AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

THE PRODUCTIVITY OF PESTICIDES - A Case Study of the Aranguez Vegetable Farmers

Edward Evans

(Economics, Agric. Dev. Section, CARICOM Secretariat, Guyana)

Introduction

The widespread use of chemicals as a means of crop protection in modern agriculture has aroused much interest in recent times. Conflicting views with respect to their cost effectiveness and more so their impact upon the society at large, are frequently echoed.

In the case of the developing countries and in particular the Caribbean Community, the issue is of paramount importance. Faced with the problems of intractable crop diseases, rising population, rapid urbanization concomitant with a demise of the agricultural sector, and the quest to protect whatever little food is produced, many have opted for shorter term solutions such as importing and utilizing large quantities of pesticides. These in return are causing an increase in the health and environmental problems experienced by their societies.

Recent studies carried out by the Institute for Food and Development Policy, revealed that the rate of pesticide poisoning in developing countries was thirteen times that in the United States.[1] Shirkie (1982) reported that 25 per cent of pesticide export coming from the United States of America (USA) are products that are banned, severely restricted, or have never been registered for domestic use. Many of these, he claims, have not been evaluated independently for their impact on human health or the environment, while others are known to cause cancer, birth defects and nerve damage. It is noteworthy that legislation in the USA governing pesticides explictly states that banned or unregistered products are legal for export.[2]

Exporting countries and supporters of the use of pesticides have been ever prompt in pointing out that pesticides contribute significantly to the fight against hunger and starvation in the developing world. Although this is true, one cannot overlook the detrimental effects that the abuse of pesticides could have on the society in the long run.

On the other hand, many farmers in the Caribbean are exclaiming at the high cost of these pesticides and the fact that a number of the chemicals are not effective against the pests when used at the manufacturers' recommended rates and separately. Instead, satisfaction is only achieved, they say, when the chemicals are combined to form a *cocktail spray* - a mixture of chemicals according to the farmers own formulations.[3] Ironically, it is a well known fact that constant exposure of pest to strong dosages of pesticides will result in a phenomenon which entomologists call *throwback*. In other words through the process of mutation a more vibrant generation of pest occurs, thus causing the

[1] This is a non-profit research organisation based in San Francisco, USA.

[2] Reports, The International Development Research Centre, Vol. 10, No.2, 1981

[3] 'Cocktail Sprays' are likely to be much more dangerous to health.

pesticides to seemingly lose their effectiveness.

Figure 1 shows the sum total imports of pesticides for the four More Developed Countries (MDC's) of the Community for the period 1978-1981.[4] In general, it may be observed that while there was a significant decrease in the volume imported in 1979, the figures for 1980 and 1981 show that total inputs are on the rise again.

In 1980 a study was undertaken by the author to determine the efficiency with which the farmers utilised pesticides in Aranguez - a vegetable producing area in Trinidad and Tobago. While this study was of an economic nature, an attempt was made to relate the findings to some of the broader health and ecological issues mentioned in previous studies. As such, the paper is divided into two sections. Section 1 deals with the economic analysis and its findings. The earlier part of Section 2 looks at some of the ecological and health aspects of an abuse of pesticides in the area. In the latter part, a strategy aimed at reducing both the quantities and detrimental externalities of pesticides used in the garden is adumbrated.

SECTION 1

The Problem

The Aranguez garden represents one of the major vegetable growing areas in Trinidad and Tobago. It is situated five miles east of Port of Spain (the capital of Trinidad & Tobago) and consists of approximately 521 acres of flat cultivable lands. The average size of a holding is one and a half (1½) acres and in 1975 there were 540 registered farmers.

The Aranguez farmers practise a system of intensive farming. The two main vegetables produced are tomato and cabbage. Thus it is not unusual to encounter large purestands of these vegetables.

One direct consequence of such a farming system is the proliferation of pests and diseases. In order to protect their crops, gardeners used a variety of pesticides all mixed together to form a cocktail spray. Furthermore, investigations revealed that most of the farmers do not adhere to the recommended rates of application of the pesticides as specified. Each farmer mixes according to his own formulation without any consultation with compatible charts. Thus, over the years, the farmers have become *hooked* on the chemicals. This tendency is further enhanced by the relative ease with which they obtain the chemicals. In Aranguez, alone, there are at least four shops retailing pesticides over the counter. Also, because of its proximity to Port of Spain, most of the new chemicals on the market are first sold and tried in the area. On the other hand, consumers are complaining about pesticide residues detected on produce purchased for consumption.

Ramnarine (80) stated that tests carried out by the Caribbean Agricultural Research and Development Institute (CARDI) on marketable cabbage obtained from the area revealed residual levels of aldrin which were above the tolerance level as specified by the Food and Agriculture Organisation (FAO). The tolerance level for aldrin, for example, is 0.02 parts per million (ppm) as against levels obtained such as 0.33 ppm. Aldrin which is a poisonous systemic pesticide when sprayed on vegetables cannot be washed off and therefore must be given a certain time for the active ingredients to be broken down before the produce becomes suitable for consumption.

The cumulative effects of these and other chemicals in food and more specifically their effects upon man,

[4] Pesticides as used here includes insecticides, nematocides, fungicides and weedicides.

are not really understood or properly documented, but certainly warrant exhaustive investigations.

Objective of Study

The broad objective of the study was to determine the efficiency of pesticides used by the Aranguez farmers. The specific objectives were to:

(a) derive the aggregate production function for vegetable production, namely tomato and cabbage, in the Aranguez garden, from data obtained from a survey of the area;

(b) determine the marginal productivity of pesticides, given the prevailing prices and cropping pattern which existed at the time of the investigations.

In addition, an attempt was made to look at efficiency from a technical point of view. That is to say, a comparison of the recommended as against the actual quantities of pesticides being applied, was undertaken.[5]

Methodology

A survey of the area was carried out in order to develop an appropriate data base. The technique of prepared questionnaires and personal interviews was utilized. A total of 65 farmers (33 purestand cabbage and 32 purestand tomato farmers) were interviewed.

The production function of the Cobb-Douglas type was used to fit the data. Such a function was chosen for the following reasons:

(a) preliminary manipulation of the data suggested that it would give a suitable fit;

(b) associated with this type of function is a number of desirable properties.[6]

(c) a review of the literature on resource efficiency (Campbell 1976, Fischer 1970, Head and Dillon 1961, *inter alia*) alluded to the fact that the use of this type of function is the most appropriate in the determination of resource productivity from farm data.

The specific form of the function used is:

$$\text{Log } Y = \text{Log } a + b_1 \log x_1 + b_2 \ldots b_7 \log x_7$$

where

- Y is the output variables i.e. value of gross yield

- $X_1 X_2 \ldots X_7$ are the input variables[7]

- $b_1, b_2 \ldots b_n$ are the regression coefficient (elasticities of production) for the respective input variables

- a is a constant.

[5] Recommended quantities are the amount specified for use by the manufacturers.

[6] Inter alia, some of these properties are:

(i) it is fairly simple to use especially in manipulation and computation;

(ii) it produces a compromise among (a) adequate fit of data, (b) computatational feasibility, and (c) sufficient degree of freedom unused to allow for statistical testing.

(iii) the exponent or regression coefficients of the equation are the elasticities of production;

(iv) it provides for the possibility of interaction between inputs or categories of inputs;

(v) this type of function is an efficient user of the degree of freedom; i.e. only one regression coefficient is required for each input available in the estimation.

[7] The following independent variables were chosen:

(a) seed ($)
(b) fertiliser ($)
(c) manure ($)
(d) land (acres)
(e) pesticides ($)
(f) labour (hrs.)
(g) tractor service (hrs.)

From such a function, it was possible to obtain the marginal value productivity of the resource in question which could subsequently be compared to a unit cost of the input, i.e. the perfect competition efficiency criterion.[8]

In order to carry out the comparison between actual and recommended quantities of pesticides it was necessary to select a representative for each of the respective crops. This was considered necessary since, as stated earlier, each farmer mixes his pesticides according to his own formulation. The selection was done on the basis of choosing a farmer whose total expenditure on pesticides approximated that of the average (mean) for the respective crops.

The recommended rates were those specified on the accompanying label of pesticides. In cases where a range was given, the average was used as the recommended rate.

The comparison was done for the dry season of 1980.

Results

Table 1 presents the results of the derived aggregate production for vegetables, namely tomato and cabbage, in the Aranguez garden.

From the tabled results it can be seen that three variables, namely, pesticides, seeds and fertilizers are significant at the five per cent probability level. The coefficient of determination, R_2 was estimated as 0.55. This means that 55 per cent of the total variations observed in the dependent variable (value of output) can be explained by the listed seven variables. The other 44 per cent may be caused by unknown or

[8] The coefficients (bs) of the Cobb-Douglas function are the elasticities of production.

Since $b_i = \frac{MP_i}{AP_i} = \frac{\text{marginal product}}{\text{average product}}$

then $MP_i = b_i AP_i$

If the equation is expressed in value terms then one obtains the marginal value productivity directly.

FIGURE 1: Sum Total Imports of Pesticides by the MDCs for period 1978-1981

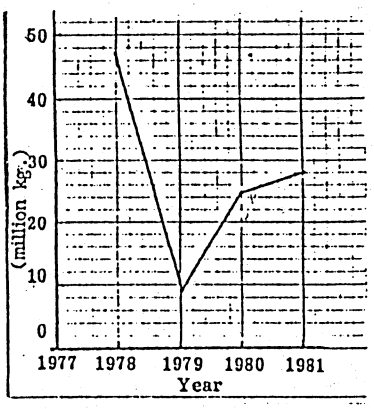

TABLE 1: Estimated Production Function

Valuables Variables	*Regression*	*Co-Efficients*
Seed ($)	*0.399**	*(0.140)*[a]
Fertilizer ($)	*0.336**	*(0.147)*
Manure ($)	*0.050*	*(0.032)*
Land (acres)	*-0.164*	*(0.190)*
Pesticides ($)	*0.384*	*(0.202)*
Labour (hrs.)	*0.172*	*(0.179)*
Tractor Services (hrs.)	*0.032*	*(0.054)*
Constant	*1.539*	*(1.558)*
R^2	*0.55*	
Total Elasticity	*1.21*	

(a) The standard error of the regression coefficients are given in the brackets.

(b) In no case did the partial correlation coefficients exceed or equal 0.8, thus no multicollinearty corrective measures were employed.

* Indicates significance at the 5 per cent probability level.

unmeasurable variables such as technology mix, management and other causal factors.

The variable land, had (in contrast to what was expected) a negative coefficient. However, it was non-significant at the chosen probability level.

The F-test which provides an overall test of the significance of the regression equation indicates that the function was significant at the one per cent probability level. The value obtained for the F-test was 10.

Table 2 presents the summary of the comparison of actual and recommended quantities of pesticides.

TABLE 2: Comparison of the Values of the Recommended and Actual Quantities of Pesticides used in Cabbage and Tomato Production (Dry Season 1980)

Vegetable	*Recommended*	*Actual Average*	
	($ per acre)		
Tomato	*731*	*1,465*	*1,410*
Cabbage	*660*	*938*	*955*

Interpretation of Results

From the information presented in Table 1, the marginal value productivity of pesticides was calculated at $5. In other words, the last dollar spent on pesticides yielded a return of $5.[9] This, therefore, indicated that the resource - pesticides - was not being utilized efficiently. In this case, it was being underutilized. In other words, to maximise profit, the farmer should increase the quantity of pesticides he currently applies up to the point where the marginal value productivity equals the value of a unit cost of the input.

Such a finding does not conform with the perceived reality of the situation existing in gardens. An explanation, however, can be found in terms of market imperfection. That is to say, in order to determine the efficiency of pesticides, making use of the classical criterion of $MVP_x = P_x$, one had to assume the existence of perfect competition in the input as well as the output markets. While this is true of the former, closer examination revealed that this operation was somewhat violated in the case of the latter. That is, the farmers are able to influence the price of the output in relation to the quantity of inputs they used. Factors which give credence to this agrement are:

(a) the higher prices obtained for produce during the wet season as compared with the dry season. Here the farmers (having to) employ more inputs during the former season, and charge higher prices for their outputs;
(b) the majority of the farmers wholesale the produce for themselves in order to obtain the highest possible prices;
(c) the Aranguez farmers are the price leaders for the other vegetable areas.
(d) most of the farmers live in close commune are related and wholesale their produce at a particular site.

One of the implications of the above is that the farmers are in a position to overutilize the resource and still appear to be underutilizing it - by virtue of their ability to influence the price of output - when mistakenly judged by the perfect competition criterion. The fact that the input is highly subsidized, in addition to entering the country duty free, may also serve as added incentive for very liberal use of the resource.

The findings of the comparison made between the actual and recommended quantities of pesticides support the above contention. This is

[9] See Appendix 1.

so, as it was found that in both cases (i.e. tomato and cabbage) the actual quantities of pesticides applied were far in excess of the recommended quantities.

Furthermore, it is noteworthy that the farmers' behaviour with respect to their use of pesticides suggest that they may be over-utilizing the resource. Appendix II shows that of the 65 farmers interviewed, approximately 97 per cent practise *Schedule Prophylactic Treatment Programme*. Here there is a set time and number of treatments independent of pest numbers (population). The idea of course is to make the uncertainty of pest attack irrelevant to their treatment decision by the use of a standard operating procedure. Three per cent of the farmers adopted an *opportunistic approach*. Here the pesticides are applied while doing some other chores, e.g., while fertilizing, watering etc. They (pesticides) are applied not because of obvious need, but rather, because of the safety it ensures for the little extra effort. Hence, opportunity becomes more important than the uncertainty of being attacked by pests.

In no case did any of the farmers interviewed practise a third approach, i.e. treatment that is based on an estimate of pest population derived either from intuition, monitoring or forecast. This approach possesses attributes such as the removal of the uncertainty of pest attack replacing it with an assumed certainty or at least a definite probability. Moreover, because it is responsive to the level of attack it provides a sound environmental management practice.

Thus, in summary, it can be said that since the assumption of perfect competition does not hold in the output market, then the condition under which the farmers maximized their profit should not be based on a fixed price of output, but rather on a variable one wherein the price of output is also a function of the amount of input used. In addition, any further model which attempts to determine the efficiency of pesticides should take into account the farmers' behaviour with respect to pesticides, particularly their attitude towards risk and uncertainty. Finally, the circumstantial evidence suggests that the farmers are over-utilizing the resource - pesticides.

SECTION II

The earlier part of this section directs attention to some of the ecological implications of an abuse of pesticides by the Aranguez farmers. In the latter part, a strategy aimed at reducing the quantity and detrimental externalities of pesticides used in the garden is adumbrated.

Ecological Health Significance of an Abuse of Pesticides by the Aranguez Farmers

The Aranguez garden is traversed by the St. Joseph and San Juan rivers. Both of these rivers empty into the Caroni river which ultimately end up in the Caroni swamp.

The Swamp, apart from being the largest in the country, is important from at least two other perspectives:

(a) it provides employment for a number of fishermen, oysters and mussels catchers;

(b) *located in the swamps is the* home of the Scarlet Ibis (Trinidad & Tobago's national bird) and at least 150 other species of birds. It is thus one of the island's main tourist attractions in and out of the Carnival season.

Since the Aranguez garden slopes from northwest to southwest, a great deal of the farm run-off finds its way in either of the rivers, ultimately ending up in the swamp. In the surface waters, therefore, are various types of pesticides run-off, which contribute to the pollution of the swamp. Chances of pesticides being present in the surface run-offs are increased because of farmers

misusing pesticides, e.g. farmers refusing to use stickers when applying pesticides in rainy season or the drenching of crops.

In 1970, many dead fish were observed in the swamp following heavy showers of rain. Deonarine (1980) reported that a possible cause of this event was pesticide poisoning.

Studies done by Deane (1976) on waves and tides in the Gulf of Paria suggested that during the dry season when pesticides enter the swamp, they accumulate as the tides and waves prevent the outflow of these pollutants. He hypothesizes that there will thus be a concentration gradient of pesticides and other pollutants from the inner part of the swamp to the *mouth*.

The level of pesticides has already been detected in both fauna and flora of the swamp (Deonarine 1980). In her report, she noted that of significance was the fact that higher concentration of the chlorinated hydrocarbon compounds (compounds from organochlorine pesticides, e.g. DDT, dieldrin) were found in the herbivorous and omnivorous organism relative to the amount found in their food which include algae and/or detritus. This therefore suggested the likelihood of an accumulation of pesticides along the food chain. Since man is the final link of the chain, this could have far-reaching consequences.

In addition, because of the complex nature of the food web existing in the swamp, interference at any state is bound to have serious repercussion. For example, the elimination of the sand fly larvae by pesticides could eventually result in the migration of the Scarlet Ibis, and this spell the end of the swamp as a tourist attraction. The sand fly larvae are invaluable sources of food for mussels, crabs and snails, which in turn are the main source of food for the Scarlet Ibis.

While it is true that there are a number of factories whose waste products ultimately end up in the swamp. and thus actively contribute to its pollution, it is still important to eliminate, or at least reduce, the presence of pesticides in the swamp. It is against such a backdrop that the following strategy is outlined.

Strategy

The major elements of the strategy are:

(a) education of farmers
(b) maintaining of proper standards in the labelling of pesticides;
(c) effective monitoring of the use of pesticides and penalties for incorrect use;
(d) efficiency and safety testing of pesticides before they are registered for sale;
(e) continuous local research for alternative chemical and non-chemical pest controls.

Education of Farmers -

- Informing them about the detrimental effects of pesticides application beyond the stipulated safe period
- Teaching them simple forecasting techniques, and helping them to appreciate the importance of the life cycles of pests
- Demonstrating the efficiency with which pesticides can be used
- Advising them about more effective pesticide applications
- Teaching them simple ways of calculating costs and returns, and making them aware of the potential savings to be made by reducing unnecessary run-off
- Making them aware of chemicals which can be used very close to harvest without unsafe residues.

Maintaining Proper Standards in Labelling of Pesticides -

All pesticides should carry labels stating:

- the maximum dosage per spray
- the interval which should occur between the final treatment and harvest time
- the maximum allowable treatment per year.

Effective Monitoring of the Use of Pesticides and Penalties for Incorrect Use -

Thus the need for:

- frequent and random checks on the residual level of pesticides in the marketed crops
- accurate results produced in a minimum of time

Efficiency and Safety Testing of Pesticides before They are Registered for Sale -

- Banning of certain persistent pesticides and the restriction of extremely toxic ones.

Continuous Local Research for Alternative Chemical and Non-chemical Pest Control -

- Need to offer the farmer as wide a range as possible of pest control alternatives so as to reduce their sole dependence on pesticides.

Figure 2 shows the interrelationship of the various parts of the strategy.

Conclusion

The limitations of the technique used point to the need for further refinements in the method of determining the efficiency of pesticide usage - in particular the need for more relevant assumptions.

The results obtained from the economic analysis, suggested that the simple model used was inadequate in terms of its ability to capture and explain what was observed. It became evident that the pesticide problem is definitely a social one. As such, any model which attempts to determine the efficiency of pesticide usage with the hope of recommending policy guidelines must take into account aspects such as the farmers' behavioural patterns - attitudes to risk and uncertainty in applying crop protection, social benefits and costs.

The author agrees with Norgaard (1976) that the only way that the pesticides problem will be resolved is by men changing their behaviour. The latter will only come about by making (especially the) farmers more aware of the dangers associated with abuse of the resource. In the meantime, since many of the countries exporting pesticides do not particularly care about the kinds of pesticides they export, the onus will be on the government of the importing countries to scrupulously examine and select the types of pesticides they import.

Finally, recognizing the fact that pesticides are necessary evils, the environmental approach taken by the author in the suggested strategy was, therefore, not to oppose their use, but rather to emphasize the need for using and choosing them properly and carefully. o

APPENDIX 1

In order to obtain the marginal dollar worth of the resources used, the following formula was applied:

$$MVP = b_i \left(\frac{\bar{Y}}{\bar{X}}\right)$$

where

b_i *is the respective elasticity of the input*

$\bar{Y}$ *is the mean value of output (in this case was calculated to be $16,917.00.*

$\bar{X}$ *is the respective mean value of the input i (in the case of pesticides it was calculated to be $1,279.00.*

APPENDIX II: Summary of Pesticides' Responses

Question: When did you spray insecticide on this crop?

Responses:	*No.*
(a) Whenever insect pest occurred	*0*
(b) Whether or not insect pests occurred	*65*
(c) Other	*0*
Total	*65*

Question: How often did you spray insecticide on this crop?

Responses:	*No.*
(a) Once every two weeks	*0*
(b) Once per week	*2*
(c) Twice per week	*35*
(d) Three times per week	*25*
*(e) Other**	
Total	*65*

*Apply while fertilizing.

APPENDIX III:

FIGURE 2: Summary of Proposed Strategy