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System Management Approach in Crop Production and Protection

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Abstract

The complexity of agricultural systems and the need to fulfill multiple objectives in sustainable agro-ecosystems call for interdisciplinary analyzes and input from a wide variety of disciplines in order to better understand the complete agronomic production system. Systems approaches have been developed to support these interdisciplinary studies; their development and use have increased strongly in the past decades. Systems analysis in agronomic systems implies the use of various types of knowledge and model-simulations. It provides concepts and tools for structured analysis, synthesis and design of systems at different scales. Each problem requires its own research approach. Based on the output requirements and data availability, the proper systems approach has to be selected. System management approach is now more relevant and important than at any previous time because of increasing realization of the inter-relatedness between components of fragile ecosystems; as comprehensive interdisciplinary analysis of agricultural production systems is seen as a necessary condition for the development of innovative, sustainable systems for the future. This paper presents an overview about system approach and its application in crop production and crop protection; in particular it reports the significance of implementation of system management approach in mitigation of pest problem in crop production.

Keywords; Agriculture production; System approach; Pest; Crop protection

1. Introduction

Pest problems are complex, dependent on climate, agronomy, technology and various ecological processes, as well as political, social and economic forces. To understand how pest problems arise and how they may be tackled, a systems view is required (Rossing and Heong, 1997). Pest management is a set of activities in agricultural production aimed at keeping pest populations or injury within economically and socially acceptable loss levels. Management implies both knowledge and intervention. One important concept that has found much application in modern pest management is that of Integrated Pest Management, which stresses the rational use of a combination of pest control techniques while enhancing the role of natural regulatory mechanisms to produce an economically and socially acceptable yield with no adverse effects on the environment (Teng and Savary, 1992).

The scientific basis for pest management was initially based on single-factor and single-pest studies which expanded to multiple-factor, multiple-pest studies and strategies. This coincided with actual demonstrations of how system components were linked, and how to manage one pest without due regard to other pests, was to invite problems. In the early years of pest management, mathematical modeling and even computer simulation were attempted although without explicit recognition of the influence of a conceptual base which was later called the systems approach (Teng and Savary, 1992).

The application of the systems approach to pest management may be considered as having started with the development of computer simulation models for insects and diseases in the late 1960s (Ruesink, 1976). Prior to about 1970, much emphasis was on the development of techniques for simulation and statistical modeling of disease and insect life cycles; in the 1970s and early 1980s, a series of simulation models for pests was developed; the late 1980s saw work to broaden the approach by including the crop and socio-economic factors and, concurrently, research to develop decision-aids for farmers and extensionists. It was also opportune that the same forces that fuelled application of the IPM concept to pest management also encouraged the application of a systems approach to pest management (Teng and Savary, 1992).

System is a limited part of reality that contains inter-related elements; a system represents more than the mere addition of its components. System approach proposes a holistic view in which systems management is predicated on the admission that overall system behavior will be influenced by changes in any system component (Rossing and Heong, 1997; USDA, 2002). Therefore, to develop an IPM scheme that fits into a sustainable farming system requires that the system first be analyzed (Rossing and Heong, 1997; Khoury and Makkouk, 2010). The practical tools of pest management often trade-off system inputs with outputs in an environment where perceptions of human and agricultural risk prevail. Pest management research is continually being challenged to derive usable tools for developing tactics and strategies that account for the human element. This review paper briefly presents concepts of systems approaches and provides illustrations on its application in crop production and protection.

2. Systems Research: Concepts and Tools

2.1. Concept of system approach

System is a collection of related elements that must function in concert to achieve a desired result (Bean and Radford, 2002). A system consists of inter linked subsystems, but is more than the sum of its subsystems. The central feature of a system is its integrity. The behavior of a system depends on how the parts are connected, and the specific relationships between them. In a system it seems that everything is connected to something else in an apparently endless web of relationships. Hence, understanding, predicting, and managing such systems requires both different view and a suitable tool or theory to guide our action. A system also contains one or more feedback loops which are central to the system behavior. Feedback loops permit a system to function in a self-managed, self-sustained way. The two key conclusions of system thinking are that the interrelated parts drive systems, and the feedback loops are circular rather than linear in nature (Anandajayasekeram *et al*., 2009)

Comparing system thinking to analytical thinking, one finds that system thinking is contextual, which is the opposite of analytical thinking. Analysis means taking something apart in order to understand it. System thinking means putting it into the context of a larger whole (Capra 1997). Systems thinking are an essential tool in the process of understanding organizational behaviors. Innovative organizations are dynamic systems, continuously changing while stable unchanging systems cannot innovate. Since the stable state of equilibrium seeks to preserve stability, it does its best not to innovate/change (Anandajayasekeram *et al*., 2009).

2.2. Systems and models

Systems research adopts the viewpoint that the real world may be divided into systems, the essence of which can be captured in models, which are simplified representations of systems. The components of a system strongly interact; and while it may be affected by components outside the system, the system itself exerts little influence on its environment (Rabbinge and De Wit, 1989). Overall system behavior is influenced by changes in any system component. As such, the systems research viewpoint may be described as holistic (Teng and Savary, 1992). The choice of system boundaries is determined by the objectives of the study, but boundaries are always chosen in such a way that the interaction between system components is considerably stronger than the interaction between system and environment (Rossing and Heong, 1997).

Systems may be classified according to various criteria. The possibility to validate a model of the system leads to the distinction of repeatable, recurring and unique systems. Falsifiable models can only be developed for repeatable or recurring systems. Models for unique systems are speculative. While production ecological aspects of agriculture usually pertain to repeatable or recurring systems. Agricultural economics sometimes deals with recurring but usually with unique systems (Rossing and Heong, 1997).

A classification of cropping systems according to principal growth factors at the field level was proposed by Rabbinge (1993). Elaborating earlier concepts by Zadoks and Schein (1979), he distinguished three production levels: potential yield, attainable yield and actual yield. Potential yield is realized when crops grow with an ample supply of water and nutrients in the absence of pests. Radiation, temperature and crop physiological aspects are growth defining factors. Growth-limiting factors such as water, nitrogen and phosphorus result in attainable yield levels that, commonly, are 20 to 50% below potential yield (Penning de Vries and Rabbinge, 1995). Although technically attainable, this yield level may not be economically attractive (Zadoks and Schein, 1979). Super imposed upon the growth-limiting factors. Growth-reducing factors such as pests, diseases, weeds and pollutants may reduce yields to below the attainable level. Experience reveals that in reality actual yield levels are often well below attainable levels.

In conjunction with production levels, Rabbinge (1993) distinguished a range of production situations. The production situation at a specific site is characterized by physical and chemical factors, such as climate, soil water holding capacity, prevalence of stones in the top soil, and cation exchange capacity. Factors determining production situations cannot be changed within one growing season. The combination of production situation and production technology results in a production level (Figure 1). In good production situations, a high production level can be realized with a given production technology. In poor production situations, greater inputs may be needed to reach a similar production level.

The classification of systems based on temporal and spatial dimensions from an ecological perspective leads to a distinction between levels of ecological aggregation; pathosystems, cropping systems, farming systems, watersheds and regions. These systems differ in size, in time scale at which key processes react and in time horizon. Pathosystems typically cover surface areas up to several square meters, have time coefficients of minutes to hours and a time horizon of weeks to months, whereas regional systems cover areas of several square kilometers, have time coefficients of months to years and a time horizon of years to decades. Emphasis on the level of social organization leads to a distinction of farming systems, village systems, provincial systems and international systems. Pest problems arise through the interaction between natural and human systems, and a definition of systems geared to solving pest problems must contain components of both systems. At the field level, crop protection issues comprise four elements, represented in a tetrahedron (Figure 2): the pest, the crop, weather and soil, and the farmer. The pest interacts with the crop. The outcome of the interaction is determined by crop and pest attributes, which are influenced by weather and soil, and by the farmer (Rossing and Heong, 1997).

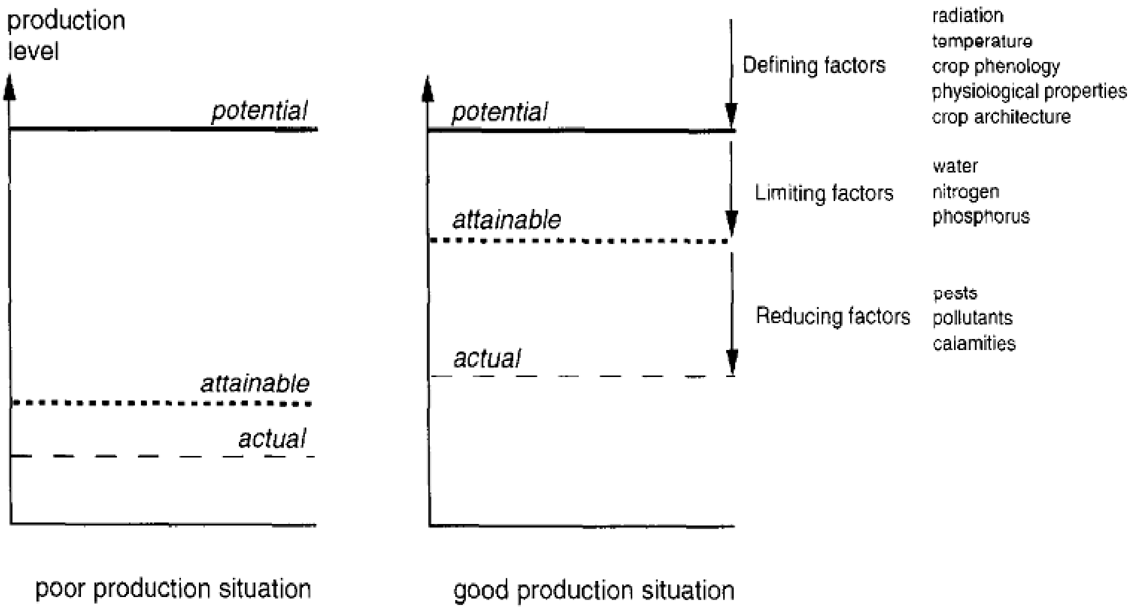

Figure 1: Production situations, production levels and associated principal growth factors (Rossing and Heong, 1997)

Studies of complex di-trophic and tri-trophic systems easily lead to situations where 'everything affects everything' at the system level, so that causes and effects cannot be disentangled. Therefore, the pest (Figure 2A) and the crop (Figure 2B) are distinguished as ecological subsystems. Studying the pest subsystems results in an understanding of its population dynamics with weather and soil, crop and management as boundary conditions. Study of the crop subsystem with pest dynamics, weather and soil. and management as inputs leads to understanding of the relation between injury caused by the pest and damage incurred by the crop. For evaluation of management options, pest and crop subsystems are studied as part of one system. Crop protection issues at the field level are part of larger issues at the farm and regional levels, which affect the interaction of the farmer with the crop-pest system (Figure 2C). Therefore, from a systems research perspective, crop protection issues need to be addressed at different levels of human and ecological organization in order to obtain sufficient diversity of options and their consequences (Rossing and Heong, 1997).

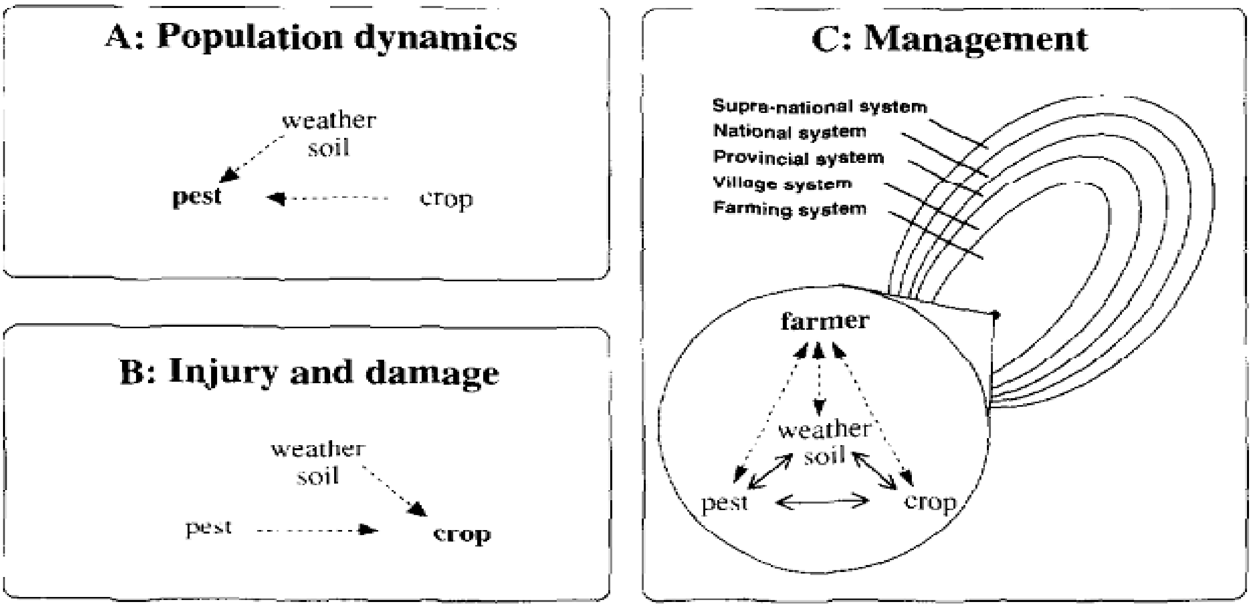

Figure 2: The pest triangle and tetrahedron and its relation to systems research at various aggregation levels (Rossing and Heong, 1997)

Models are simplified representations of systems and capture key system components. When applied to problem solving, models may be qualitative or quantitative, but usually they start as qualitative representations of reality. Qualitative models in systems research come in many forms, like decision trees, option-consequence matrices and relational diagrams. In quantitative systems research, dynamic simulation models are important vehicles for explaining systems behavior. Quantitative systems research is based on the assumption that, at any moment in time, the system can be characterized by a measurable state and that rates, which describe changes in the system, can be expressed mathematically. Dynamic simulation models contain descriptions of the processes which govern systems behavior in time and space. The level of detail required in describing the processes is determined by the questions asked (Rabbinge *et al*., 1989; Leffelaar, 1993; Rossing and Heong, 1997). Usually, the time coefficient at the process level is two or three orders of magnitude, *i.e*. a factor 100 to 1000, smaller than that at the system level. Thus, simulation models are used to 'explain' systems behavior based on a description of process behavior. Such explanatory models are juxtaposed to statistical models in which one aspect of systems behavior is correlated to other aspects. The statistical approach results in descriptive models that capture the main aspects of systems at the systems level and relate inputs of the agricultural production process to outcome (Rossing and Heong, 1997).

2.3. Developmental phases

In the process of systems research, three phases may be distinguished (Figure 3). These are problem identification, system design and management and increasing production ecological insight (Rossing and Heong, 1997). During the phase of problem identification, the problem is defined and key components and processes are identified. A useful distinction can be made between ecological and technical components of a system versus management aspects. Problem identification results in a conceptual model of the system. Management science provides a suite of descriptive techniques for problem description and decision analysis. When the results for the conceptual phase lead to the conclusion that all relevant information is available, the next phase is to design improved systems management (Figure 3). Often, more information on production ecological relationships is needed, necessitating a phase of increasing ecological insight before embarking upon systems design and management. During the phase of increasing ecological insight, production ecological theory and experiments are used to quantify key processes.

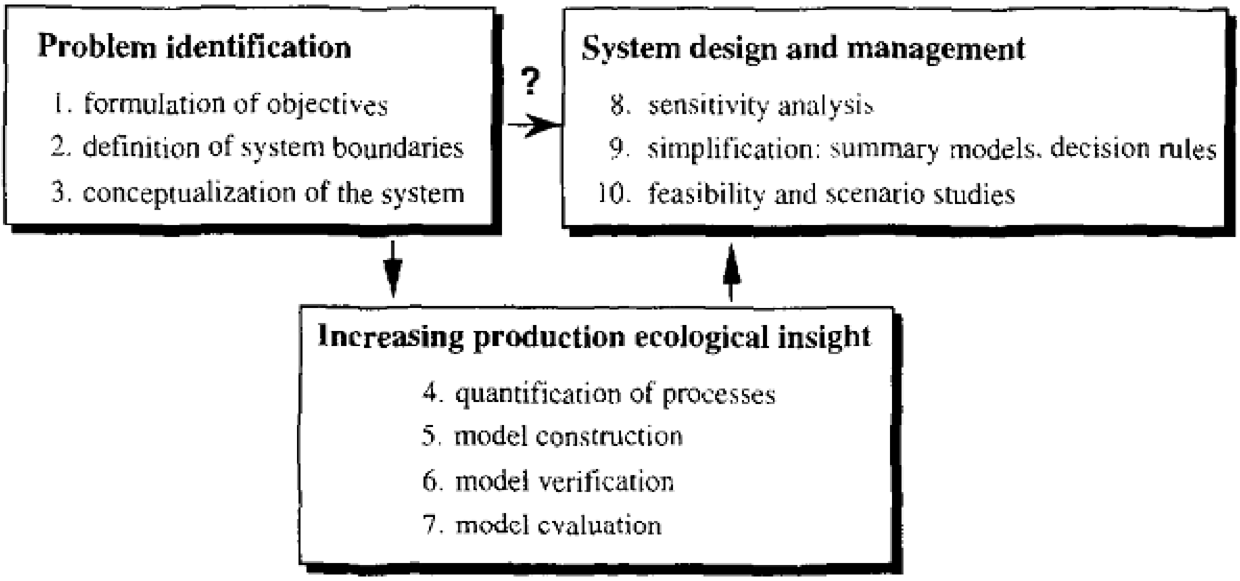

Figure 3: Developmental phases in systems research (Rossing and Heong, 1997)

During this phase a comprehensive simulation model is constructed that represents a complex hypothesis of the causes of systems behavior. Correct representation of the model in computer code should be verified. Hypothesis testing, or evaluation of model behavior in relation to real world behavior, is an indispensable part of this phase. Procedures such as calibration can help to assess the degree to which the system is understood (Rossing and Heong, 1997). During the phase of systems design and management, various options for solving the problem are identified and confronted with objectives. Usually, simplification of the information obtained in the previous phases is needed. Depending upon the time horizon of the study, options may be more or less speculative. Several procedures exist for identifying current and speculative options and assessing them in terms of objectives. These may take the shape of decision trees, pay-off matrices discrimination analyses (Rossing and Heong, 1997).

2.4. Pest problems and management domain

Methodology for improved problem definition includes the early work on crop loss profiles, followed by the synoptic approaches and integrated pest surveys in several countries. The analysis of pest seasonal and historical profile patterns and the qualitative interpretation of hierarchical relationships among components of a system have also been successfully applied in rice and potato (Heong, 1990; Teng and Savary, 1992). Recently, a significant step was made with the use of methods that allow the identification of corresponding pest profiles and patterns of cropping practices in a crop ecosystem that may be jointly amenable to solution. This improved problem definition has resulted in more focused development of descriptive and quantitative models at the sub-system level (Teng and Savary, 1992).

The systems approach is particularly relevant to problem definition and hierarchization in complex agricultural systems (Teng, 1985). Too often is the systems approach, or systems analysis, equated to the development, testing, and evaluation of a simulation model. Heong (1985) has reviewed the semi-quantitative methods to address key issues in pest management. Among these methods is the use of pest profiles over time, *i.e.* the diagrammatic representation of the succession of pests during the cropping season, at the various development stages of the crop. A damage matrix may allow the identification of the most important pests, and help in prioritizing pests to be managed and/or research actions to be taken (Heong, 1985). Decision trees can be developed to compare methods for selected pests, and identify questions to be solved before implementing these methods, such as the planting times of the damage thresholds (Teng and Savary, 1992).

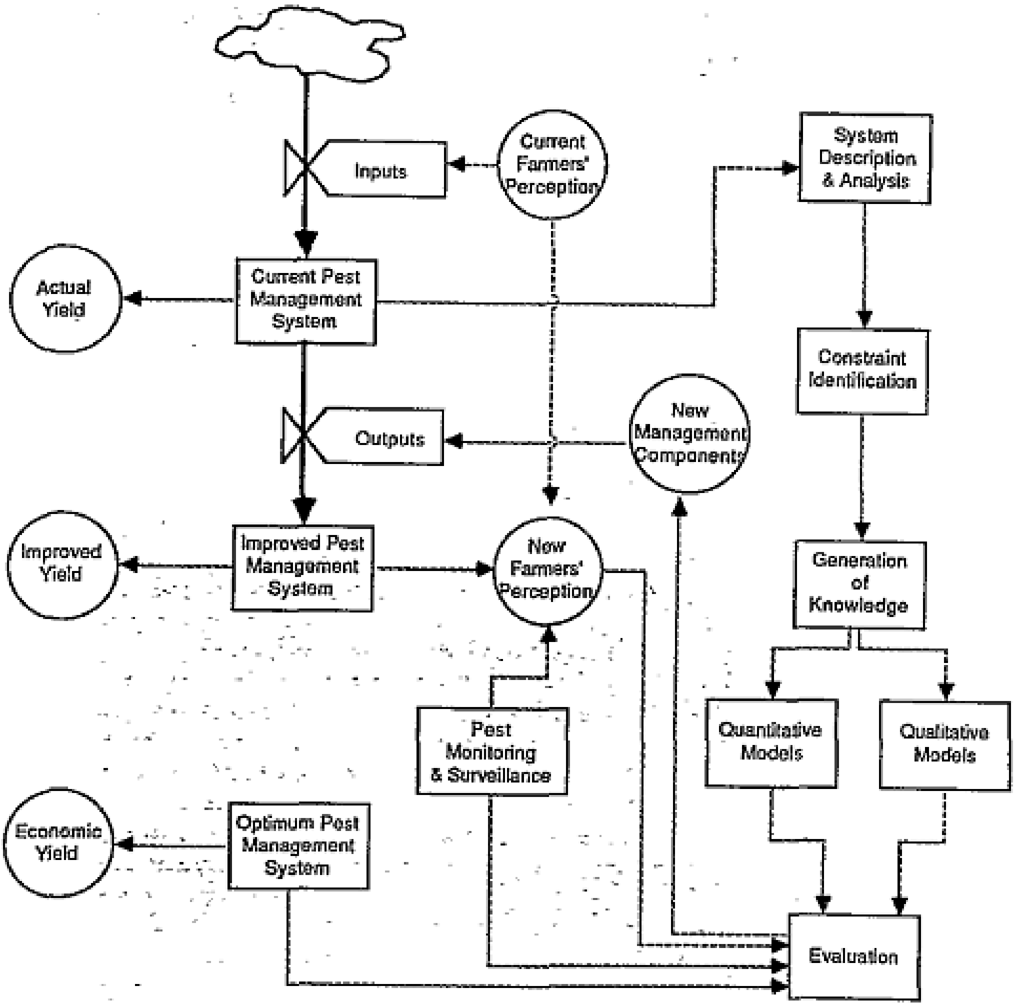

Figure 4: Schematic of phases to apply the systems approach in pest management (Teng and Savary, 1992)

In using the systems approach to improve pest management, one tangible output is a list of intervention points where the system behavior may be improved. These may take the form of research gaps specific policy changes needed to facilitate changes at a farm level or specific implementation steps. A sequence of steps may be conceptualized as in Figure 4. The role of systems analysis is to provide a reliable description of the system so that relevant questions are raised to guide the subsequent implementation.

3. Application of the System Approach to Plant Protection

The concept and use of multiple management practices to guard against the introduction of plant pathogen and other food borne pests has been used since 1660's. The protocol required to export unshu orange from Japan to the United State is a well known example of a system approach that has been in use for more than 30 years. The goal of any nation phytosanitory import regulations is to prevent entry and establishment of exotic or non indigenous organism, including plant pathogen that pose a risk to plant life or health (USDA, 2002).

Either entry or establishment must be prevented. So, an effective system approaches may employ independent mitigation measure targeting either or both entry and establishment. If a commodity is to be imported and distributed in areas where condition are suitable for establishment of a targeted pathogen, mitigation method providing a high degree of confidence that a targeted pathogen would be detected and eliminated at origin would be most favorable. If, however, distribution of an imported commodity were limited to those areas where neither the commodity nor suitable hosts for the targeted pathogen are found, it would be there for, be less critical to detect and eliminate the pathogen before entry of the commodity. This presumes that the commodity will transshipped to areas where host material is present (USDA, 2002).

The focus of system approach, as with other pest mitigation measures is to reduce probability of entry or establishment of a targeted pest to an acceptable level. As described earlier, the system approaches share similar design and implementation to integrated pest management in crop. In an integrated pest management (IPM) program for crop specific pathogen, the grower implements serious of mitigation practices known as the IPM elements; which in combination minimize risks associated with the plant pathogen (USDA, 2002).The IPM technique also has application to insect and weed pest management as well. IPM labeling of produce require that a number of prescribed IPM elements be adopted in that production system. The catalog of IPM elements represents a range of crop specific and agro-eco-region specific practices intended to mitigate the risk of an unacceptable pest management outcome. Common elements include resistant crop varieties, crop rotation, cultural practices, biological control, physical barriers to pest infestation and chemical method (Razdan and Gupta, 2009; Khoury and Makkouk, 2010).

An effective IPM system conjoins basic, implementation and maintenance research with stakeholder input to identify effective and manageable elements. In the system Stakeholders participation in the development of an effective system approach for imported and exported agricultural product is critical. In a system approach, as with an IPM approach, two or more independent control mitigation measures are required. If only one measure is used, they form a pyramid, each measure building on the prior measure and increasing the probability of preventing the entrance and establishment of unwanted pathogen (USDA, 2002).

In system approach, while each of the elements employed mitigate the risk of pest introduction, they cannot eliminate it. This is true irrespective of the suite pest mitigating elements deployed. Simple stated, there is no such thing as zero risk so long as human enterprise and trade continue, no individual control measure can be guaranteed to be 1005 effective. Risk mitigation efforts, for instance rarely address the introduction of a targeted pest that might result from smuggling.

In designing specific system approach, a team approach involving the participation of scientific specialist and stalk holders should be employed from the beginning of its design through its implementation, and during maintenance and enforcement. Such a team would first conduct a risk analysis quantifying the likelihood of introduction and establishment and the potential harm a pest or a group of pests could cause. Once these risks have been assessed, the team would then identify and evaluate the effectiveness of the elements or measures that could be used to reduce the risk of establishment of a plant pathogen to an acceptable level (USDA, 2002).

4. Significance of System Approach in Plant Disease Management

A systems approach integrates measures to meet phytosanitary import requirements. Systems approaches provide, where appropriate, an equivalent alternative to procedures such as treatments or replace more restrictive measures like prohibition. This is achieved by considering the combined effect of different conditions and procedures. System approaches provide the opportunity to consider both pre- and post-harvest procedures that may contribute to the effective management of pest risk (FAO, 2002).

Conventional methods to prevent the movement of pests and pathogens are based on certification, endpoint inspections, and quarantines. These methods, although well intentioned, have failed to prevent contaminated plants from being shipped. There are many reasons why: for example, plants may be infected but not express symptoms; fungistatic materials may suppress disease temporarily; and pots or potting media may be infested but go unnoticed. Pathogens are particularly easy to miss when infecting roots. Furthermore, symptoms may not be recognized by plant inspectors, especially if they are caused by a new pathogen. The cost of inspection is also very high (Parke and Grünwald, 2012). Thus, the current system is both economically unsustainable and inadequate from a regulatory standpoint. Thus, it is important to consider systems approaches among pest risk management options because the integration of measures may be less trade restrictive than other risk management options; particularly where the alternative is prohibition (FAO, 2002).

The benefits of a total system approach would be immense, directly to farming and indirectly to society. The approach takes into account impacts on our natural resources such as the preservation of flora and fauna, quality and diversity of landscape, and conservation of energy and nonrenewable resources. Long term sociological benefits would also emerge in areas of employment, public health, and well being of persons associated with agriculture (Lewis *et al*., 1997).

5. Characteristics of Systems Approaches

A systems approach requires two or more measures that are independent of each other, and may include any number of measures that are dependent on each other. An advantage of the systems approach is the ability to address variability and uncertainty by modifying the number and strength of measures to meet phytosanitary import requirements. Measures used in a systems approach may be applied pre- and/or post-harvest wherever national plant protection organizations (NPPOs) have the ability to oversee and ensure compliance with phytosanitary procedures. Thus, a systems approach may include measures applied in the place of production, during the post-harvest period, at the packing house, or during shipment and distribution of the commodity (FAO, 2002).

Cultural practices, crop treatment, post-harvest disinfestations, inspection and other procedures may be integrated in a systems approach. Risk management measures designed to prevent contamination or re-infestation are generally included in a systems approach. Likewise, procedures such as pest surveillance, trapping and sampling can also be components of a systems approach. Measures that do not kill pests or reduce their prevalence but reduce their potential for entry or establishment (safeguards) can be included in a systems approach. Examples include designated harvest or shipping periods, restrictions on the maturity, color, hardness, or other condition of the commodity, the use of resistant hosts, and limited distribution or restricted use at the destination (FAO, 2002).

6. Circumstances for Use of system approach

According to FAO (2002) report systems approaches may be considered when one or more of the following circumstances apply:

- individual measures are:
    - not adequate to meet phytosanitary import requirements
    - not available (or likely to become unavailable)
    - detrimental (to commodity, human health, environment)
    - not cost effective
    - overly trade restrictive and not feasible
- the pest and pest-host relationship is well known
- a systems approach has been demonstrated to be effective for a similar pest/commodity situation
- there is the possibility to assess the effectiveness of individual measures either qualitatively or quantitatively
- relevant growing, harvesting, packing, transportation and distribution practices are well-known and standardized
- individual measures can be monitored and corrected
- prevalence of the pest(s) is known and can be monitored
- a systems approach is cost effective (e.g. considering the value and/or volume of commodity).

7. Developing a System Approach

The process of developing systems approaches may include consultation with industry, the scientific community, and trading partner(s). It may also include measures that are added or strengthened to compensate for uncertainty due to data gaps, variability, or lack of experience is the application of procedures. The level of such compensation included in a systems approach should be commensurate with the level of uncertainty. Experience and the provision of additional information may provide the basis for renewed consideration of the number and strength of measures with a view to modifying the systems approach accordingly. The development of a systems approach involves: obtaining from a PRA the identity of the pest risk and the description of the pathway, identifying where and when management measures occur or can be applied, distinguishing between measures that are essential to the system and other factors or conditions, identifying independent and dependent measures and options for the compensation for uncertainty, assessing the individual and integrated efficacy of measures that are essential to the system, assessing feasibility and trade restrictiveness, consultation and implementation with documentation and reporting (FAO, 2002).

7.1. Data and knowledge requirements

Generally, system approach will be more difficult to develop and implement than probity for postharvest treatment. The degree of difficulty largely depends upon how much biological, risk mitigation and other information is already known. Since the dynamics of any crop/pest complex are shaped by the biology of the crop and related biological complex, it's so climate regime and local agronomic practice, each specific system approach for a crop or pest complex must be a unique assemblage of tactics. In the best case, as specific systems approach would have comparatively fewer negative impacts on commodity quality, or allow for speeder and there for more cost effective trade than alternative risk mitigation measure. A joint workshop of USDA-ARS and USDA-APHIS identified the conditions that allow for a successful systems approach to be developed (Liquid *et al.*, 1997).

- Pest(s) associated with the commodity are known;
- Basic biology of the pests(s) is known. Including pest/host relationship, alternate hosts, habitat selection

and population dynamics;

- Knowledge of the pathogen and disease cycle;
- System exist for field surveillance and/or detection of pest(s) in shipment,
- Knowledge of harvesting, packing and marketing practices exists;
- No alternative method is available for obtaining phytosanitory security or a system approach is more desirable because it doesn't damage the commodity and is more effective
- Sufficient volume of the commodity is shipped to justify and offset the program costs,
- Some degree of redundancy and independence between program components can be designed to allow for variability in pest populations or partial failure of other components and phytosanitory security is apparent either by qualitative or quantitative assessment.

The development of system approach must be undertaken in a methodical manner, making the best use of the knowledge of the pathogen and host biology, pathogen ecological requirements, the marketing and distribution system, and the level of risk acceptable to the importing country. It is important to realize that control measure must be both effective and practical. The international plant protection convention (IPPC) developed a set of steps to be taken to develop and implements a system approach (IPPC, 2000).

- Identify the pest risk, pathway risk
- Describe the pathway
- Identify where management measure occur or can be applied
- Distinguish essential measure and other factors or conditions;
- Identify independent and dependent measures and redundancy;
- Assess the individual and integrated efficacy of essential measures;
- Assess the feasibility and trade restriction impact
- Consult and negotiate with importing country
- Implement with documentation and reporting; and
- Reviewing and modifies as necessary

7.2. Components of a System Approach

The component available for inclusion in a systems approach run the entire gamut of pathogen management, but can generally be divided into four categories; Exclusion of pathogen, detection of the pathogen, elimination of detected pathogen population and/or risk reduction of establishment, and this should always be based on the integration of basic concepts such as avoidance, exclusion, eradication, protection, resistance and therapy, as described by Razdan and Gupta (2009) and Khoury and Makkouk (2010).

8. Systems Engineering

The system approach to safeguarding against plant pathogens is scientifically sound, accepted by the international trade community, and has been successfully implemented in the past. The challenge is to build confidence in its efficacy. The primary limitation and concerns that were uncovered during the study had to do, not with the concept and principles of the system approach, but with the process employed by APHIS in developing and implementing a specific system approach. Particularly, the area of concern includes: Customer involvement, implementation of an approved system approach protocol for a specific crop/exporting nation combination, and ongoing monitoring of the implementation of the protocol (USDA, 2002).

System engineering is described by the international council on system engineering "the discipline of developing and engineering complex systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting these requirements, and then proceeding with design synthesis and system validation while considering the complete problem. System engineering integrates all the displines and specialty groups into a team effort forming a structured design process that proceeds from concept to production to operation in an orderly fashion. In lay terms, system engineering is the bridge between solution now available through advancements in science and technology and the needs of customer (USDA, 2002). The life cycle of any system can be divided into seven major stages (Wymore, 1994): Requirement development, concept development, full-scale engineering, system development, system test, system operation, and retirement and replacement.

9. System approach in Ethiopia

The system approach is not new in Ethiopian agriculture; it has been practiced for several decayeds (Tsedeke, 2006). However in each area the system has to be adapted to the local circumstances. Despite the fact that the importance of application of system approaches in plant disease management, the system has been not fully practiced in Ethiopian agriculture due to three major constraints; primarily due to lack of awareness about benefits of system approach and its implementation. Secondly, like many other disciplines, system research and development efforts have suffered from the lack of continuity and policy support for system approach in particular and crop protection in general. Part of the problem with the lack of policy support stems perhaps from the lack of understanding of what system approach is all about. Very often, system approach is equated with total abandonment of use of external inputs, particularly pesticides, and therefore those who stand for this approach are activists rather than contributors to government policy of improved food security. Thus, efforts should be made to creating awareness about on the importance of system approach, through education, to dispel this misconception. Thirdly, lack of coordination and collaboration within and among institution are the core problems in implementing system management approaches in Ethiopia (Mohammed *et al*., 2006; Tsedeke, 2006).

It is well established that, success and sustainability of any system management strategy, depends on their involvement in helping generate locally specific techniques and solutions suitable for their particular farming systems and integrating control components that are ecologically sound and readily available to them. Training and awareness raising of farmers, disease survey teams, agricultural development officers, extension agents and policy makers remains to be an important factor for the successful implementation of system approach strategies (Khoury and Makkouk, 2010).In spite of the fact, that all direct stakeholders including farmers, extension workers, and local crop protection technicians should have a practical understanding of the ecology, etiology and epidemiology of the major diseases of the crop. Intensive training using participatory approaches should be used to empower farmers with the appropriate knowledge to become better managers of their own fields translating this knowledge into appropriate decision- making tools and practical control tactics (Mohammed *et al*., 2006).

10. Conclusion

Systems approaches provide concepts and tools for structured analysis, synthesis and design of systems at different scales. It is now more relevant and important than at any previous time because of increasing realization of the inter-relatedness between components of fragile ecosystems. For agricultural development, and more specifically, for an accelerated adoption of the systems approach in pest management, a toolkit may have to be developed for countries in order to reduce the lag time between generation of global principles and development of site-specific management tools. The combination of quantifiable mitigation measures results in an increased level of phystosanitory security unattainable with any of the measures used alone. System approach has been used successfully for more than three decayed as a strategy for crop production and protection in different part of the world. Management options and their relation to objectives are made explicit. In simple decision problems, the result of a systems study may be a recommended action. In more complex problems, however, the role of systems approaches is to provide biological and technical information to enable a realistic perception of the problem and the options for its solution. Generally, as system management approach is stresses on holism and utilizing agro-ecological principles, it will hold a great potential in the coming decayeds in increasing agricultural productivity and development throughout the world.

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