Staff Paper Series

STAFF PAPER P71-9 MAY 1971

Some Economic Aspects of Pesticide Use

by
John J. Waelti

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture
St. Paul, Minnesota 55101

Staff Paper P71-9 June 1971

SOME ECONOMIC ASPECTS OF PESTICIDE USE

by

John J. Waelti

SOME ECONOMIC ASPECTS OF PESTICIDE USE*

by

John J. Waelti**

The Basic Economic Question

Man, selfish creature that he is, has unlimited wants and only limited resources with which to satisfy these wants, leading directly to the necessity of making choices. The logic of choice is the substance of economics, which deals with the allocation of limited resources among alternative uses.

When the economist refers to limited resources, he is referring to the finite amounts of land, labor, capital, and entrepreneurship[1/] which exist at a given time. Land is the factor of primary relevance to this discussion. The economist includes in his definition of land not only farmland in its traditional concept, but all natural resources such as forests, minerals, water, fisheries, wildlife, and even air.

Until recently, water and air were thought to be free goods. These resources were present in such abundance that no scarcity was evident, and hence, no allocation problem was associated with them. Recently, however, it has become evident that even air is limited. For example, when the use of air

---

1/ Entrepreneurship includes but is not limited to management. In technical economic terms, it includes other functions such as provision of capital and innovation.

* Based on a lecture delivered to participants in Soil Science 3-118, a Seminar on Soils Pollution and Public Policy, October 6, 1970.

The author gratefully acknowledges the suggestions of Harold Jensen, Emiel Owens, and Willis Peterson of the Department of Agricultural and Applied Economics and Gerald Miller of the Department of Agronomy and Plant Genetics, which contributed to the improvement of this paper.

** Associate Professor, Department of Agricultural and Applied Economics, University of Minnesota.

as a medium for the discharge of wastes becomes competitive with use of air for breathing, causing discomfort or health hazard, we have an allocation, or an economic problem.

The costs and benefits of pesticide use constitute an allocation problem, or a problem of choice. The economic problem related to pesticides has two major aspects which are the subject of this discussion. First, there is the economic behavior of the individual or businessman which is dictated by decisions regarding profit maximization. The second is the broader problem of effects of pesticide use on our environment. To the extent that pesticide use may be detrimental to wildlife or may have other undesirable side effects, we have an allocation or an economic problem in the sense that use of pesticides to enhance crop quality and/or yields is at a cost in terms of something else. The problem is one of choice.

At this point, it is necessary to clarify a serious misconception about economics. This is the misconception that economics deals only with goods and services that are bought and sold in the marketplace and can be measured in financial or monetary terms. Many people believe that the study of economics is concerned only with items which are measured in the marketplace and is not concerned with non-market items such as environmental or aesthetic considerations. It is true that because it is <u>easier</u> to deal with goods and services that <u>are</u> priced in the marketplace, most economic studies have been of a quantitative nature revolving around the marketplace to the neglect of those items not priced in the market system.

In fact, however, the ultimate criterion of resource allocation is maximization of human welfare, which cannot be measured in cardinal terms. Nevertheless, a substantial body of economic theory has been built around this concept. To the

extent that factors other than those of the marketplace affect human welfare, economics is logically concerned with these non-market items as well.

It is this characteristic--the concern with human welfare--that often leads to a "middle course" by the economist and is the reason for his being viewed with some distrust by both the ecologist and by the "practical" businessman. The ecologist worries that the economist's preoccupation with man could be to the detriment of other values. The "practical" businessman on the other hand never fully trusts anyone who deals in such "fuzzy" concepts as human welfare.

With this background, what are the relevant economic concepts related to pesticide use - both at the level of the individual firm and for the broader considerations of the environment and society in general?

Economic Decisions of the Individual Firm

As with any sole proprietor, the matter of economic survival dictates that the individual farmer act in such a manner that profits are maximized (or losses minimized). With a given technology, the individual farmer is faced with a given set of cost curves as shown in figure 1. The average costs of production decrease with increased output up to a point before rising as output is increased still further. The marginal cost curve indicates the additional cost of an additional unit of output, and rises as output is increased.1/

The market price of a commodity is determined by the intersection of the market supply and demand curves as shown in figure 2. The farmer is referred to

---

1/ Though it is not necessary for this discussion, it can be proven that as the marginal cost curve rises, it must intersect the average cost curve at its lowest point, thereafter remaining higher than the average cost curve.

BEFORE TECHNOLOGY

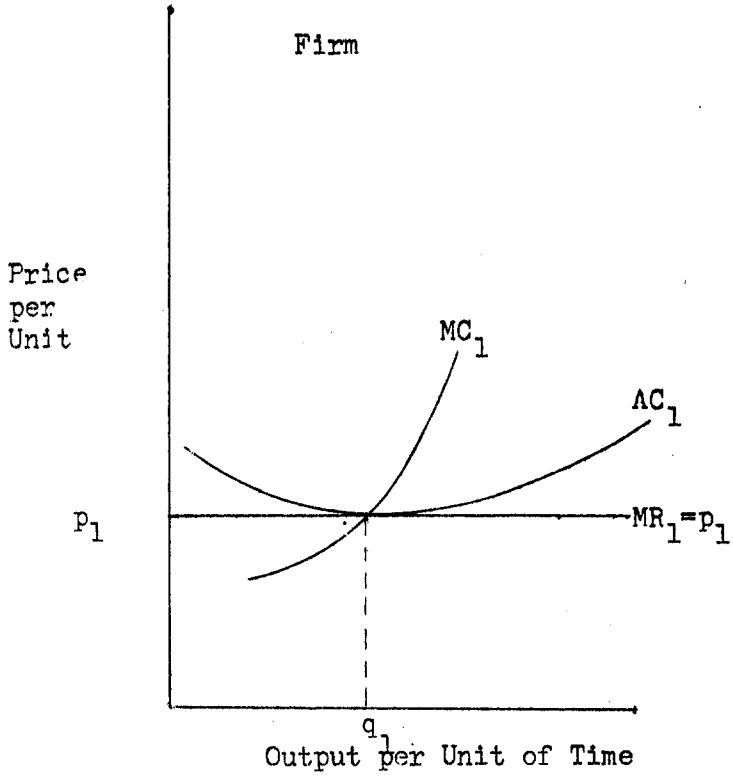

Figure 1

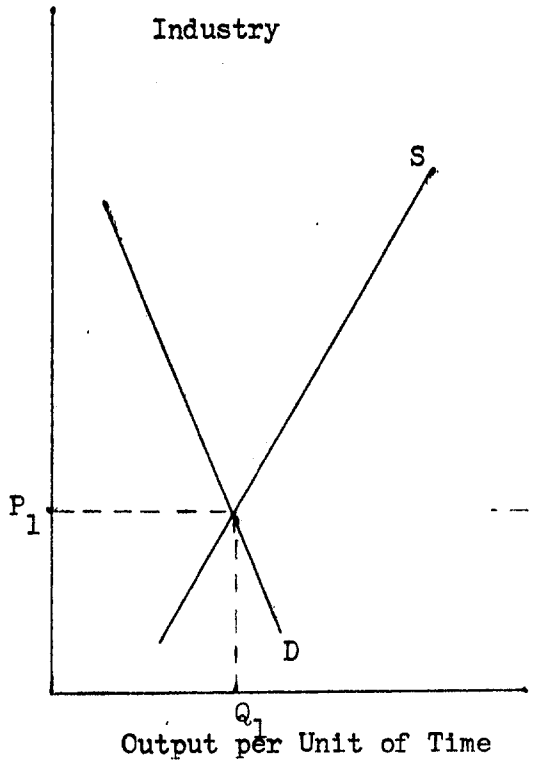

Figure 2

AFTER TECHNOLOGY

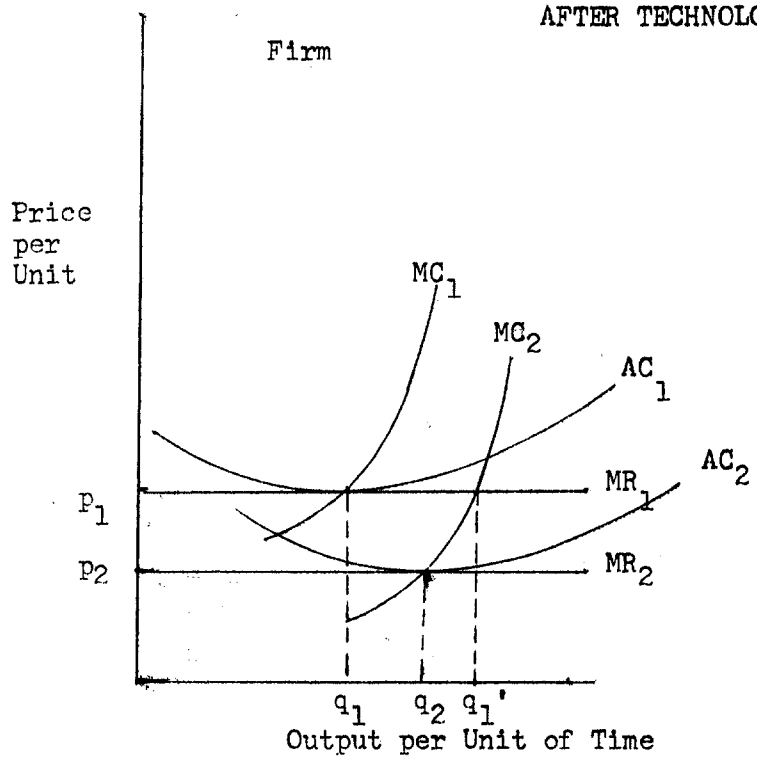

Figure 3

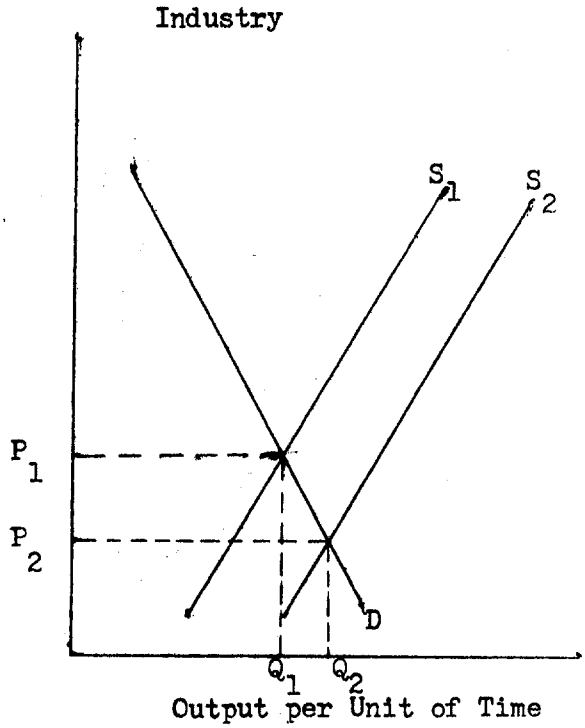

Figure 4

as a "price taker" in the sense that each farmer produces such a small portion of the total market that, acting by himself, he cannot affect price by withholding his product from the market.2/ Therefore, the farmer receives the same unit price whether he produces 1,000 units or 5,000 units of product, resulting in a marginal revenue3/ curve that is a horizontal line as shown in figure 1.

The profit maximizing rule is to produce to the point where marginal revenue equals marginal costs. In non-technical language, this is simply the common sense assertion that the rational producer will increase output if the additional cost for each additional unit of production is less than the return from that additional unit, and will keep increasing output until the cost incurred for increasing output just covers the dollar return of the additional output. Beyond this point, where the cost of additional output exceeds the return from that unit of output, it is not rational to produce.

At equilibrium, then, with supply and demand in figure 2 yielding a market output of Q_1 with a price of P_1, under a given technology, the producer shown in figure 1 will produce at level of q_1.4/

Now, let us assume that a new technology is developed, such as the introduction of a pesticide that increases yields. The effect of this is to lower the average and marginal cost curves of the individual producer as shown in figure 3.

2/ In more technical terms, there is "pure competition" on the selling side of the market.

3/ Marginal revenue is the additional revenue received for an additional unit sold. In the case of most agricultural production, marginal revenue is identical to price since, to the individual producer, price is unchanged with the volume he sells.

4/ It would appear that there is no net profit at this point since average cost of production equals price. However, it can be assumed for sake of simplicity, that a profit to the producer large enough to keep the resources in production is included in the cost of production.

The non-technical interpretation of a lowering of the cost curve is that a given level of output can now be produced at a lower cost, or in the relevant ranges of production, increased output can be produced at a given cost.

Using our decision rule logic, the farmer now, in producing where marginal cost equals marginal revenue, would produce at level q_1'. This would leave a greater profit than before since marginal revenue (price) is greater than average cost of production (assuming that price would remain unchanged).

The above conclusions are predicated on the premise that price remains unchanged. However, this is not likely to happen since the new technology is available to all producers. If all producers increase output in the manner postulated above, the total market supply curve will increase, as indicated by a shift to the right or S_2 in figure 4. This will result in a lower market price P_2, which is reflected back to the farmer as MR_2 in figure 3.

After these market adjustments occur[5/], the individual farmer is left with the same profit as before the new technology was introduced, (price again equals average cost of production) while producing more at lower cost. Market output has increased to Q_2 resulting in a lower price, P_2.

It will be noted that, with price of P_2, the individual producer will produce at point q_2. The final equilibrium will still be a higher level of output and lower price than before the new technology was introduced.

The motivating force behind pesticide use is the opportunity for lower cost of production and higher profits. Table 1 shows the results of one experiment in estimating the economic incentive to use pesticides.

5/ These adjustments occur after some time period. Therefore, the first producers who use the cost lowering technology reap the greatest gains.

Table 1: Returns for Corn and Soybeans as Affected by Weed Control Method, Average of Three Locations, Four Years, Minnesota*

CORN[1]/

Additional Costs for Herbicide Use		Additional Returns for Herbicide Use	
Cost of Chemical	3.50	Saving of Cultivation	.75
Spraying	1.00	Value of Additional Production (Yield Increases from 89-113 Bu/A)	28.80
Total	4.50	Total	29.55

Additional Return - Additional Cost (29.55 - 4.50) = $25.05

SOYBEANS[1]/

Additional Costs for Herbicide Use		Additional Returns for Herbicide Use	
Cost of Chemical	4.00	Saving of Cultivation	.75
Spraying	1.00	Value of Additional Production (Yield Increases from 23-29 Bu/A)	15.00
Total	5.00	Total	15.75

Additional Return - Additional Cost (15.75 - 5.00) = $10.75

1/ Assumptions: Spraying Cost = $1.00 Per Acre
Cultivating Cost = $1.50 for 3 Times; $.75 for 1 Time
Spraying Saves 2 Cultivations
Corn Price = $1.20 Per Bushel
Soybean Price = $2.50 Per Bushel

* Source: Gerald R. Miller, The Value of Weed Control and Crop Production, report issued by the Agricultural Extension Service, University of Minnesota and U.S.D.A.

Suppose a producer refused to go along with the new technology. If others adopt the new technology and the single individual does not, price is driven down and the individual is still producing at the higher cost level and is now facing possible losses. Therefore, the individual producer not only has incentive for adopting the new technology, but is economically forced to adopt it because of the competitive nature of production and pricing.

One reason generally cited for extensive pesticide use is that of producing a higher quality product. For example, apples showing evidence of damage by pests are not saleable and present problems in processing operations. Our previous logic remains unchanged, however, as the use of pesticides can be viewed as increasing the production and market supply of undamaged fruit. In the absence of pesticides, the cost of producing unblemished fruit would be greatly increased, resulting in higher market prices because of reduced market supply. Hence, there is a net incentive to the producer to use pesticides in order to reduce costs and increase profits or minimize losses. The net result of pesticide use is greater output and lower market prices than if pesticides were not used. In other words, society is benefitted by higher quality food at lower monetary cost. The U. S. Department of Agriculture reports that if pesticides were not used, crop and livestock production would drop by 25 to 30 percent. Furthermore, "This cut in production could boost the price of farm products by 50 to 75 percent, and increase foods share of the family budget from less than one-fifth at present to as much as one-third."6/

It is sometimes stated that the reason for pesticide use is as a labor saving technique. It is possible that there are cases where there is a net amount of labor saved - such as substituting use of herbicides for mechanical cultivation of corn. However, in many cases, use of a pesticide or herbicide necessitates additional labor. The deciding factor as to whether pesticides will be used is a computation of expected costs vs. expected returns to the producer in dollar terms. The individual producer calculates benefits and costs expected to accrue to him. He does not - indeed, he cannot if he is concerned about

---

6/ U. S. Senate, hearings before the Subcommittee on Migratory Labor on the Committee on Labor and Public Welfare, United States Senate, Ninety First Congress, First and Second Sessions on Pesticides and the Farm Worker, August 1, 1969, Part 6-A, p. 3195, Testimony by U. S. Dept. of Agriculture.

economic survival - take into account benefits and costs of pesticide use that are incident upon others. The implication is that if, for whatever reason, it is decided that public policy should be to reduce or limit the use of pesticides, it cannot be done through appeal to producers, since the individual producer, because of the extremely competitive nature of agricultural product markets, is economically forced to use the lowest cost production techniques.

This conclusion leads directly to the possible alternative of public regulation and the necessity to examine the public economics of pesticide use.

The Public Economics of Pesticide Use

In a capitalistic system such as that of the U. S., resources are allocated basically according to the price and market system. Most economists agree that this provides for a generally efficient allocation of resources, but that there are several limitations. One of these limitations is that some costs and benefits are not incident on the decision maker, but are incident upon the general public. Costs and benefits which are incident upon the general public are called social costs and benefits.

As an example of social benefits, the benefits of cancer research are widespread and shared by all, and are not readily calculated. Therefore, no individual firm has the incentive to undertake such activity on its own, resulting in the necessity for public subsidy.

The classic example of social costs is the reduced water or air quality which may result from effluent discharged by an industry or municipality. These costs are not readily measured in monetary terms and are incident on other than those directly responsible for the effluent discharge.

Consider the case of pesticide use which may result in social costs. As we have seen, the individual producer is economically forced to consider the costs and benefits that accrue only to himself. To the extent that there may be costs incident on the general public associated with pesticide use, such as damage to the environment, the private economic decision of the individual will not result in the socially optimum allocation of resources.7/ The net result on resource allocation is that if there are costs, such as environmental damage for which there is no economic incentive to be taken into account by the individual producer, then the real costs of pesticide use may be understated. An alternative way of stating the problem is that where social costs are present, marginal and average costs as viewed by the firm are lower than these costs as viewed by society. The increased output at lower prices (which can be measured) is at the cost of possible damage to the environment (which is more difficult to measure). Economic logic suggests that all costs and benefits be considered.

It should be pointed out that there may be social benefits associated with pesticide use, such as an abundant food supply or disease control associated with a reduced mosquito population. These benefits should be entered into the social decision calculus along with the social costs.

This discussion does not imply that a basically capitalistic system, or the profit motive, is responsible for pollution or other undesirable side effects of production. The manager of a state farm in the Soviet Union similarly has no incentive to consider effects on the total environment in striving to meet state imposed production quotas. Instead, he uses the least cost (according to his unit of accounting) methods to attain his production. Similarly, as the American

---

7/ The author is not making the case that there is or is not environmental damage resulting from pesticides. The economic logic is based on the premise that if there are net external or social costs not taken into account by the decision maker, the real costs of using pesticides are understated.

industrialist in producing at the lowest cost (to the firm) finds it convenient to use the public's atmosphere as a receptacle of wastes,[8] so the Soviet Industrialist finds it convenient to use the "peoples'" air in attaining state imposed production quotas.

The key point is that a misallocation of resources and the need for public policy result not from ideology or type of economic system, but from a situation where the effects of decisions are incident on other than the decision makers.

The net effect on resource allocation, if there are net external or social costs associated with use of pesticides, is that more resources are expended on pesticides, more food is produced at lower monetary cost, and social costs are greater than would be the case if pesticides were not used.

The possible social costs associated with pesticide use have created pressure for control of pesticide use. The basic short run question then boils down to: How much is the public willing to pay in terms of higher food prices, and less disease control for a reduction in use of pesticides? The long run question is: How can we increase the range of options in order that we might enjoy the benefits of disease control and an abundant high quality food supply and at the same time reduce the possible environmental risks?

Implications for Policy

The question of pesticide use is not one of an "either - or" nature. No responsible person advocates a total ban of all pesticides. Similarly, no responsible person advocates unlimited use of any and all pesticides. The relevant questions involve trade-offs of the nature of how much are we willing to increase

---

8/ The implication is not that industrialists are "greedy", but that there is no short run economic incentive for them to act otherwise under current "rules of the game". The rational policy response, if changes are desired, is to tighten up the rules of the game.

food costs in return for restricting the use of the most harmful or potentially harmful pesticides.

For example, one estimate that has been made is that the total ban of all pesticides would cost $410 million in Minnesota in terms of lost production. In contrast, the ban of "hard" pesticides[9] only would cost about $41 million in terms of lost production in Minnesota.[10] In some states, magnitude of difference between effects of banning all pesticides and "hard"pesticides is even greater.

The economic nature of the pesticide controversy suggests several precautions to be taken in policy formulation. As we have seen, for any rational policy measures, the competitive nature of the agricultural industry must be taken into account. Because the individual producer is economically forced to use the least cost means of production, it would seem that regulations must apply to all producers of a particular product. However, there are some other considerations.

If restrictions on pesticide use affected all producers equally, (in terms of increasing production costs) theoretically there should be no significant decrease in profits to producers in general, since reduced supply would indicate a higher price, leaving the consumer to bear the cost of restricted pesticide use. In fact, because of reduced supply and higher prices, profits to some farmers would be expected to increase. However, the economic effects on farmers would be very unevenly realized. For example, some producers of a particular product, because of unique conditions of a climatic or geographical nature, may

---

9/ "Hard" pesticides refer to those classes of pesticides such as chlorinated hydrocarbons which break down very slowly and are very persistent in the environment.

10/ Pesticides Report to Great Lakes States Governors by the Lake States Agricultural Committee, August 1, 1969. Reported in Farm Chemicals, December 1969, p. 34.

be more dependent on pesticide use than other producers. To the extent that this occurs, it is more difficult to restrict use across the board for a particular pesticide, as some producers may suffer greatly reduced yields and economic hardships. One possible way to avoid extreme cases would be to provide for use to stave off a potential crop failure. However, this may still leave some producers at a competitive disadvantage compared to others. These producers may not have production alternatives sufficient to maintain an adequate level of living although others may gain through higher prices resulting from reduced supply.11/

A more general example of the previous case relates to where production of the total crop is dependent on use of pesticides. It may not be possible to ban pesticides for production of certain fruit crops, for example, because production would be so drastically affected. This might incur a particular economic hardship on a region dependent on production and processing of a specific commodity. The argument that banning of pesticides would affect producers unequally by changing their relative competitive positions is partially negated by the fact that introduction of pesticides altered an earlier existing competitive pattern. Those producers who were able to produce efficiently without pesticides and whose yields increased only modestly with pesticide use were made worse off with introduction of pesticides compared to those producers whose yields were greatly increased by pesticide use.

To the extent that a ban on pesticide use would increase food prices and alter existing competitive patterns, some producers would gain and others would lose. Consumers would definitely face overall higher food prices.

11/ This situation is very similar to that which results from a public policy of implementing sudden and significant cutbacks in defense contracts. In the absence of a policy to ease the transition, workers are unemployed and the burden of undertaking the policy is very unevenly distributed.

Implications for Research

Not all costs and benefits of pesticide use are accounted for in the price system. One of the most urgent tasks is for reliable technical information to be obtained and, where known, to be made available to the public. Only in this way, can the public have a basis on which to decide how much to forego in terms of food prices in return for less dependence on the more harmful pesticides[12/] and have a basis for policy decision.

The search for more specific pesticides with fewer side effects should continue. This will take public research effort and is competitive with other pressing needs for public revenues at the State and Federal levels. It is involved with the question of public priorities, which is another area of widespread disagreement. It is easy to support more pesticide research, in principle. But when other public programs must be cut back, or taxes increased, support is likely to dwindle.

The effort to develop biological methods of pest control should be continued. Since this is not a profitable endeavor for private enterprise, it will be necessary for such research to be publicly supported. Again, this will involve increased resources devoted to the scientific research side of the public sector and to public and private foundations.

Research on side effects of pesticides as well as on the development of more effective, more specific pesticides and on other methods of pest control is especially

---

12/ On the matter of environmental effects of pesticides, there will very likely always be some areas of uncertainty. In the opinion of the author, where there is great uncertainty as to potential environmental damage, society should err on the side of caution by attempting to limit use of the more potentially harmful pesticides. This is a personal opinion, a value judgement on the part of the author, not a professional statement. In the area of value judgements, there is ample room for rational, informed people to have sincere differences of opinion.

important in view of the fact that pesticide use is predicted to increase in the coming years. It is not likely that the world's population is going to level off in the immediate future and there is need for improvement in the diets of much of the already existing population.13/ Research on the long run effect of pesticides on man is needed. The effect on migrant workers who have considerable exposure to pesticides is a particularly neglected area of research.

Although the use of an incomplete and "unbalanced" technology sometimes has harmful side effects, it is only through proper development and application of a more "balanced" technology that the present world population can be maintained under conditions that offer the prospect for orderly processes of change and improvement. Greater knowledge on all aspects of pesticide use and alternative methods of increasing production are a necessary part of a more balanced technology.

13/ Virtually all agricultural scientists agree that effort to slow down the rate of increase of the world's population must occur simultaneously with effort to increase food supply.

REFERENCES

"Pesticides Report," to the Great Lakes States Governors by the Lake States Agricultural Committee, August 1, 1969. Reported in Farm Chemicals, December 1969, p. 34.

Gerald R. Miller, The Value of Weed Control in Crop Production, report issued by the Agricultural Extension Service, University of Minnesota, and USDA.

Max R. Langham and W. F. Edwards, "Externalities in Pesticide Use," American Journal of Agricultural Economics, Vol. 51, No. 5, December 1959.

Oris C. Herfindahl and Allen V. Kneese, Quality of the Environment: An Economic Approach to Some Problems in Using Land, Water and Air, RFF, Inc., (Baltimore, Johns Hopkins Press, 1965).

U. S. Senate, Hearings Before the Subcommittee on Migratory Labor on the Committee on Labor and Public Welfare on Pesticides and the Farm Worker, Part 6-A, (Washington, D. C., GPO, 1970).