2. THE ROLE OF INTEGRATED PLANT PROTECTION IN SMALL SCALE FARMING AND IN THE PROTECTION OF THE ENVIRONMENT

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INTRODUCTION

Human beings are one of the most environmentally demanding biological species. Humans depend on the land for shelter, spatial distribution and for the provision of plants and animals for food and other utilities. The rivers and water masses provide humans with life saving water, while the atmosphere provides life giving gases. Humans form part of the complex ecosystem with the rest of the environment in which plants and animals co-exist. Both the physical and biological elements of the environment form a delicate balance which provides checks and balances for maintenance of the required equilibrium for self substance.

However, human beings, with their manipulative brain and, acting on the permission of the Creator as the Bible states, decided to bring the whole environment (physical and biological) to their advantage and to use the resources there - in for their benefit. However, somewhere along the line, mankind have failed to appreciate that the Creator had put the environment to what he considered wise use by humans. This should mean the use of environmental resources in such a way as to maintain a stable equilibrium in various ecosystems that constitute the environment.

Man as the cause of environmental disequilibrium

The unwise use of environmental resources by mankind has brought about gross environmental disequilibrium. The human population has overshot itself and exceeded the levels that can safely be sustained in some environments in Asia, Latin America and Africa. With the increase in human population , resource requirements by humans also increased, setting up a spiral of competition between humans themselves and between humans and other animal species. This competition for resources such as food, shelter and water in some areas has brought about depletion or near depletion of such resources as forest, water resources and indigenous plants. As a result of the ever-increasing clearance of forests of grow enough food and provide fuel and timber, mankind has precipitated drought conditions which in turn have decreased crop production with a consequential reduction in availability of food for both humans and other animals. The compound effects of over-population and depletion of plant life leading to baring of soil, has caused soil erosion and loss of soil fertility through rain wash, leaching and overcropping. Thus, an ever-increasing environmental imbalance has been set in motion where pests and diseases have less hosts outside what man and his domestic animals require. Consequently, man came into competition with pests and diseases for his crop plants, domesticated animals and other plants in man's economy.

Mankind seeking solutions to problems of his making

Mankind has endeavoured to correct or arrest the situation. Many different approaches have been used to try and prevent abuse and/or depletion of environmental resources. Some measures have taken single aspects of the environment as targets for correction using unidisciplinary approaches such as proper tillage as means of soil conservation, pest control in field crops, afforestation, prevention of soil wash and erosion using contour ridges or through establishment of plants.

However, the latter approaches have not managed to effectively arrest the overall environmental degradation and the fast depletion of the life saving resources because factors involved in environmental ecology are multiple and require a holistic approach to seeking solutions to problems. It is pleasing to note that environmental problems are now being taken seriously and there are calls for multidisciplinary approaches to seeking solutions.

Van Emden (8) writing about pest control and its ecology, stated that there is more to pest control than applying poisonous chemicals. To obtain maximum impact in pest control, it is necessary to visualise the total environment of crops not only including soil, weather, insects and plants but also the social, economic and industrial environments with which the crops are inexorably enmeshed (See Figure 1). Methods of pest control used will affect our food supply.

In the past, the title of this paper would have been "crop pests and disease management or control", that is, limiting the scope of this discussion to pests, diseases and crops. Yet pests and diseases have hosts in both crops and non crop plants; and pests, diseases and plants are also a part of our overall environment. The theme of this seminar paper is therefore, a step in the right direction towards a holistic approach to solving problems of man and his environment by further investigating the plant kingdom and the realms of integrated plant protection. It is hoped that scientists will make a concerted effort to put the plant kingdom in its proper perspective in the environment with both crop and non crop plants featuring within integrated plant protection. The welfare of plants should now be considered, not only in the light of protection against pests and diseases but other injuries should also be considered. Injury and destruction of plant life can be caused by human and other animal activities or by adverse environmental conditions. Any of these can tip the pest and pathogen ecological balance against plant life, resulting in plant damage or destruction.

Man has possibly been the greatest single factor in the injury and destruction of plants in recent history. By tampering with the environment through the multitude of human activities man has adversely affected climatic conditions to the detriment of, not only plant life but, to that of himself and other animals. Consequently, man's efforts to produce food through crop production have met with stiff competition from pests, diseases, weeds and climatic hazards. Man, therefore, has had to devise various ways of protecting what, he has at various stages considered plants of his economy.

Ideally, all plants forms should be protected. However, man must select certain animals and plants to protect. Similarly, mankind has also to choose which plants and animals to eliminate in order to minimise competition for resources. The choice in the delicate environment is very difficult and in many cases, wrong choices are made, resulting in serious plant pests and disease outbreaks. Man, at different times, has plants he considers of economic importance which may include silvicultural plants, aesthetic plants, fruits and flowers, medicinal plants and, of course, plants providing food and fibre. Essentially, plant protection is a system, where man must manipulate factors such as those shown in Figure 1 so that the incidence of pests and diseases remains below the economic threshold levels. It must be emphasised that such manipulation of environmental factors must not cause serious imbalances.

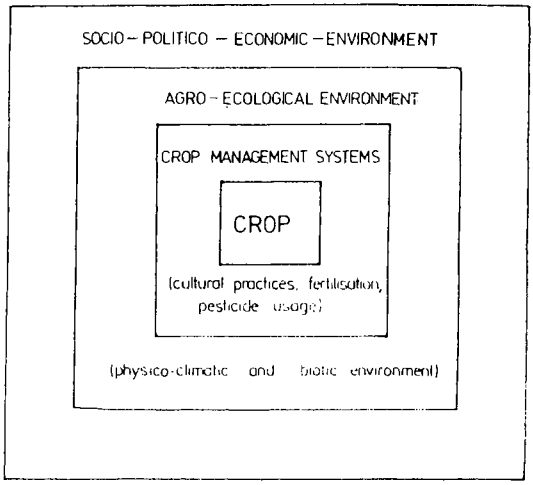

Figure 1: Interrelations of crops, crop management systems, the agroecosystem and the socio-politico-economic environment

THE IMPORTANCE OF DIFFERENT PLANT TYPES

(i) Non crop plants

Non crop plants are important components of the environment, being the primary producers in the food chain. Forest trees provide fuel, timber and are essential in the process of rain formation. Other non crop plants provide human food, shelter, timber and fuel, medicines and, help prevent soil erosion.

(ii) Crop plants

Crop plants can be divided into food and non food crops. Both types are economically important to mankind.

(a) Non food crop plants

Non food crop plants include cultivated forest plants, cultivated medicinal, aesthetic and shelter or hedge plants. There are also a variety of non food crops grown for cash and/or foreign currency earnings. Some plants are grown to protect or stabilise fragile soils, while others are grown to feed livestock.

(b) Food crop plants

Out of some 80,000 known edible plant species, man at one time or another is said to have used 3,000 for food, with 150 of them being cultivated to some significant level. Less than 20 crops are said to currently provide 90 per cent of the world's human food (Innovative Biological Technologies for Lesser Developed Countries: Workshop Proceedings, 1985). Because food is a primary requirement of man, both plant and animal species that provide this basic necessity have been greatly protected by mankind, using at his disposal.

PLANT PROTECTION

Ever since man noticed that plants were prone to damage or destruction by various agents (including man himself), the latter devised and engaged in various methods to protect plants he considered economically important. The levels of protection have depended on the levels of importance of the particular plants in the society. For example, forest plants have a wider economic impact on the society as a whole, while one field crop may be personal property in short economic terms (although individual field crops taken on national terms will also have an impact on the society as a whole). Therefore, there exists plant protection practices at international, national and individual farmers' levels.

(a) Protection of plants through international understanding

It has become the interest of nations the world over to protect as much vegetation over the earth's surface as possible against the ravages of human and other animals. International pressure has jogged national minds and prompted national governments to enact laws against international trafficking in plant life and unwanted destruction of plants including forest and bush clearing. There are also phytosanitary and quarantine regulations which operate between nations to prevent importation and exportation of plants infested with pests and diseases that may lead to plant damage in the importing countries.

(b) Protection of plants by national governments

National governments have awakened to the levels of serious environmental degradation and destruction of flora and fauna in their own countries by setting up agencies at both policy and implementation levels to safeguard environmental resources. Zimbabwe has set up a Ministry of Natural Resources and Conservation whose responsibility is to protect and conserve plant and animal life and to educate and co-ordinate other ministries on the proper uses of the environmental resources. The Zimbabwe Ministry of Natural Resources and Conservation and its various departments work hand in hand with other ministries/departments to implement laws against unwanted destruction of plant life. The Plant Protection Research Institute of the Department of Research and Specialist Services is a policing and/or implementation agency of the Government's regulations against:

(a) removal or destruction of protected plants.

(b) importation or export of infested plant material that would endanger plant life in Zimbabwe or in the other importing countries respectively.

(c) spread of plant pests and diseases within the country.

(d) protection of plant damage by pests and diseases.

Plant Protection Research Institute is also linked to the International and Regional Migratory Pests Organisations which advise, monitor and or co-ordinate control activities.

The Department of National Parks and Wildlife in the Ministry of Natural Resources in Zimbabwe is responsible for the protection of crop plants against Quelea birds, elephants and other wild life species. Some plants are designated rare and threatened with extinction and, are protected by law from any forms of removal or damage. Forests or bush clearance by mechanical or forest fires are restricted or prohibited depending on the circumstances involved.

(c) Protection of plants for individual farmer's benefits

Plant and animal species that provide the basic necessities - food and cash for mankind - have commanded a great deal of human interest, time, effort and other resources to produce and protect. Such is the importance placed on the desired food and cash crops, that man has sometimes cleared vast areas of land to give way to mono or selected mixed cultures of crops for years on end.

The consequences of this tampering with the environment has been the culturing of pests and diseases of these specific crops over the years to levels of economic significance or to epidemic proportions necessitating protection of the crops.

Efforts to correct the crop pest and disease problems have taken various twists in the evolution of pest management strategies, with sometimes significant short term benefits. However, because the strategies adopted have not always taken cognisance of the interrelationships between the flora and fauna in the environment, long term solutions have not been always achieved. If anything, the ecological imbalances caused by some of the adopted cropping systems accompanied by unidisciplinary selective pest and disease control methods have exacerbated and or compounded pest problems. The following are some of the pest management strategies used.

(i) Cultural control practices

When man grows plants for his benefit, minimum or no competition between his required plants with undesirable plant species is permitted. Man protects his crop plants from competition for space, light, water and nutrients by eliminating or controlling the numbers of other plant species. This can be effected by mechanical weeding or by the use of selective herbicides. Crop plants are also protected from competition by scheduling time of planting, by using intercropping methods to give competitive advantage to the crops or, by the use of varieties selected or bred for superior competitive qualities. Good agronomic conditions are also used to give crop plants competitive

advantage over undesired plants. These may include flooding to kill weeds and fertilisation to suppress weed species sensitive to certain fertilisers.

Crop plants can be protected from adverse climatic conditions such as rainstorms/blizzards etc. by building barriers or growing them in protected areas such as glass or green houses.

Cultural control practices are also used to protect plants from damage by pests and diseases. Cultural pest control methods entail the manipulation of cropping practices to weaken the mobility of or dislocate the lifecycle of the pest or pathogen. The latter practices involve the use of sanitation, crop combinations and rotation, tillage methods, crop nutrition, irrigation, fallow and, the use of trap crops. The use of resistant varieties can also be considered under the cultural practices used to control pests and diseases. Similarly, farmers are sometimes advised to avoid growing susceptible crops in pest infested areas or during peak pest activity periods/seasons. For example, in Zimbabwe, summer wheat is discouraged in order to avoid pest-carry overs. Cotton stover in Zimbabwe has to be destroyed by a nationally announced date to avoid pest build-up. However, it is not always possible to effectively stop farmers from growing crops they require for one reason or the other.

(ii) Chemical control

The use of pesticides could be considered the fastest and perhaps the most dramatic way of controlling pests and diseases. However, the use of pesticide is severely limited especially in subsistence farming in developing countries. Factors that limit the use of pesticide in controlling pests and diseases are: pest resistance build up, prohibitive costs involved, lack of or inadequate knowledge in the proper usage and disposal of pesticides and the unavailability of chemicals and application equipment.

(iii) Biological control of pests and diseases

Biological control of pests and diseases involves introduction of natural enemies including competitor species. The latter are said to act indirectly e.g. soil microbes produce toxins or chemical exudates that can immobilise or inhibit growth or reproduction of pathogenic organisms.

Entwistle (3) and Tagawa *et al* (7) have reported control of insect plant pests by the use of viruses. In Zimbabwe effective control of the semi loopers (insects) *Trichoplusia crichalcea* and *Plusia chalcite*, the most common pests of soyabean, has been achieved using semi looper nuclear polyhydrosis virus (NPV) (1). Some plant diseases are known to be controlled by beneficial microorganisms (5). Similar examples exist in biological control of plant parasitic nematodes where *Pasteuria penetrans* has been found to control *Meloidogyne* spp although this method has yet to prove its economic application.

Biological control has been effectively used to control insect pests but has limited local application in the control of weeds. The use of competitor species is said to have important application to soil pathogens (4).

(iv) Integrated plant protection

Alternate to a single control strategy and a single parasite, is integrated control of plant pests and diseases. Two concepts have been developed. One, the control of more than one pest affecting a crop is considered to constitute integrated control. The second concept is defined as the use of two or more methods or techniques to control specific pests/diseases.

The term integrated pest control or management was originally used to describe the use of insecticides in such a way as to allow natural enemies of the insect pests to operate in support of the chemical control agent i.e. integrated pest control was the combining or integration of biological and chemical control methods (6). However, the term integrated control has now been broadened in meaning to include the integration of as many as required methods of control to manage, not only insects but also other plant pathogens and weeds. The latter broader concept, fits in the theme of this volume of papers.

The most common integrated pest control strategy used is a combination of one or more cultural practices with or without chemical control. For example, in Zimbabwe, farmers are aware of the performance of certain maize varieties in their specific environments. Consequently, they will choose a variety they consider appropriate and then select what they consider healthy seed (pest/disease free) for planting and, follow their long evolved cultural practices for planting and managing their crop in order to avoid weed competition and pest infestation. Alternatively, farmers may adopt research recommendations on the management of the crop. Those that can afford chemical control will integrate mechanical weed control methods with the chemical control of such pests as stem borers when they appear.

Depending on the crop and on the socio-economic standing of the farmer, more sophisticated and expensive combinations of various pest control strategies can be integrated to control specific pests, diseases and weeds.

CONSTRAINTS TO THE USE OF INTEGRATED PLANT PROTECTION STRATEGIES

Although integrated plant protection may seem most suitable for small scale African farmers, the scope of its applicability is limited by many factors including the limited range of possible technologies to integrate:

(a) Chemical control, as a component of integrated control, is limited to a very few farmers and very small range of chemicals because of the cost and availability factor as well as lack of knowledge of the proper use of chemicals. If available, it is usually limited to use in cash crops and not subsistence crops.

(b) Lack of knowledge of the range of possible packages of integrated control technologies available.

(c) The multiplicity of factors involved in integrated plant protection may pose a technological barrier to the small scale farmers, not forgetting the psychological exasperation that may result from the slow results from integrated pest or disease control in the wake of a serious disease or pest outbreak.

(d) Non-availability of integrated plant protection technology

Despite the fact that the concept of integrated pest control dates back to the 1950's, there are not many packages of practices available for small scale African farmers from research. This may be due to the different and changing cropping patterns in various parts of Africa to which the different pest populations and disease incidence may be related.

(e) Lack of research-extension linkages

As and when the integrated plant protection technology is available, farmers will still suffer from the poor research-extension linkages to effectively transfer technology.

(f) Research in integrated plant protection has generally been relegated to a secondary position compared with single pest/disease control. This could be due to the multiplicity of the dimensions involved and hence the complexity of the designs and techniques required to address the factorial objectives of the experiments. Furthermore, in most of the African countries, research training and infrustructure has been geared to disciplinary research which compartmentalises research approaches. Within the individual disciplines, research training has been further narrowed to single pest specialisation within specific crops. As if that is not enough, responsibilities of plant protection in some African countries are placed under different institutes or departments, and even worse, under different ministries. As a result, planning and actual implementation of integrated pest management research and/or programmes in the context of the environment becomes limited.

The diversity of the farming systems and the socio-economic limitations in Africa also compound the problem of implementing integrated pest management research.

One such socio-economic limitation in some of the African countries is the availability of land and land tenure systems which can determine whether or not a farmer has land and can practice crop rotation or fallow to control pests, diseases and weeds. Cultural norms and food preferences can also be locality-specific and thereby limit the extent of applicability of research.

POSSIBLE ADVANTAGES OF INTEGRATED PLANT PROTECTION

Integrated plant protection is potentially a cost effective approach to plant protection. The combination of control strategies can be selected with the primary low cost criteria in view of the socio-economic status of the target group of African farmers. This is possible through emphasising the role of cultural, agronomic and host resistance strategies are developed with the cognisance of what is acceptable and appropriate for the locality concerned at any point in time, the chances for adoption will be increased.

(a) Safety to humans and untargeted fauna and flora

Since integrated crop protection practices do not entirely depend on the use of pesticides, there are better chances for human and animal health safety.

Therefore, minimal use, or where possible, avoidance of pesticides should be the aim of integrated plant protection.

(b) Safety to environment

Environmental resources including water, gases and biosphere are the most important resources for human inheritance. Their safe-guard is one of the vital responsibilities of man for the present and future generations. Integrated plant protection provides a chance to safeguard and sustain the natural environment.

DISCUSSION

Integrated plant protection has an important role to play in small scale farming systems in Africa because it has the potential properties of flexibility, acceptability and practicability, to suit the needs and means of the African farmer. In most of the Southern African countries, the need to arrest and correct the deteriorating food situation, the precariously degraded environments and, the consequential poverty spiral is a matter of urgency. Integrated plant protection with special consideration for the protection of the environment, seems an appropriate approach to solving pest, disease and environmental problems. However, long term plans must be drawn which involve policy definition at the political level and at various levels of the government implementing agencies.

From a national point of view, government agencies charged with policing and implementing environmental activities must be properly co-ordinated to a level of amalgamating institutes performing plant protection activities. For example, weed and other pest and disease research should be integrated and, phytosanitary and quarantine services should fall under one management.

Training and retraining should be carried out in plant protection in order to equip future and existing staff with the necessary capability to work within the broadened operational sphere. There is also a need to use the Farming System Research (FSR) approach and diagnostic methodologies training should take account of this requirement which would bring the researchers to recognise the importance of the sociological factors in the farming systems they will be working in. Proper diagnostic methodologies will bring out the role of women in the food systems and hence help to integrate women in development in order to fully utilise human resources.

Integrated plant protection can play a significant role in co-ordinating research-extension and farmers' activities in the production systems of the African small scale farmers and, in improving the diagnosis of the latter's plant production problems in the context of the overall environment. By drawing on the diagnostic methodologies of FSR, integrated plant protection can bring about integration of research disciplines within prevailing socio-economic environments.

This way, it should be possible to develop technologies appropriate and acceptable to the target farmers that will also help to sustain their environmental heritage.

SUMMARY

Integrated plant protection can play an important role in the war against pests, diseases, weeds and the fast deteriorating environment. Presently, integrated plant protection is being practised to a limited extent due to various constraints.

Integrated plant protection has a potentially more significant role to play in the African small scale farming systems because the approach has room for flexibility to suit the needs and means of the user. However, policy adjustments at national levels are required to facilitate the necessary adjustments by the implementing agencies to accommodate the restructuring of institutions and the training of staff needed to operate integrated plant protection research programmes. Farmer training to improve the levels of technology adoption is also required. Strengthening of research-extension and, farmer communication is necessary to improve technology generation and transfer.

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