associated with the use of IPM is peanut, (b) IPM contributes to increased net yield and net return, while it leads to decreased pesticide use. The latter benefits both the environment and the personal health of those who would come into contact with the pesticides. Further, (c) new and promising IPM techniques for peanut are being developed by Peanut CRSP sponsored research efforts, which show that chemicals used for southern corn rootworm control can be reduced by 42 tons annually for a savings of about $840,000 in the Virginia-North Carolina area.

I. INTRODUCTION

Integrated Pest Management (IPM) is a multiple purpose, multiple practice system for agricultural pest control. The IPM program differs in important respects from predecessor programs for controlling pests. Among its relevant features we would emphasize first that, unlike the conventional pest control which utilizes heavy scheduled use of pesticides, IPM is aimed at protecting the environment and useful insects; pesticides are used efficiently and only when needed. Second, at the same time, IPM was designed with profit in mind; its use should maintain or increase profitability. However, gross yields alone are not the focus. Indeed a small amount of pest damage may easily be tolerable if the overall management regime is less expensive. From this point of view, the following four farming practices may be considered as the typical IPM components for peanut growers: 1). scouting (for pest damage), 2). leaf spot advisory, 3) periodic weed checks, and 4). treating fields differently by switching spray intervals (Garber and Hoban, 1990 p.5).

Besides the farming practices discussed above, a variety of factors are important in effective pest control and increasing the net profitability of peanut farming: (1) determining the timing and economic threshold of pesticide application, (2) preserving the natural enemies of insect pests, (3) temporary and long term conditions of the natural environment (e.g. weather and soil type), and (4) countering the pesticide resistance of pests (Brandenburg, 1990; Brandenburg and Kennedy, 1987; Satayavirut, 1988). (Much previous research has focused upon analyzing the possibility of increasing peanut yield and the analysis of pesticide uses.) However, given the complex array of potential influences, there is no single perfect method for pest control.

Another trend of IPM research, based upon a diffusion research orientation, has focused upon farm and grower characteristics (Anosike et. al., 1990, Hooks et al., 1983; Rajotte et. al., 1987). They found that grower and farm characteristics such as age, education, income, and farm size were positively associated with accepting IPM. These characteristics were the key determinants to accepting a new IPM technology. In addition, some research has emphasized psychosocial orientations (i.e., grower's attitudes and perception toward factors which could influence IPM adoption) in the process of IPM adoption (Garber and Hoban, 1990; Thomas et. al., 1990). The underlying assumption of this model is that the decision to adopt IPM is a function of access to information and positive attitude toward IPM (Garber and Hoban, 1990; Hooks et. al., 1983).

The decision to adopt a new technology is made through the process of communication and social interaction. For this reason, growers' attitudes and perception will also influence the processes of IPM adoption in addition to farm and grower characteristics. The following attitudes and perceptions are emphasized in this report because they are hypothesized to distinguish IPM cooperators from IPM non-cooperators: (1) the perception of effectiveness of pesticide uses, (2) attitude toward protecting the environment, and (3) Supporting attitude of growers' family and social network toward adopting IPM.

Knowing a grower's attitudes and perception toward IPM is still not enough to explain the wide variations in IPM adoption. For more adequate understanding of IPM acceptance, it is necessary to examine the social contexts in which social interaction and communication take place. The best example of them is the social network in which each individual engages in everyday life. The social network is particularly important when it serves as a source of information in promoting IPM adoption (Rajotte et al., 1987; Thomas et. al. 1990).

In this study, the social network will be considered as will social contacts and perception associated with extension specialists and the reference group such as opinion leaders and other growers. Based upon the preceding research emphases discussed above, this study will focus upon social-psychological and social context factors such as psychological attitudes and social network associated with IPM adoption. Previous research suggests that farm and grower characteristics are important determinants in adopting IPM. However, it is also critical to understand the processes and social context where IPM is diffused. In short, the focus is on explaining how these social and social psychological factors mediate the process of IPM acceptance under which grower and farm characteristics are given. In addition, we will examine the importance of three groups of factors (farm and farmer's characteristics, psychological attitudes, and social network) in accepting IPM.

II. FARM AND FARMER'S CHARACTERISTICS AND IPM ADOPTION[2]

1. Grower Characteristics and IPM Adoption

Generally, diffusion research has suggested that there is a positive relationship between early adoption of new ideas and level of education (Rogers, 1983) (see, Figure 1, Path 1).[3] Besides affecting the timing of adoption, individuals' intellectual level and their comprehension of the new idea may be important factors affecting their persuasibility (Zimbardo and Ebbesen, 1969). In other words, a grower's educational level, which is associated with intelligence and better information processing ability, can enhance the acceptance of IPM (Anosike and Coughenour, 1990; Thomas et. al., 1990). Thus, the educational level among growers will be a positive indicator of IPM acceptance.

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[2]In this paper age and education represent grower characteristics. Farm characteristics mean land and socioeconomic resources that growers have. Farm size and cropping are the most typical indicator to these resources. Farm size is considered by acreage, irrigation status, and gross income. Cropping consists of the percentage of peanut crops, other IPM crops, and non-IPM crops. For more detailed classification of Farm and Farmer's Characteristics, see Appendix 2, page 23.

[3]For the entire model of IPM adoption, see Appendix 1, page 22.

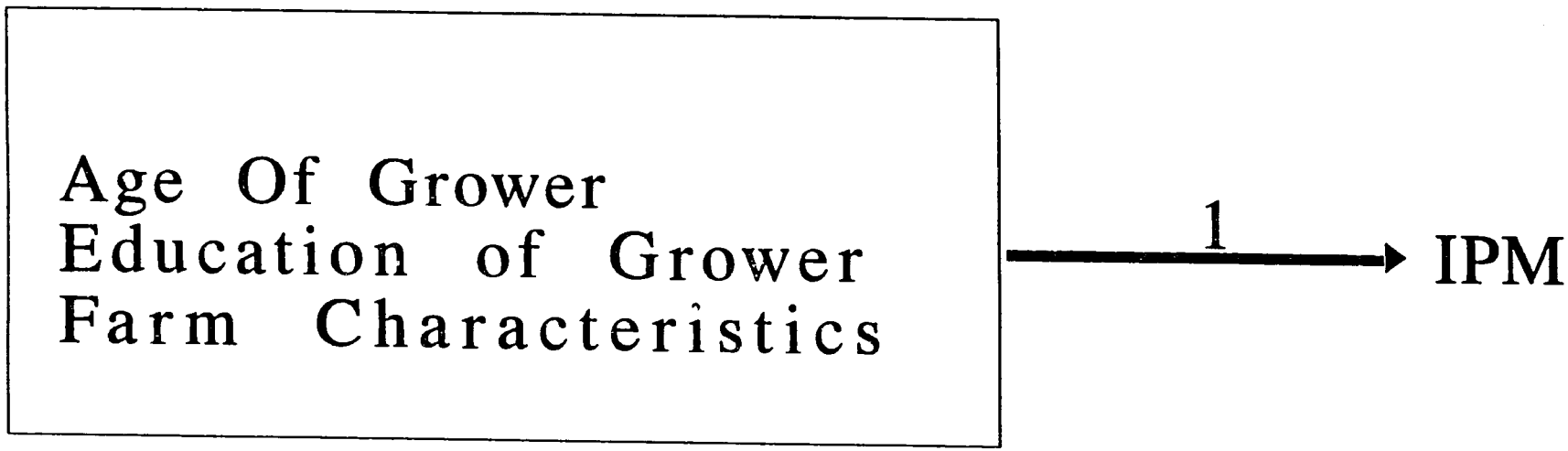

Figure 1. Farm and Farmer's Characteristics and IPM Adoption (Path 1)

Age has a negative influence on adopting IPM. Generally, older growers are less energetic in responding to a new goal and less willing to accept risk (Anosike and Coughenour, 1990; Thomas et. al., 1990). The negative relationship of age to IPM adoption is also due to the younger growers' tendency to be more active in collecting information about pest control and more sensitive to increasing their economic benefits. Age and education level are helpful in identifying the most likely IPM converts, but do not provide information which would increase the effectiveness of technology transfer efforts with all potential IPM users. The same is true for farm characteristics.

2. Farm Characteristics and IPM Adoption

Previous IPM research supports the idea that farm size is significant to the adoption of IPM. Hooks and his colleagues (1983) point out that small farm size can play a role in the economic constraint which hinders adopting behavior. The constraints mean that adequate land and capital resources can facilitate using more complex technologies and employing high technology equipment (Hooks et. al., 1983 p. 319). In other words, large farm size functions as a facilitator in the diffusion process because the "ability to farm large acreage satisfies a necessary condition for the use of other technologies" (Hooks et. al., 1983 p. 311). This line of reasoning suggests that farm size is positively related to IPM adoption because, generally, farm size can be a powerful indicator of other more complex farm characteristics. Moreover, large farm size is a typical characteristic of growers who produce a variety of crops.

III. PSYCHOLOGICAL ATTITUDES AND IPM ADOPTION

1. Farm and Farmer's Characteristics and Psychological Attitudes

Grower characteristics are also associated with the perception of pesticide effectiveness. (See Figure 2, Path 2 for illustration.) Age, as indicated, has a negative relationship to IPM adoption. The older growers rely more upon their experience than the younger growers. Thus, the older growers are more likely than the younger growers to believe in the effectiveness of pesticides. However, education has a negative relationship to belief in the effectiveness of pesticide. In short, younger and better educated growers are less likely to believe in the conventional effectiveness of pesticide uses. Furthermore, they are more willing to take risks in adopting a new idea (Thomas et. al., 1990). In conjunction with this, we hypothesize that concern for protecting the environment is positively associated with grower characteristics such as high education and younger age.

Rogers (1983) suggests, in his review of diffusion research, that innovators or early adopters show the following personal characteristics: "less dogmatic," and "more empathetic," (that is, the ability to take the role of others), and more "rational." Based upon this finding, we can infer that these tendencies are more closely related with high education than with low education. Therefore, it is hypothesized that high education also leads growers

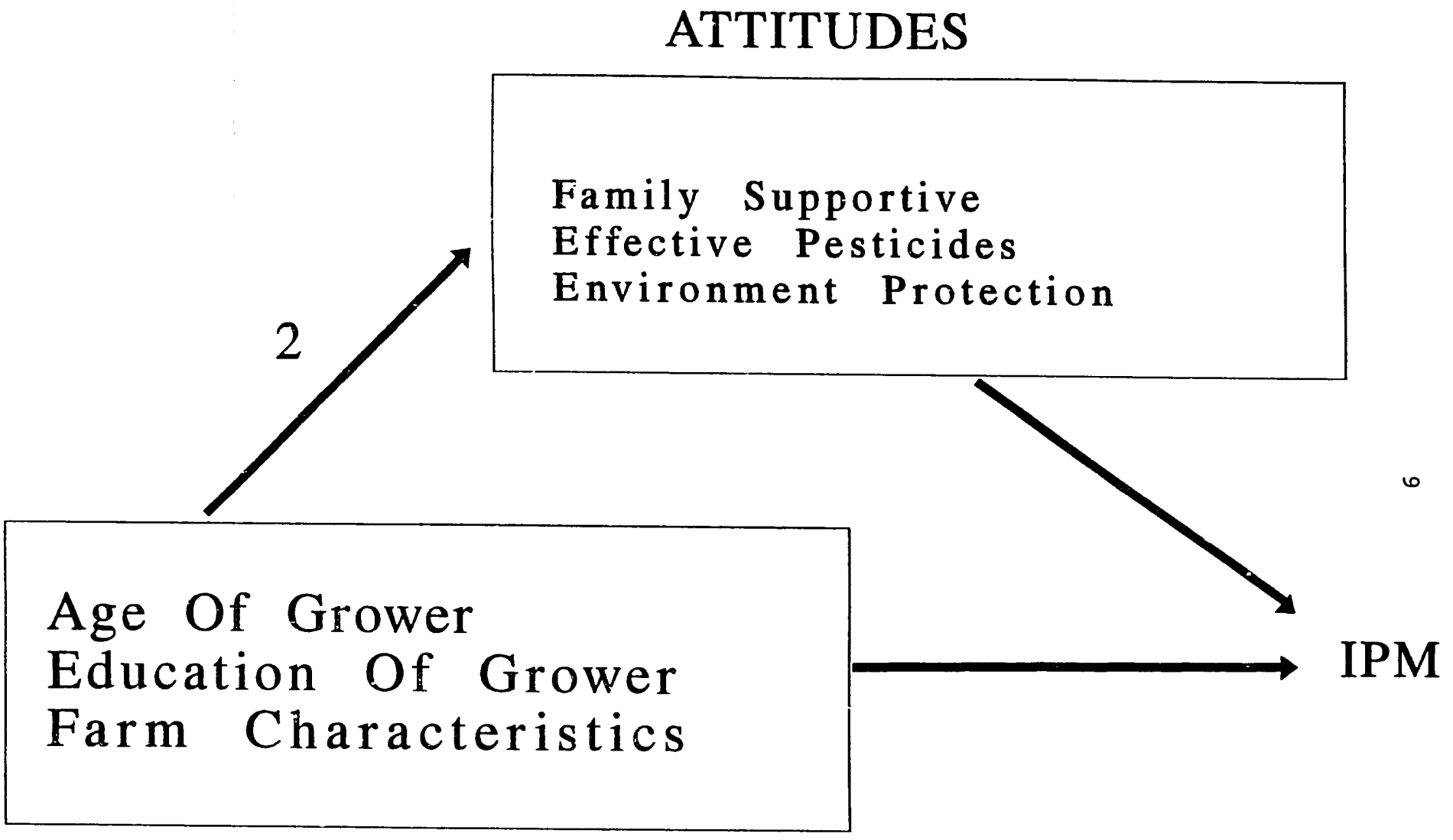

Figure 2. Farm and Farmer's Characteristics and Attitudes (Path 2)

to more openness to their spouse's and children's opinions. Consequently, education should have a positive association with the influence of family support for IPM.

Age is expected to play a negative role in IPM support from the family. As children grow up, the older growers are more likely than the younger growers to experience the "empty nest" situation due to the children's marriages and leaving home. As a result, they are less likely to share their opinions with their children and vice-versa. Moreover, they tend to depend relatively more upon their experience and past farming practices rather than upon the opinion of their family members. This tendency becomes more pronounced if the older growers are less concerned with keeping up with new information and research. Thus, we assume that as a grower's age increases, there is less chance to get support for IPM from their family.

Farm characteristics play a role associated with grower characteristics such as education. The two characteristics are indicators of socioeconomic status. It is highly possible that the effect of farm characteristics is mediated through grower characteristics and that the two characteristics correlate or exhibit an interaction effect. It is expected that farm characteristics may have a similar relationship with psychological attitudes.

2. Psychological Attitudes and IPM Adoption

IPM Adoption is influenced directly by changing growers' attitudes. (See Figure 3, Path 3). Little research has focused upon social psychological aspects (Garber and Hoban, 1990; Thomas et, al., 1990). The decision to adopt a new technology in good part depends upon individual orientation. Generally, a person makes up his or her mind on the basis of perceptions and attitudes toward a certain object or event. At the same time, the individual decision is also influenced by the evaluation and validation from significant others such as family, friends, and colleagues (Blumer, 1969). The underlying logic of this hypothesis is that attitudes are influenced by patterns of social interaction in everyday life; in turn, attitude change precedes behavioral change. IPM diffusion inherently requires an attitude change process. Generally, people change their attitudes because they are influenced by others to change their attitudes (Zimbardo and Ebbesen, 1969). Knowledge of this same social attitude change process can be applied to the IPM diffusion process.

It is possible to employ social psychological aspects to differentiate IPM cooperators and non-cooperators by analyzing their attitudes associated with IPM adoption. Thus, the perception of pesticide effectiveness can be a significant indicator of IPM cooperators and non-cooperators. Growers who believe that pesticide is very effective in controlling harmful insects, are more likely to be reluctant to adopt IPM (e.g., because they depend upon their confirmed past experience with pesticide pest control rather than risk the untried new IPM technology). Thus, these growers tend to be more frequent users of pesticides. Growers who doubt the effectiveness of pesticide are more likely to become IPM cooperators.

IPM adoption is also influenced by the growers' attitudes about protecting the environment. Garber and Hoban (1990) found that a grower's attitude about protecting the

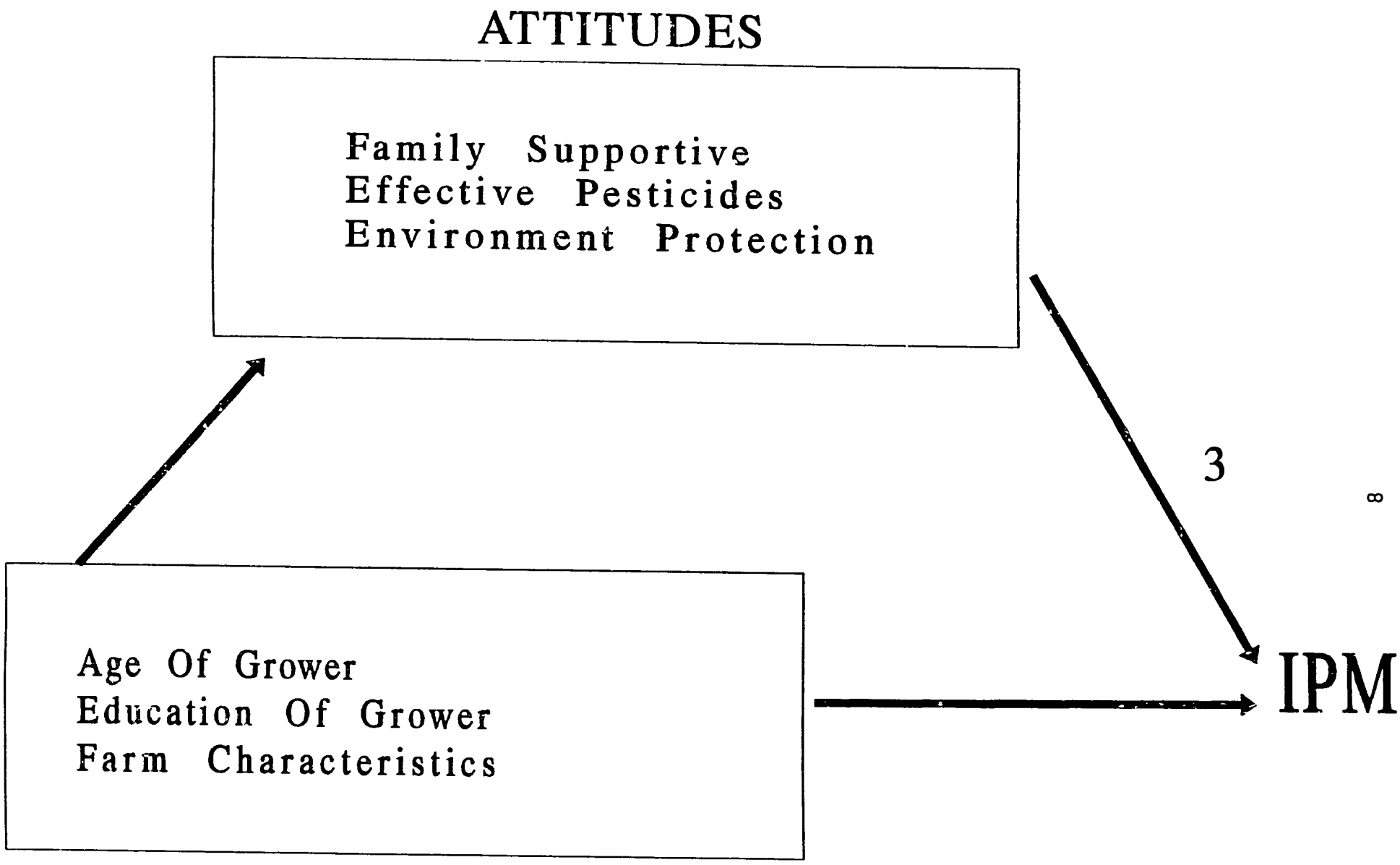

Figure 3. Attitudes and IPM Adoption (Path 3)

environment was positively related to IPM acceptance. If growers have an interest in protecting the environment, they are more likely to accept IPM than those who do not care about the environment. Thomas et, al. (1990) found that preservation of beneficial insects as an IPM practice was used more frequently by better educated growers who had higher gross farm sales. This suggests that a pro-environment attitude is positively related to education.

The other dimension of the social psychological aspect comes from the influence of the growers' families' attitudes toward IPM. Family may be an important source of decision making information associated with the adoption of IPM. IPM support from the grower's family may be a significant indicator of the potential to change growers' attitude toward IPM because family is one of the powerful influences on personal attitudes. One way of producing a general change in behavior is interpersonal communication between people who know each other such as members of a family (Zimbardo and Ebbesen, 1969).

IPM support from the family can create dissonance which motivates a change to IPM adoption. According to cognitive dissonance theory, if growers do not support IPM adoption, the supportive attitude for IPM from their family would be a dissonant factor. In this case, the theory predicts that growers would attempt to reduce this cognitive inconsistency (Zimbardo and Ebbesen, 1969). They may experience persistent dissonance, if they become aware that the benefits and desirability of IPM are perceived and felt strongly by family members. Thus, because growers are under the personal influence of their family, because of the importance of IPM, and given this dissonance status, farmers may change to a consonant one (that is, to accept IPM) in an attempt to reduce the dissonance.

IV. SOCIAL NETWORK

1. Farm and Farmer's Characteristics and Social Network

Grower's adoption of IPM will be affected by several direct and indirect factors. The level of grower's education will have a positive effect and age will have a negative effect on pre-adoption behavior (e.g. extension and reference group contact). In other words, younger and better educated people have more contact than others with information sources about new technologies (Thomas et. al., 1990). Furthermore, Thomas et. al. (1990) argue that favorable beliefs and cognitive information accelerate adoption behavior. According to their study, private consultants, group meetings, and interpersonal communications were important sources of information in influencing IPM beliefs and adoption.

The diffusion process, according to Garber and Hoban (1990) can be explained by social learning theory. They argue that the diffusion process may be accelerated by change agents. This point is supported by Rogers (1962). He argues that a change agent is an important factor in influencing clients' innovation decisions. In addition to this, he emphasizes the importance of the role of opinion leaders. Opinion leaders, in general, have effects on other individuals' attitudes and behavior. "Change agent success is positively related to the extent that he or she works through opinion leaders" (Rogers, 1962 p. 331). In this context, we can assume that

grower characteristics and farm characteristics are closely related with extension contact, perception of extension, and perception of reference group (see Figure 4, Path 4).

According to some studies (Garber and Hoban, 1990; Thomas et. al., 1990), age is negatively associated with extension contact, perception of extension, and perception of reference group. Thus, younger growers are more likely to contact agents and they are alert to the importance of knowledge of innovations. Younger farmers are more likely to rely on their reference group through interpersonal communication. However, according to Rogers (1962), there is no consistent evidence about the relationship of age and innovativeness; about half of the 228 studies on this subject show no relationship. Therefore, certain conditions may overcome the age factor and need to be identified through research.

As Rogers (1962) theorized, earlier adopters have several socioeconomic characteristics: 1) more years of education, 2) higher literacy rates, 3) higher social status, 4) larger-sized farms, and 5) more likely to have a commercial economic orientation. In other words, more educated people are more likely to innovate. Therefore, they are more likely to contact an agent in order to secure new ideas and technologies. And thus they are aware of the importance of extension.

Farm characteristics which can be addressed as socioeconomic status include gross income, acreage, and irrigation status. Gross farm income is positively related with extension contact. In other words, larger growers are more likely to keep up with new research, and to adopt IPM practices. The growers who have a higher socioeconomic status will likely have greater innovativeness. Farm characteristics are also positively associated with extension contact and perception of extension.

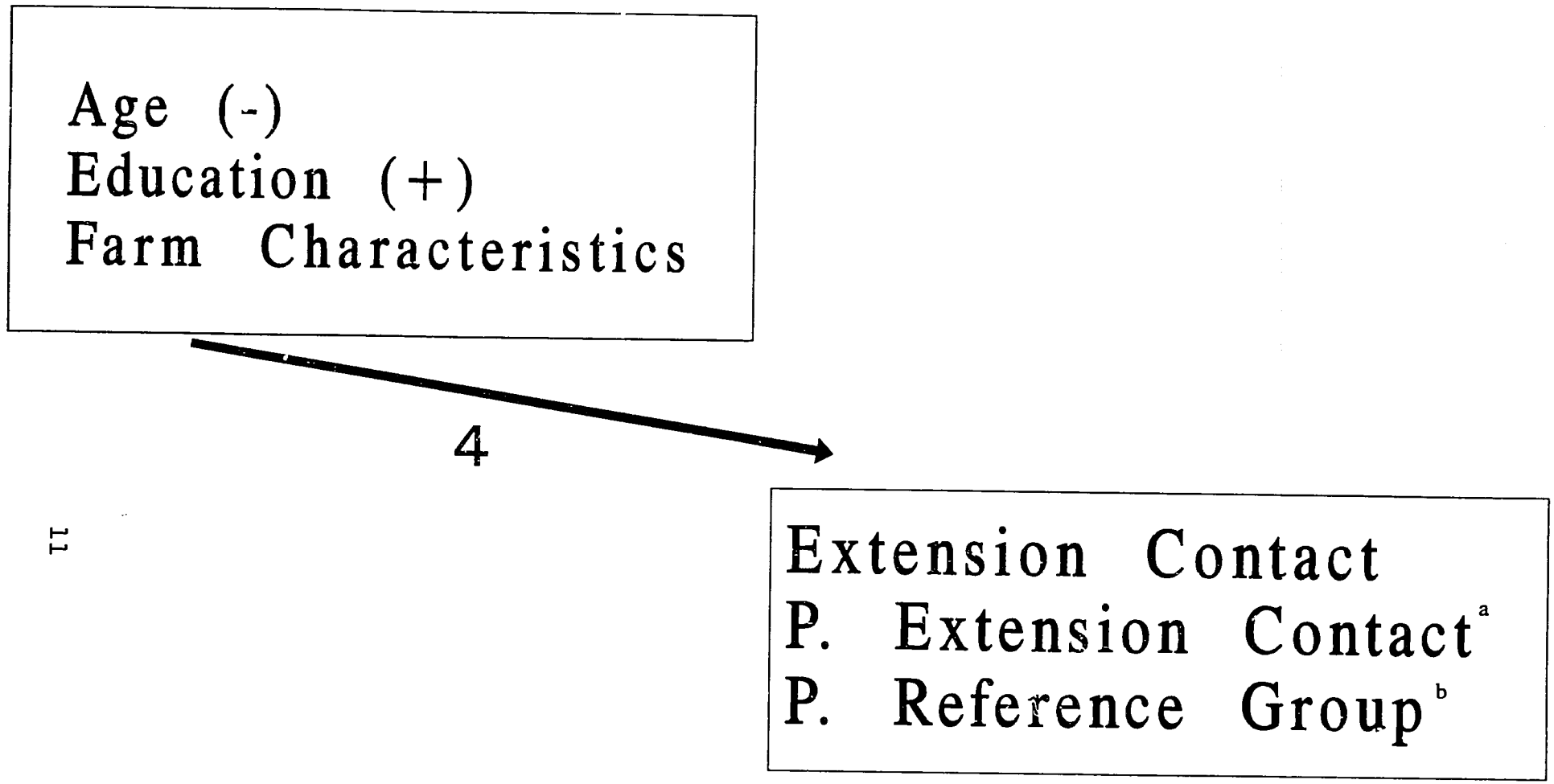

Figure 4. Farm and Farmer's Characteristics and Social Network (Path 4)

[a] Perception of Extension Contact

[b] Perception of Reference Group

2. Social Network and IPM Adoption

When IPM methods are applied, pest control costs are lower than with exclusive use of conventional methods, and net yields are often higher. Thus IPM practices substituted for pesticide use can be effective in reducing pest population and the incidence of pesticide resistance (Brandenburg et. al., 1987).

Evidence reviewed above suggests that grower characteristics and farm characteristics have a direct effect on IPM beliefs and IPM adoption. However, IPM adoption may be accelerated by extension contact and its awareness (see, Figure 5, Path 5).

Social learning and diffusion theories explain how individuals change their attitudes and behaviors as a result of interpersonal communication with another individual (Rogers, 1962). Information exchange facilitates change in attitudes and behavior. Therefore, reference groups as opinion leaders have an important role in adopting IPM behavior. Rogers argued that earlier adopters are more highly interconnected socially, they have greater exposure to interpersonal communication channels, and they are likely to be opinion leaders. Therefore, the adoption of IPM is a system process deeply rooted in the social and psychological context. In short, psychological attitudes, grower characteristics, and farm characteristics have an important role in adopting IPM behavior. IPM adoption leads to increased net yields and a decrease in pesticide use.

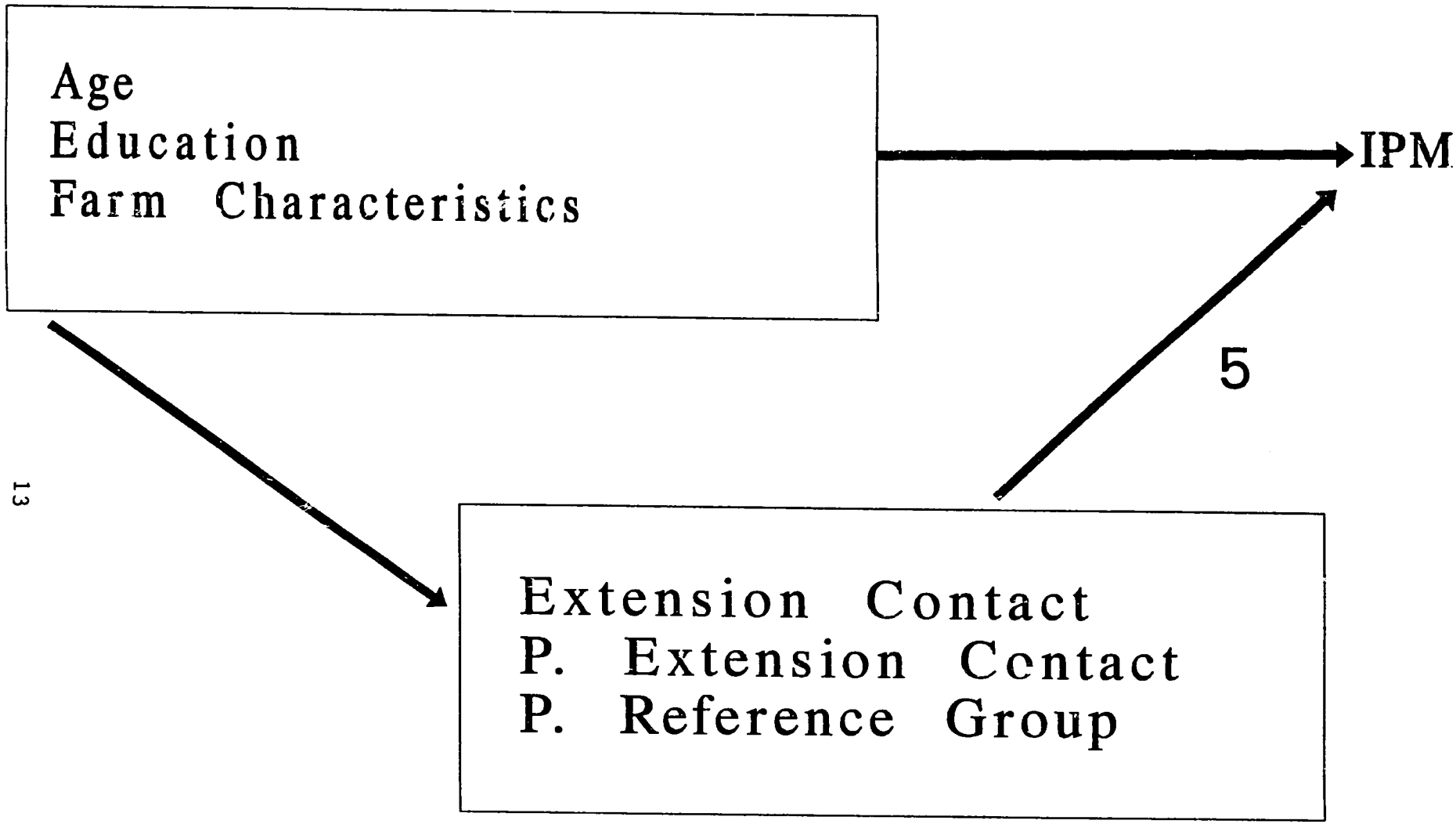

Figure 5. Social Network and IPM Adoption (Path 5)

V. BENEFITS OF IPM

Integrated Pest Management (IPM) is designed for the purpose of increasing net yield and protecting the environment at the same time. For this reason, it considers many possible farming practices. Several benefits are possible through adoption IPM technology first, IPM can reduce the costs associated with pest management. Second, it reduces crop losses. Third, it is able to reduce chemical use. Fourth, it reduces negative impacts on human health and the environment (Rajotte et. al., 1987). In the case of peanut growing, it can "reduce pesticide expenditures by $20~50/acre" (Linker, 1989 p.26).

The National Evaluation of Extension's IPM programs (Rajotte et. al., 1987) contains actual data on increasing net yield and decreasing pesticide costs.[4] Table 1 shows net yield and net return in accordance with crops and different levels of IPM use. Although the amount of benefits of IPM were not constant, generally, IPM contributed to increased net yield and net return, while it led directly to decreased pesticide costs.

In general there are large differences in net yields by level of IPM use. A variety of factors undoubtedly account for these differences and there are marked differences between types of crops. For peanuts there are large net returns. The range is $106.60 per acre for "High Users" and $59.72 for "Low Users." There are also reductions in pesticide costs. Increasing the number of IPM users among peanut farmers would have substantial additional socioeconomic impacts.

The most profitable crop associated with IPM technology is peanut, whereas the least profitable one is tobacco. Furthermore, high IPM users experienced lower losses than did low users and non-users, even for crops such as apple and corn which did not produce net returns.

Similarly, Thomas and his associates (1990) found in their study of Texas cotton growers that IPM was also effective in producing increased net yield.[5] In addition, the amount of net yield increases as growers come to adopt more practices of IPM. Consequently, as Rajotte and his colleagues (1987) pointed out, IPM is an effective and useful program for growers because it increases quality of crop yield and net financial returns.

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[4]Moreover, Rajotte and his colleagues (1987) argue that "considering only the approximately 3500 growers in this study (covering 15 states and 9 commodities), IPM users experienced a total difference in net returns over non-users in excess of $54 million per year" (Executive Summary p.7).

[5]They analyzed the two types of cotton for this purpose. The net yield was; upland-type cotton: 1,009.33 Ibs/acre, pima-type cotton: 141 Ibs/acre.

Table 1. Benefits of IPM by crops and level of IPM use

State	Crop	% of IPM Non-Users	Net Yield[a]	Net Return[b]	Pesticide Costs
Georgia	Peanut	20.7	239.45 (LBS/Acre)	106.40H[c] ($/acre)	43.79 H ($/acre)
				59.72 L[d]	38.11 L
				32.65 N[e]	48.93 N
Indiana	Corn	31.0	9.35 (Bushel/acre)	-18.10 H	25.30 H
				-21.46 L	23.46 L
				-48.66 N	17.41 N
New York	Apple	19.3	82.5 (Bushel/acre)	-122.07 H	143.64 H
				-160.91 L	156.19 L
				-371.10 N	169.25 N
North Carolina	Tobacco	13.3	6.35 (Pounds/acre)	2,046.89 H	56.71 H
				1,983.05 L	53.96 L
				2,027.83 N	56.58 N
Virginia	Soybean	25.1	0.85 (Bushel/Acre)	26.49 H	19.64 H
				15.35 L	15.92 L
				19.69 N	15.15 N

Source: The National Evaluation of Extension's Integrated Pest Management (IPM) Programs conducted by Virginia Cooperative Extension Service, Virginia Tech and Virginia State, and United States Department of Agriculture-Extension Service

[a]Net Yield= the average yield of low and high users - the yield of Non-users.

[b]Net Returns= (Gross Returns - Total Preharvest Costs (i.e. Pest Management Costs such as pesticide application, scouting costs) - Total Harvest Costs - Fixed Costs (i.e. Machinery and Equipment and Land Charge))

[c]H= High Users of IPM

[d]L= Low Users of IPM

[e]N= Non-Users of IPM

VI. Promising New IPM Technology For Peanuts

IPM techniques continue to be developed. Education and extension agencies' adoption technology needs to be developed concomitantly. An example of new and evolving IPM technology is the CRSP funded basic research done by Dr. William Campbell and his students at North Carolina State University in the 1980's.[6]

This line of work has been continued at North Carolina State by the applied research of Brandenburg, Barbour, and Herbert (1992). In this recent research populations of adult male southern corn rootworms (SCR) were monitored and percent pod damage evaluated, for 107 peanut fields in North Carolina and Virginia from 1986 through 1990.

While the percent pod damage was not consistently related to numbers of adult male SCR as determined by pheromone catches, fields with trap catches with less than or equal to 45 beetles per trap per week appeared to be at low risk for SCR damage. When SCR numbers averaged less than 45 beetles per trap per week, percent pod damage averaged less than 3%, suggesting that this number may be used as a low-end cutoff for SCR treatment. Using this number as a low-end treatment cutoff would have eliminated pesticide treatment for SCR control on about 17% of the sample (42,000 acres of Virginia and North Carolina peanuts), reducing the amount of active ingredients applied in this sample by 42 tons.

This reduction in pesticide treatment represents a savings of approximately $840,000, without including application costs, nor any environmental consequences. Current work by Barbercheck (unpub data) and Brandenburg and Barbour (unpub data) are further refining the guidelines. The use of feeding on floral attractants in traps to capture both males and females will most likely lead to a more accurate estimate of potential rootworm threat and significantly increase the percent acreage not requiring treatment. In addition, work using a soil drainage model has great potential for further refinement in identifying high risk fields.

These new studies suggest IPM practices which would increase the percentage of acreage on which we can eliminate chemical treatment from 17% to at least 40% of peanut acreage. This would represent a two million dollar savings annually in pesticide costs in just the Virginia-North Carolina peanut area alone. These benefits are derived directly from the initial and on-going Peanut CRSP research.[7]

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[6]Examples of IPM work related to peanuts include: G. E. Brust, and G. L. House, 1990a and 1990b; L. S. Boykin et. al., 1984; R. N. Holley, et. al. Theses (supported by CRSP) related to this work on peanut include: Browde, 1988; Brust, 1989; Keeley, 1987; C. W. Kollmer, 1985; Satayavirut, 1988.

[7]Personal communication from Dr. R. L. Brandenburg, Department of Entomology, North Carolina State University, June 1992.

While the authors did not feel the results were ready for incorporation into an IPM program, the data do provide a basis for future perfection of the idea. They recommend future research incorporating factors directly related to survival of SCR eggs and/or larvae, such as moisture content of the top 5-10 mm. of soil (where eggs and early instar SCR are found) and increasing top density in sampling.

With such sophisticated IPM techniques, crop, economic, and environmental impacts will need sophisticated adoption strategies and tactics in order to gain farmer cooperation in their application. Research developing and refining a strategy for encouraging and speeding IPM adoption, therefore, is greatly needed now so that adoption techniques will be available when the new IPM technologies are ready.

VII. SUMMARY AND CONCLUSION

Previous IPM research indicates that grower and farm characteristics significantly influence IPM adoption. These characteristics have served as the fundamental factor distinguishing IPM cooperators from non-cooperators. However, for more adequate understanding of IPM adoption processes, this paper points to a need for more emphasis on psychological and social factors such as grower's attitudes and social network which can mediate the relationship between farm and farmer's characteristics and IPM adoption. This mediating role comes from the fact that the two categories (social and social-psychological factors) discussed can create opportunities for communication and social contacts, which are the central social mechanisms facilitating IPM acceptance: (1) Favorable attitudes and perception associated with IPM are prerequisite to IPM adoption and need to be studied. (2) The social network functions as an important information delivery channel and information enhancement and legitimization which leads to IPM adoption, but needs research to specify the most effective techniques and strategies. In other words, the diffusion of IPM technology eventually depends on the social interaction of growers, their family members, and attitudes and perception of IPM and the environment.

The most important benefits from IPM adoption are increased net yield and net financial returns. However, to preserve these benefits, the following considerations should be assessed in future IPM research. First, as Garber and Hoban (1990) point out, how to motivate use of all possible IPM methods and practices for growers is not resolved. Generally, growers participate in only some IPM practices, even though average net yield increases as the number of IPM practices increase (Thomas et al.). The research question of how to promote the whole group of IPM practices needs to be assessed in order to produce optimal benefits of IPM. Second, it is still open to question whether growers will consider environmental and health issues, as well as, the economic benefits from IPM adoption at the same time. Just how important these attitudes are to the adoption process is an important research question.

Thus, future research will need to concentrate on how to most effectively educate growers about the importance of the non-economic benefits of IPM such as preserving the general environment and especially useful insects. (Rajotte et. al., 1987) The third issue is how

to motivate IPM adoption for "non-cooperators" (growers who do not participate in agricultural extension programs). In addition, another type of non-cooperator is growers who do not contact extension agents frequently (Garber and Hoban, 1990). However, most of the IPM research has focused on analyzing factors which predict which growers will be "non-cooperators." It is clear that future research efforts need to focus on how to motivate IPM use among non-cooperators and partial cooperators. We need to know how to develop social strategies to produce a higher proportion of IPM adoption in the future.

The above lines of research are needed to take advantage of new IPM technologies which are being developed. Some of them are more complicated in their application and calculation (e.g. the use of pheromone traps) and eduction and extension agencies will need a thorough knowledge of the factors involved in adoption in order to improve technology transfer.

Past research has helped identify a number of variables related to technology transfer. However, most of the research focuses on variables which have severe short-comings in terms of technology transfer applications. Socioeconomic status of farmers and farm characteristics alone provide a deterministic view. They provide no leverage to help increase actual IPM adoption. What is needed is the identification of factors which are more easily changed and which will increase IPM adoption rates. Age and education are status markers, not intrinsic causal factors. For example, the age relationship to adoption rates is likely due to cohort conditions (such as type and amount of education required and available during the school years of elder farmers). The important questions remain; what are the primary causal variable in IPM adoption? Which of these can change agents most easily influence? How can the rate of adoption and proportion of farmers adopting IPM be increased? We have started by developing a model of this process. It now requires further investigation and verification. This then needs to be integrated into the development of strategies which can increase the adoption of the wide range of IPM techniques available.

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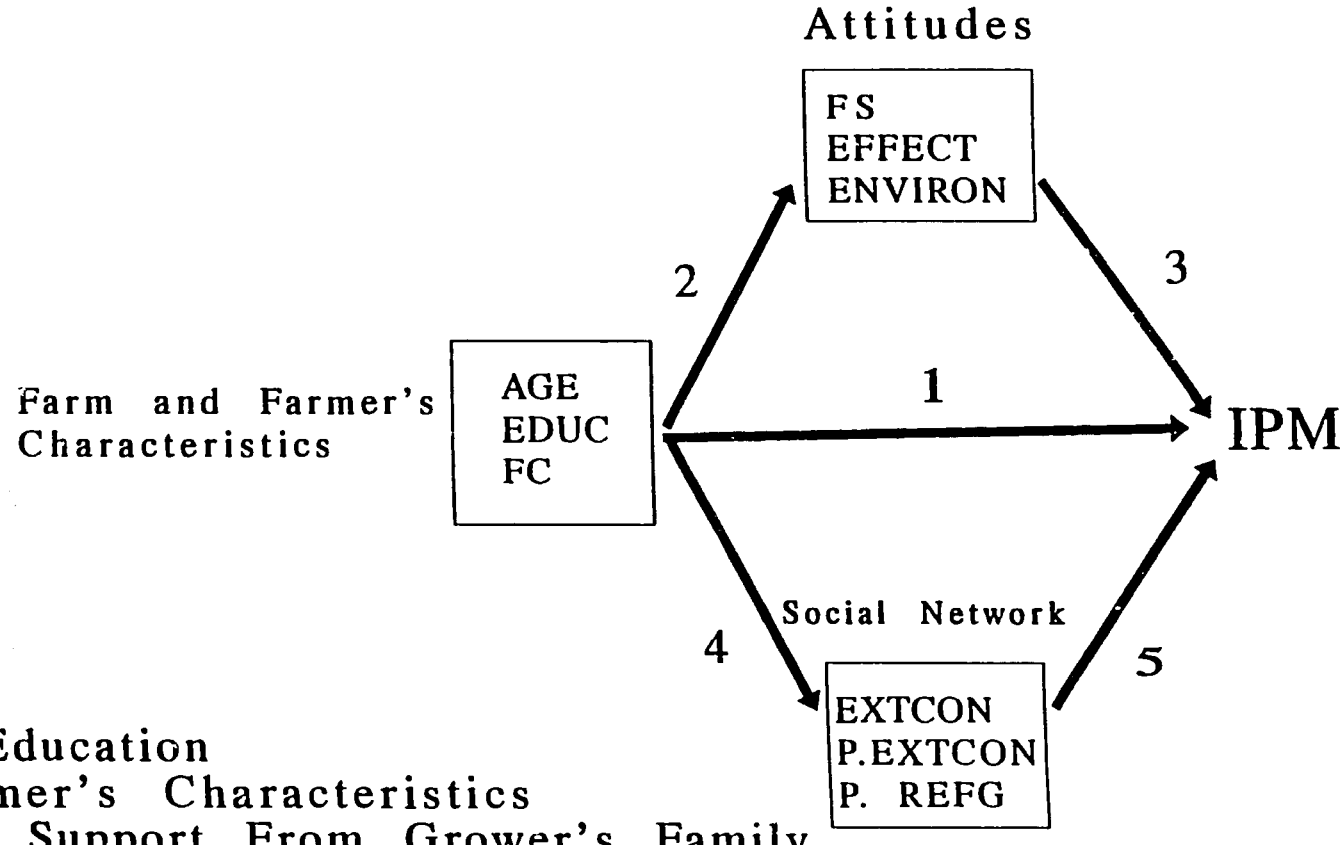
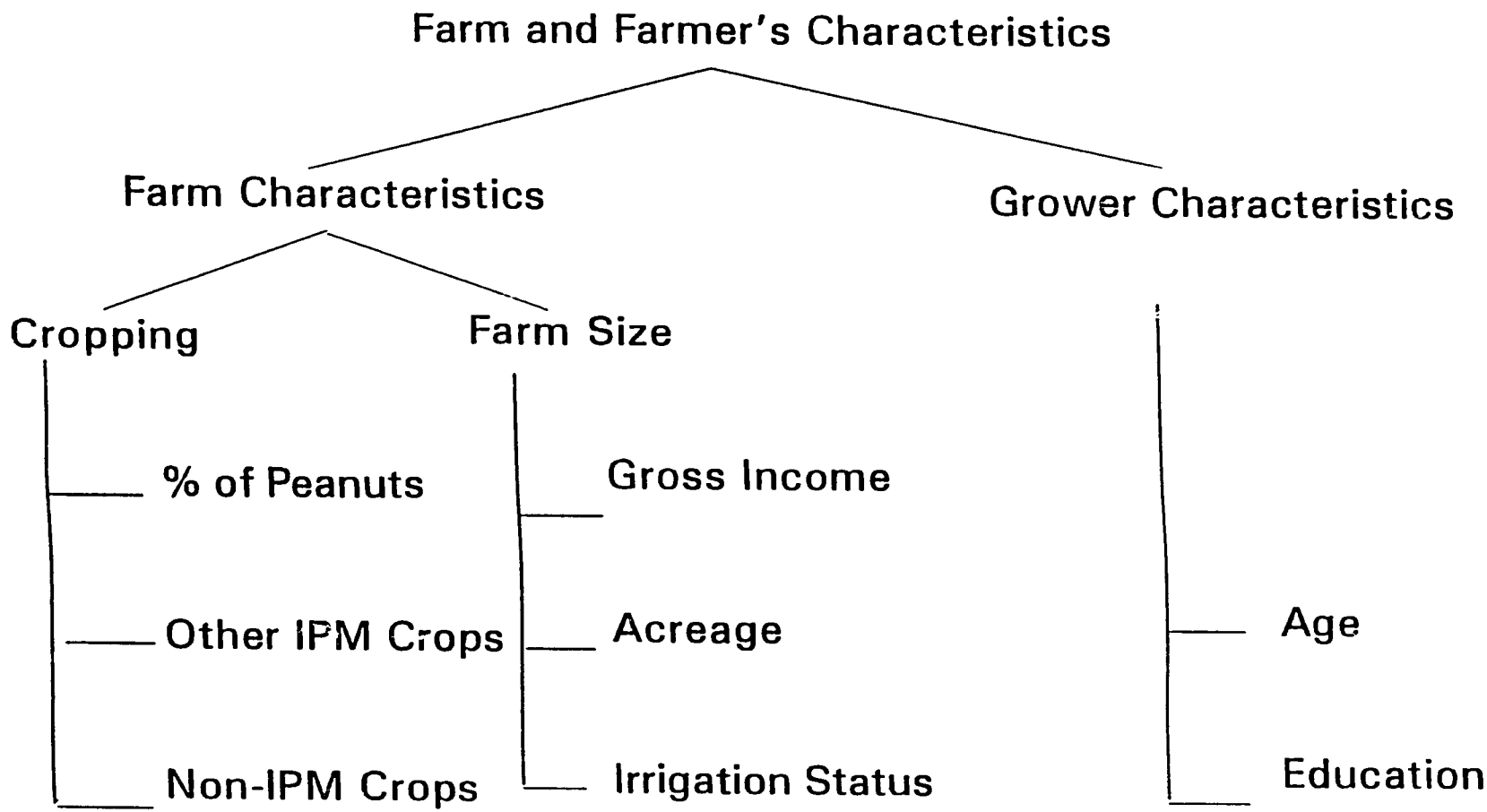
Appendix 1

Model off IPM Adoption



EDUC = Education
FC = Farmer's Characteristics
FS = IPM Support From Grower's Family
EFFECT = Attitude for Effectiveness of Pesticide Uses
ENVIRO = Pro-Environment Attitude
EXTCON = Extension Contact
P. EXTCON = Perception of Extension Contact
P. REFG = Perception of Reference Group
IPM = IPM Adoption

Appendix 2

Path Diagram of Farm and Farmer's Characteristics