
Strategies of Education, Enforcement and Engineering to Improve Pesticide Management and Safety

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Abstract. The dramatic worldwide increase in the use of chemical pesticides in agriculture has created unforeseen consequences resulting in threats to human health and the environment. Integrated strategies of education, enforcement and engineering may well be the most effective ways to deal with these problems. To test this proposition, professionals from agricultural and medical organisations in the Caribbean basin region were questioned on their knowledge and opinions in relation to the need for educational, enforcement and engineering strategies related to pesticide management and safety. The results indicated that the participants believed that all three approaches are needed, although education was the strategy most favoured. Evidence for the support of integrated strategies was also indicated in the participants' replies. A discussion of the three approaches and the best methods for achieving successful results, including the agro-medical approach, in the areas of safe use and management of pesticides is included.

Introduction

The increased use of new technologies for agricultural development in the last 30 years is a well-documented fact. This is most dramatically demonstrated in developing countries by the Green Revolution. The introduction of new varieties not only started the development of new techniques and equipment, but accelerated the demand for fertilizers and chemical pesticides.

The Green Revolution has been described as a chain reaction (Over, 1979; Pearse, 1980), and as in the chemistry laboratory where a chain reaction may sometimes accelerate rapidly, the same can happen with technological innovations. At the time a new technique, such as the use of chemical pesticides, is introduced unforeseen problems often result (Havens and Flynn, 1973). Today, evidence suggests that not only are chemical pesticides used in increasing quantities throughout the world, but they are sometimes used and handled in an irresponsible way (Bull, 1982). This has led to a pesticide safety problem (Davies *et al.*, 1982; Anon., 1981).

This problem may have arisen because insufficient information and training was available when the pesticide was distributed, and techniques for its safe and appropriate use were not made clear to the user. The results of such incomplete dissemination of information can sometimes be fatal. Current literature documents the ill effects of chemical pesticides in the area of human health (Davies *et al.*, 1982; Gore *et al.*, 1981; Copplestone, 1977), as well as the adverse effects on the environment. The problem of misuse of pesticides is not simply a problem of developing countries, it is worldwide (Van Heemstra and Tordoir, 1982). It is difficult to see who would deal with this problem. Many people are involved including government agencies and public officials in health and agriculture, the manufacturers and distributors of the pesticides, and the users all carry responsibility for the safe handling and use of pesticides.

A number of approaches to deal with the problem of pesticide safety have been suggested. They all fall into one of three categories, those of education, enforcement or engineering (Paisley, 1981).

1. An education strategy features, among other approaches, various extension and training activities, particularly directed to the use of pesticides (Davies *et al.*, 1982; van Heemstra and Tordoir, 1982; Gooding, 1980).

2. An enforcement strategy involves government regulations to control the availability and use of chemical pesticides (Upholt, 1977).

3. An engineering strategy stresses technological developments such as new containers, dose sizes, application and safety equipment developed especially for the users (Reynolds, 1982).

These approaches are not new in themselves but this paper considers the combination of all three and studies if a coordinated effort involving education, enforcement and engineering, could provide an efficient and effective solution for dealing with the problems of pesticide safety in the developing world. A number of professional agricultural and health workers from the Caribbean region were questioned on their level of awareness, knowledge and opinions on the need for such multiple strategies. Their replies provide insights not only into the need for such strategies but guidance on their potential acceptance and usefulness.

The questionnaire

A questionnaire was designed to study the attitudes of public and private professionals who were working in the field of pest control and measure their knowledge, awareness and opinions on the use of pesticides. All were taking part in two three-day agro-medical training programmes in Trinidad-Tobago and St. Lucia in the West Indies. The Trinidad programme was for agricultural and health personnel from Trinidad-Tobago, and the St. Lucia programme included professionals from 14 Caribbean basin nations.

The 18-item questionnaire was designed to find out: 1. information and opinions about various approaches and strategies currently being used to control the use and effects of pesticides, and 2. information and opinions on which approaches and strategies the workers thought should be used. Questions focused on the three strategies of education, enforcement and engineering. Compulsory and multiple choice questions were used in each of the strategy areas. The questionnaires were scored and the results coded and analysed. Answers to the multiple choice questions were individually scored by two raters and placed into appropriate categories. Each question was analysed and the results are presented in Table 1. Eighty-eight of the 109 (81%) participants in the two training sessions completed the questionnaire. Since the primary purpose of bringing these individuals together was to receive intensive training in the agro-medical approach to pesticide management, most of the participants represented either agricultural or health professions. Each participant's statement of profession or occupation was independently assessed by two scorers: 39 represented agricultural professions, 42 represented health professions and 7 were unclassifiable or unknown. Both public and private sectors were well represented. The agricultural group included agronomists, entomologists, agricultural officers, plant pathologists, pest control officers, agricultural inventory managers, crop protection officers, sales representatives, agricultural extension officers and agricultural assistants. They were represented at national, regional and local levels. The health officials included medical doctors, hospital officials, district health officers, environmental health specialists, public health inspectors, safety officers, nurses and health supervisors. The majority of this group represented the public sector, and national, regional and local perspectives and responsibilities were well balanced. As a group, those questioned were experienced, in their own fields

TABLE 1. PROFESSIONS AND PREVIOUS EDUCATION OF THOSE PARTICIPATING IN THE QUESTIONNAIRE

Number of participants	Trinidad-Tobago	St. Lucia	Total
Total in training	70	39	109
Completing questionnaire	61 (87%)	27 (70%)	88 (81%)
Agricultural profession	25 (41%)	14 (52%)	39 (45%)
Health profession	30 (49%)	12 (44%)	42 (47%)
Not classified	6 (10%)	1 (4%)	7 (8%)
Professional experience (Av.)	—	—	7.02 years
Type of formal education (%)			
Graduate degree	—	—	43%
College degree	—	—	25%
High school,			
Technical school, or less	—	—	32%

averaging more than seven years of professional experience, with a range from 20 years to less than one year. As a group, they were relatively well educated. Forty-three percent had been awarded graduate degrees, 25% had college degrees and 32% had either a high school degree, technical school degree, or less. Sixty-nine percent of all those questioned were participants in the Trinidad training site, while the St. Lucia participants represented 31% of the total.

An interesting fact to emerge from the questionnaire was that 92% of those taking part in this study felt that pesticides were a necessary part of agricultural production in their community.

Results

The results of the questionnaire are presented as the total number of participants who represented the Caribbean region. It was decided that this was more meaningful than presenting the results for each individual country, especially if they are related to other parts of the world. In addition to this total or cumulative analysis the variable of agricultural and health professions was judged to be important, again if results are to be generalised.

The questionnaire included several items that asked specific questions on each of the three strategies for pesticide safety.

Education strategies

Three specific questions were asked that related to existing educational activities in pesticide management. One sought opinions on the need for regular training in safe management of pesticides for those who handle pesticides; 100% of the respondents either strongly agreed or agreed with this statement (see Table 2A). Furthermore, 78 of

TABLE 2. SOME RESPONSES TO QUESTIONS INVOLVING AN EDUCATIONAL APPROACH

Questions	No. of replies	% replies	% awareness of participants
A Do you agree there is a need for regular training in the safe management of pesticides? (n=87)			
Strongly Agree	84	96.6	
Agree	3	3.4	
B Which form of information in the safe use of pesticides are you most aware of? (n=88)			
Number aware	78		88.6
Extension bulletins	43	24.0	55.1
Radio	39	21.8	50.0
Continuing Education or Training Programmes	23	12.8	29.5
Posters	23	12.8	29.5
Newspapers	20	11.2	25.6
TV	16	8.9	20.5
Magazines	8	4.6	10.3
Other	7	3.9	9.0
Total replies	179		
Don't know/not aware	10		11.4
C Do you know of training in pesticide management provided for? (n=88)			
Number who knew	47		53.4
Mixers of pesticides	29	26.1	61.7
Transporters of pesticides	9	8.2	19.1
Those who apply pesticides	42	37.8	89.4
Field workers	31	27.9	65.9
Total replies	111		
Don't know	41		46.6

n=number of people answering question.

the 88 participants (or 89%) reported that they were personally aware of the regular availability of at least one of nine forms of information on the safe use of pesticides (see Table 2B). This indicates that a diverse set of methods is already used to disseminate information. However, the low frequency for most methods suggests that they are not used often enough. Extension bulletins and radio broadcasts were the most effective ways of disseminating information. Table 2B shows that other methods such as posters, newspapers or magazines were not so effective. Nearly 13% of all participants were unaware of any regular approaches to information dissemination (see Table 2B).

Further support for these results is found in the participants' answers to a question on whether they were personally aware of training in pesticide management for workers who handle pesticides (see Table 2C). Forty-seven of the 88 (53%) participants indicated that they were personally aware of training for the four categories of handlers. The highest number, 42 reporting, was for the category, of pesticide sprayman. The results show that there is either little awareness of regular training or very little regular training has been offered. These facts must be framed against the previously reported fact that 100% of the respondents either strongly agreed or agreed that regular training in safe management of pesticides is needed for those who handle chemical pesticides.

Enforcement strategies

Fifty-nine participants, representing 8 of the 16 countries, indicated that some type of pesticide legislation or regulation had been adopted in their country. For those who indicated legislation existed, 67.8% believed the legislation has not been effective in promoting safer pesticide management (see Table 3). The open-ended question

TABLE 3. EFFECTIVENESS OF PESTICIDE LEGISLATION

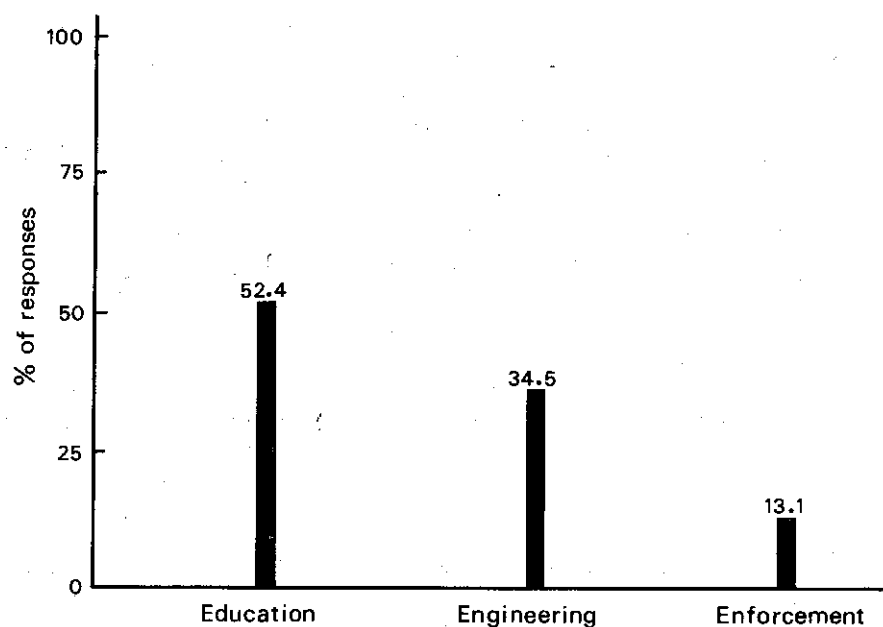
	No. of replies	% replies
A Has legislation been adopted? (<i>n</i> =88)		
Yes	59	67
No	24	27
Don't know	5	6
B How effective do you believe this legislation has been in promoting more safe pesticide management? (<i>n</i> =59)		
Very effective	1	1.7
Somewhat effective	9	15.3
Not too effective	19	32.2
Not at all effective	21	35.6
Don't know/no opinion	9	15.3

n=number of people answering the question.

asking for two suggestions for improving the enforcement and effectiveness of these laws and regulations, elicited 145 different responses from 69 participants. (See Fig. 1.) Answers independently assessed by two raters were categorised as either education, enforcement or engineering related suggestions. Educational approaches were the most frequent. Enforcement responses, e.g., more regulations, enforcement laws and more penalties, represented 34.5% of the responses; engineering responses, e.g., monitoring and agency integration (viewed as a form of organisational engineering), represented 13.1% of the responses and educational suggestions, e.g., qualified staff, public education, training personnel and use of media, were 52.4% of the total responses.

Engineering strategies

An engineering strategy is difficult to define. Clearly, technological developments in packaging, distribution and safety equipment are engineering approaches, and for the purpose of this study, coordination of different agencies, or the development of community resources such as poison control and first aid centres were considered to be examples of engineering approaches, in the form of social, organisational or institutional developments or methods of dealing with issues of pesticide safety.



$n=69$. Total number of responses=145

Fig. 1. Suggestions for improving the enforcement and effectiveness of pesticide laws and regulations.

TABLE 4. ENGINEERING APPROACHES TO EFFECTIVE PESTICIDE MANAGEMENT

	No. of replies	% replies
A How necessary do you feel a poison information centre is for your community? ($n=87$)		
Greatest necessity	46	52.9
Very necessary	32	36.8
Somewhat necessary	9	10.3
Unnecessary	0	0
B How important is it to have a first aid centre with qualified staff in your community? ($n=76$)		
Very important	69	90.8
Somewhat important	5	6.6
Not too important	2	2.6
Not at all important	0	0
C What is the likelihood of establishing a local first aid centre with qualified staff? ($n=73$)		
Very likely	23	31.5
Somewhat likely	19	26.0
Not too likely	25	34.2
Not at all likely	6	8.2

n =number of people answering the question.

Almost all participants (90%) believed a poison information centre was needed and that a first aid centre was important (97%). Eleven participants, representing five countries, reported such centres already existed (see Table 4A and B). Participants who had indicated that a first aid centre did not currently exist were asked about the likelihood for establishing such a centre staffed with qualified personnel. Results (see Table 4C) indicate that only a small majority thought such a possibility was likely. A high percentage (42.4%) were of the opinion that such a development was unlikely.

Multiple strategies

One of the aims of this study was to determine whether agricultural and health professionals responsible for dealing with pesticide management and safety issues considered multiple strategies useful. Consequently, they were asked to state preferences in terms of "activities, programmes or efforts" to be used "to encourage more effective pesticide management;" 79 respondents suggested 171 different activities, programmes or efforts. These suggestions were reviewed and categorised as either educational, enforcement and engineering strategies.

Educational strategies as such, in-service training, education of the public, on-going education such as workshops etc., and extension efforts were preferred accounting for 78.1% of all responses. Enforcement strategies such as, enforcing laws and new legislation represented 13.5% of the responses, and engineering approaches, such as poison control centres, agro-medical associations and monitoring approaches, totalled 11.1%.

Table 5 and Fig. 2 present the results of analyses on the basis of responses by two professional groups, those of agriculture and health, as well as all participants. Both groups expressed preference for educational strategies, with enforcement and engineering approaches receiving less support. In general, agriculturalists expressed a stronger preference for education (81% of all their responses) than did the health professionals (70.7%).

TABLE 5. MULTIPLE STRATEGIES FOR MORE EFFECTIVE PESTICIDE MANAGEMENT

Strategies	All Participants (n=81)		Agricultural Profession (n=39)		Health Profession (n=42)	
	No. of replies	% replies	No. of replies	% replies	No. of replies	% replies
A Enforcement						
Enforcement laws	16	9.4	7	8.8	9	9.8
Improved legislation	7	4.1	2	2.6	5	5.4
No. responses	23	13.5	9	11.4	14	15.2
B Engineering						
Poison control centres	2	1.2	0	0	2	2.2
Monitoring	7	4.1	3	3.8	4	4.3
Agro-medical association	10	5.8	3	3.8	7	7.6
No. responses	19	11.1	6	7.6	13	14.1
C Education						
In-service training	50	29.2	29	36.7	29	31.5
Public education/media	58	33.8	24	30.4	26	28.3
Continuing education	17	10.0	7	8.8	10	10.9
Extension approaches	4	2.3	4	5.1	0	0
No. responses	129	75.4	64	81.0	65	70.7
Total number of responses	171	100.0	79	100.0	92	100.0

Responses to the question: What activities, programmes and efforts do you prefer to encourage more effective pesticide management?
n=number of people answering the question.

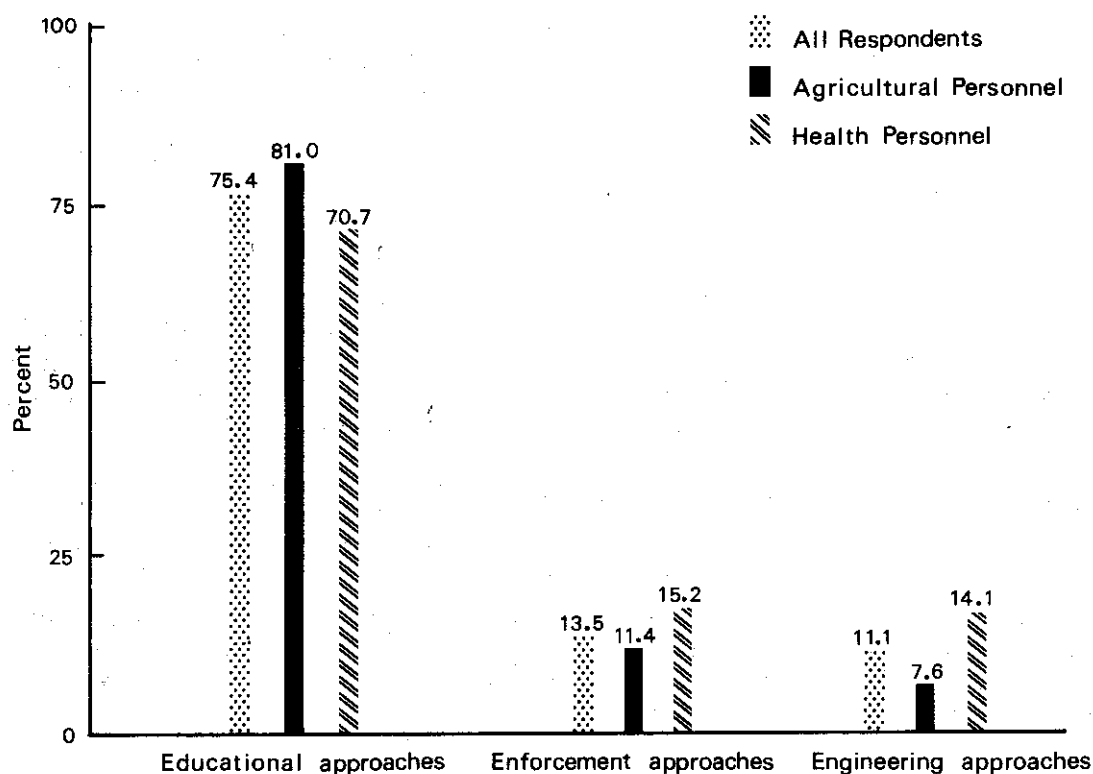


Fig. 2. Comparison of preferred multiple strategies for increasing the effectiveness of pesticide management.

Discussion

The participants in this study were working professionals in the fields of health and agriculture, in both the public and private sectors. All participated in a Caribbean region 'train the trainer' programme in the agro-medical approach to pesticide management, and many, but not a majority, were in positions connected with education, especially extension education. Many were service workers especially those in health care, while others were research workers. It is likely that this group is representative of the training cadre of agricultural and health professionals responsible for pesticide management activities in the 16 countries represented. Since over half of all participants were from Trinidad-Tobago, that area may be over-represented in this non-random sample, but it can be considered as representative of the region.

The results indicated both the level of awareness of the participants in terms of what is available through enforcement, engineering and educational strategies in relation to pesticide safety, as well as assessing their opinions on what is needed in these areas. It is clear that this group believes the three strategies are all important. However, education outweighs the other two and the results indicate that educational approaches are preferred for dealing with problems of pesticide management and safety. Education is the clear method of choice for increasing the effectiveness of pesticide management regulations and the enforcement of regulations, and is in fact, an important part of the engineering and enforcement strategies. Participants supported the development of first aid and poison control centres which would be staffed by trained personnel.

Participants also believed education was important in itself. The education of the public through mass media and continuing educational programmes in various communities and institutions, and the in-service training of personnel responsible for dealing with questions on the safe management and use of pesticides, were all specifically identified as approaches which could be used for dealing with the problem of pesticide safety. The fact that many participants were not directly involved in educational activities did not seem to influence them one way or the other. The differences between responses of the agriculturalists, many of whom were education orientated, and the health workers involved in service work, were minor. Both groups expressed a strong preference for education. However, the replies reflected true diversity. Where many saw education in a formal manner with qualified and trained personnel produced by institutions of education, many saw education from a communication or social marketing perspective with the use of the media as a means to reach the public with education campaigns. Others preferred education from an in-service staff development perspective, and still others saw education from a community or non-formal education perspective such as extension activities.

This diversity is probably reflective of the respondents' diversity. If education, as Cremin (1978) argues, is a deliberate and systematic activity to change behavioural attitudes, increase skills and understanding and sensibilities, then each of the many approaches to education suggested is legitimate and appropriate.

Education is not, however, the sole method. The need for effective regulations and the enforcement of regulations, as well as a need for engineering approaches, including social engineering, were all recognised by the participants as important. Interestingly, few of them mentioned research and development approaches relating to safety equipment, packaging, disease resistance, or other areas as important.

The results of this study indicate that the need for all three strategies is felt, with a preference for an educational strategy. This conclusion seems to coincide with experience in other areas. For example, in dealing with public use of forestry resources in the USA, although engineering and enforcement strategies have been used to reduce the incidence of forest fires, an educational strategy has become the last resort. Engineering or enforcement strategies are only partially successful when dealing with a problem such as forest fires. Success depends also on an educational strategy. This seems also to be true in the case of pesticide management and safety.

Governments may promulgate and enforce regulations and monitor the use of pesticides. The chemical or occupational safety industry may engineer newer and safer ways to transport, distribute and use pesticides. Ultimately, however, every user of pesticides must be aware, know, be sensitive to, and be able to use and handle the pesticides safely. It is the function of educational efforts to create such changes in awareness and attitude, and to develop skills and abilities. It is through education, broadly defined, that a technology such as pesticides can be safely transferred.

Conclusions

This study is based on a questionnaire completed by professionals working in the Caribbean region. It is debatable if the conclusions drawn from this study apply to other parts of the world. However, with respect to pesticide management and safety, the problem is worldwide, and agricultural and health personnel in both public and private sectors alike face problems similar to those found in the Caribbean region. Consequently, it is feasible that the results of this study, which indicate that the strategies of education, enforcement and engineering are all needed to deal effectively with the problem, apply to other parts of the world.

More attention must be given to the problem by governments, development agencies and the pesticide industry. All must accept the fact that multiple and integrated approaches are needed to minimise human health and environmental problems associated with the use of pesticides. Governmental agencies appropriately can develop enforcement methods, and through research pursue engineering strategies such as the development of new equipment, alternative methods of pest control, the appropriate use of chemicals, and social engineering developments such as community resources, and encourage educational approaches such as training, public communication campaigns and education via informal educational institutions, etc.

The private sector must aggressively pursue both engineering and educational strategies. Its educational responsibilities are multiple and manufacturers, distributors and vendors of pesticides must provide more information, better labels and training, and work through existing rural and urban communities such as the first aid centres, clinics, schools, organised groups, etc., to reach more individuals in need of the information and safe practices. The private sector also has an important role in relation to enforcement. Legislation and enforcement on the use and availability of pesticides are crucial and enlightened advice from the private sector is critical.

Educators from every sector have unique roles to fill, and should work closely with pesticide and crop protection specialists, and the medical profession. Effective cooperation will increase their chances of success in making the users of pesticides more aware of the associated safety problems.

The implementation of an integrated approach to the problem of pesticide safety is difficult because of the diversity of the different sectors involved, and the difficulty of coordinating their efforts.

Currently, the agro-medical approach to pesticide management offers a useful model for successful implementation (Davies *et al.*, 1982). This approach, built upon the integration of agriculture, applied chemistry and medicine, is applied to issues of safe use and management of pesticides. Furthermore, it advocates the creation of an organisation dedicated to the development of integrated strategies which include education, enforcement and engineering. It is likely that only through systematic efforts such as an agro-medical organisation, involving public and private sectors, can the needed capabilities be developed. Consequently, such an approach offers the best method for successfully combining education, enforcement and engineering to deal with the immense and worldwide problems associated with the use or misuse of chemical pesticides.

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