REALIZATION OF INTEGRATED PEST MANAGEMENT METHODOLOGY IN CLOSED BIOLOGICAL COMMUNITIES

SHAABAN ABD-RABOU[1] AND VLADIMIR V. GOULI[2]

1. *Plant Protection Research Institute, ARC, Dokki, Giza, Egypt*
2. *University of Vermont, 661 Spear Street, Burlington, VT 05405-0105, USA*

At present time the methodology of the Integrated Pest Management (IPM) is universally recognized and constituted the basis for strategy and tactics of plant protection around the world. From first report of Australian scientists P.W. Geier and L.R. Clark, which was made in Warsaw (Poland) in 1960 on Meeting of International Union for Conservation of Nature and Natural Resources when was expressed idea of "management" in conformity to pest control, IPM methodology is received completed development and reach impressive achievements (Pedigo, Higley, 1996; Pasqualini, 2000). In spite of the fact that IPM is intensive elaborated practically in all direction of plant protection there is not common generally accepted definition this conception. Most frequently, IPM is defined as "a system in which two or more methods are used to control a pest. These methods may include cultural practices, natural enemies, and selective pesticides" (Bohmont, 1996). Lane Greer and Steve Diver (1999) describes IPM as "...a simple, practical, and, most important, flexible way to manage insects, mites, diseases, weeds and vertebrates". Leanne Pundt and Tina Smith (2003) gives the following definition, - "IPM brings together all available management options including cultural, physical, mechanical, biological and chemical tactics". Such definitions, however, do not reflect the basic principles, by which IPM differs from pre-existing complex plant protection systems. Primarily, IPM is based on an ecological approach which considerations activity of natural regulation mechanisms and utilizes protection methods concerned not only with economic interests, but also with effects on the environment, human health, quality of agricultural production etc. With respect to modern science and practical experience, IPM is involved in all pest control spheres including agriculture, forestry for control of phytophagous noxious organisms and veterinary and medicine for control arthropods and others living organisms having importance as pathogen agents or vector of pathogenic microorganisms for people and agricultural animals. In these spheres, IPM can be give definition as a mobile complex of measures directed to conservation and activation of the natural regulation mechanisms of pest and which provides the optimal long-time suppression of noxious species, according to ecological, economical, medical, aesthetical and other human society requirements.

According to IPM strategy and tactics we can use simple classification of biological communities. All diversity of the ecosystems can be divided into two big groups, natural ecosystems and artificial ecosystems (Fig. 1). At present time the natural ecosystems can be conditionally divided on three principal groups depending on human activity. These are the virgin ecosystems, ecosystems with limited maintain of human activity and ecosystem with intensive human economic activity. This division is conditional because human activity has global character. Each type of ecosystem will have specific IPM application based on special analysis. Our analysis of the IPM in agriculture, with regard to the artificial types of biological community, is based on common well-known ideas. First, each ecosystem is a functional unit of the living organisms with chemical and physical factors making up its non-living environment. IPM has been created to control the harmful for people organisms infesting a specific crop, forest or other community. To diminish the damage caused by harmful organisms, IPM utilizes the natural factors of the ecosystem to limit the number of pests and the level of injury potentially caused by them. Some of these factors include plant resistance, environmental manipulation (cultural practices, for example), introduction of natural enemies against pests etc. These factors can be employed to help decrease the population of the noxious organism below the economic threshold level. Different measures are used for engaging the natural factors of the ecosystem. These measures are referred to as "adjusting actions". In some cases, conducting the "adjusting actions" once is enough to solve one or more pest control problems. If the "adjusting actions" are not enough and pest numbers are increased to a dangerous level, reaching the economic threshold "correction actions" are conducted. At this point, methods, which have the least negative secondary action on non-target organisms, are used to reduce the population of the noxious organism. Basically, this involves the use of biological means or chemical pesticides with highly selective activity.

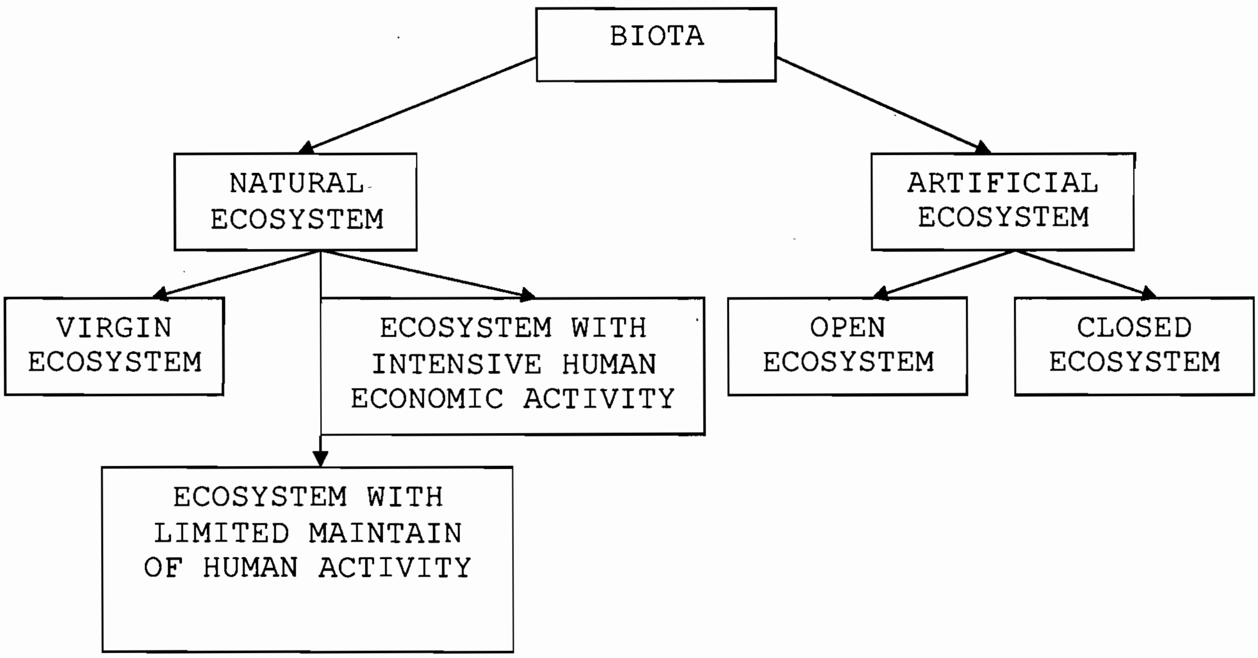

Fig. 1. Common classification of different type of ecosystems

When conducting the "correcting actions" result to secondary effects (such as subsoil water pollution, residual pesticides in plants and agricultural products, threats to human health, and reduction in the number of natural enemies) as well as the primary effect (reduction in the number of phytophagous organisms) must be use special monitoring. The monitoring is very important link in IPM system because sometimes value of damage from negative consequences connected with use of "correcting actions" can significantly exceed the value of crop harvest. Artificial ecosystems are the biological communities that have been created and maintained by man with the purpose of accumulating large quantities of biomass. Man removes this biomass and, as a result, competes with the vast complex of natural consumers. In response to this competition, artificial ecosystems have developed powerful protection mechanisms. Here, modern agricultural and industrial ecosystems meet. This relationship depends largely on the input of energy and materials in vast quantities. To ensure survival, man need to actively protect the ecosystem using agricultural technology. This technology can bridge the gap between agro-ecosystems and natural ecosystems. These methods must be direct in order to conserve the species diversity in the agro-ecosystem, fully degrade vegetable remains, eliminate the volume of toxic substances entering into the environment etc. The theory and practice IPM are designed to achieve these results.

IPM is based on the theory of biogeocenology in which different types of biological communities (biocenoses), composed of different species, interact with one another and with the chemical and physical factors making up their non-living environment. IPM combines traditional biological sciences, molecular biology, genetics, genetic engineering etc. Although, it has been demonstrated that IPM can be successful on many crops in countries with intensive plant growing (Cuperus et al., 1993; Reuveni, 1995), the practically of IPM is realized with great difficulty. For example, the proportion of crop area in Canada and the United States under IPM management ranges from 2% for grains to 100% for organically-grown vegetables and apples (Hall, 1995). This discrepancy was discovered through research organized and funded by the United States government in 1972. Consequently, the United States Department of Agriculture (USDA) developed a strategic plan for a department-wide IPM initiative with the goal of reaching 75% of the nation's food crop acres by the year 2000. The resulting overall expenditures for IPM in 1996 were estimated to be $187.7 million and $200 million in 1997. As the practical realization of IPM occurs and new factual material concerning the elements of IPM accumulates, a more precise definition can be assigned. But, it is necessary to note that all IPM application aspects are thoroughly elaborating only for the artificial open ecosystems. The IPM systems were created for all most important agricultural crops and these systems are improved permanently. This situation concerns first of all the open artificial ecosystems which have closely contact with surrounded wild biological community. These ecosystems have biotic regulatory mechanisms which sometimes suppress pest number under economic injury level. As example it is possible to mention about explosive viral and fungal epizootics in army-worm – *Pseudaletia unipuncta* (Haworth) (Lepidoptera: Noctuidae) populations in north-eastern agricultural regions of the USA which reduce insect numbers significantly low than economic injury level. In natural biological communities when regulatory mechanisms are not destroyed many potentially dangerous phytophagous do not have any economic importance. Other situation takes place in case the closed biological communities as modern greenhouses and hothouses. As a rule modern greenhouses are completely isolating from surrounded wild biological communities. Here is forming the artificial closed ecosystem. In this case we can consider any noxious phytophagous organism as alien species. As a result, we can not speak about IPM approaches. Here is specific situation and all declarations about valuable IPM strategy in greenhouses are only paid a tribute of respect to fashion. We can not realize the basic IPM principal in greenhouses so far as regulatory biotic factors are completely absent. Conducting regular sanitation has to prevent closed greenhouse community from penetration both pests and beneficial organisms. But it is very difficult to provide complete plants isolation in greenhouses and often either pest penetrates into closed community. The pests are got in optimal environmental conditions and it can cause serious plant damage. In this situation we can consider the pest as alien species and as corollary it is necessary to apply any control measures without economic or other thresholds. As a rule, it is realizing on practice (Rettke, 2003). But, final decision about control measures will depend on specific situation including peculiarities and condition of plants, harmfulness and biology of pest. Each species greenhouse plants has specific properties having importance for protection strategy, It is, first of all, sensitiveness to different phytophagous organisms, acceptable level of damage, vegetation period etc. The vegetation period has very important significance for acceptance decision about control measures because the plant with short period can reach marketable condition before period when pests augment threatening number.

The principal greenhouse pests around world are small suctorial arthropods – thrips [(*Thrips tabaci* (Lindeman) and *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae)], whiteflies [(*Trialeurodes vaporariorum* (Westwood) and

Bemisia tabaci (Genn.) Complex (Homoptera : Aleyrodidae)], aphids [*Aphis gossypii* Glover, *Aulacorthum solani*(Kaltenbach), *Myzus persica*(Sulzer) (Homoptera : Aphididae) and et others], mites [(*Tetranycus urticae* Koch, *T. cinnabarinus* (Boisduval) (Acari: Tetranychidae)], scales (*Coccus hesperidum* Linnaeus (Homoptera : Coccidae)), fungus gnats and shore flies [(*Bradysia spp.*(Diptera : Sciardae) , *Scatella stagnalis* (Diptera : Ephydridae)] and same others. Greenhouse pests are currently managed through biological control on 5% of the about 300 000 hectares of protected cultivation worldwide (Van Lenteren, 2000). Biological control is the action of natural enemies that maintains a host (or pest) population at levels lower than would occur in the absence of these enemies. Such natural enemies generally include predators, parasitoids and pathogenic microorganisms. Implementing a biological control program in a greenhouse is management intensive and requires more knowledge on the part of the grower than do traditional pest control programs. Proper species identification is very important before a control program using predators or parasitoids is initiated. Release rate, timing, placement, temperature and pesticide use also influence the success or failure of biological control efforts.

Parasitic hymenoptera play a major role in regulating the numbers of many insect species and have been responsible for more success of biological control than all other groups of natural enemies. The parasitic hymenoptera appear to be a special group with rapid evolving, many sibling species of biotypes exist in nature. There are about 250000 species of parasitic hymenoptera in the world from which of pests by parasitoids have been descried. Many outstanding success in the biological control of serious pests by parasitoids have been recorded (Abd-Rabou, 2002). The parasitoid *Encarsia formosa* Gahan (Hymenoptera : Aphelinidae) is the best example of the control by parasitoids on greenhouse vegetable crops and is considered one of the most outstanding successes in biological control. Insecticidal soap, horticultural oils and the bacterium *Bacillus thuringiensis* are examples of insecticides that can be safely integrated into biological control program. All common pests in greenhouses have very high level fertility and short development period. For example, two-spotted mites – *T. urticae* demands for development one generation only 7 days at optimal conditions. During one season this pest can give in greenhouse around 20 generations. As a result growers are conducted control measures when they observe first signs of plant damage and pest presence.

The realization of IPM in greenhouses is extremely limited. The greenhouse environment provides optimal physical conditions, an abundance of food and no natural enemies to act as regulatory agents. In this case, as in the case of quarantined species, research connected with the establishment of an economic threshold level has a minimal significance because the initial infestation spreads very fast. Practical recommendations have confirm this assertion. For example, control information for cyclamen mites from Cornell and Rutgers Cooperative Extension (USA) is following – "Early detection is key for the suppression of the cyclamen mite, since it is capable of spreading rapidly within a greenhouse. Pylon (chlorfenapyr) has proven to be an effective miticide against this mite" (Rettke, 2003). For western flower thrips control is recommended "...several insecticide applications should be applied at 5 day intervals to reduce a thrips infestation. None of the recommended insecticides are effective with one application. Research has shown that 5-day application intervals are more effective than 7-day intervals" (Sanderson, 1990). It is factually traditional approach without any IPM strategy. Analysis of real everyday practice of plant protection in greenhouses show very specific situation with application of IPM in comparison with open natural or agricultural communities.

When monitoring plant sanitary conditions in greenhouses, we must not forget that biotic factors, regulating the number of phytophagous organisms, are absent or very limited. As a result, the main concept of IPM, which postulates the implementation of ecological approaches to solve pest regulation problems, loses meaning. The situation is radically changed when the biological agents are used in the greenhouses. The introduction of one or several species of secondary consumers, used for biological control, creates a system in which the main IPM principles can be acted out in full measure. The practical realization of full or partial biological plant protection under greenhouse conditions requires that additional corrective measures accompany IPM strategy and tactic. These corrective measures are necessary because of the unique relationship between phytophagous populations and secondary consumers. By using biological agents, such as insect killing or antagonistic fungi, activity of the target microorganisms is delayed by 3-5 days or more. When using entomopathogenic fungi, the delay is connected with the time that needed to overcome the hosts primary defense against the pathogen and the incubation period of the disease. During this period same arthropods, such as ticks and aphids, can complete the life stage during which they are most vulnerable to fungi attack. For example, fungus *Beauveria bassiana* during artificial application against western flower thrips demands 6-7 days for provoke maximum mortality level of insects but in this period the pest can complete larval development. Therefore, economic thresholds need to account for the number of pest, in a particular development phase, per unit area. As a rule, each biological method requires it's own economic threshold level. Such economic thresholds need to consider initial numbers of noxious organism, speed of development, specific of damages and peculiarities in the influences of biological means on the pest, including incubation period in case of application of microbial pesticide, speed of death, and decline of pest harmfulness after control measures. At present time specialists for microbial control of pests do not given sufficient consideration for study change of the pest harmfulness after application of microbial pesticides. Many industrial and cottage microbial formulations have antifidant and repellent properties. As a result the number of living pest on any estimative unit (twig, leaf etc) will not reflect real potential damage this pest because plant treatment helping microbial formulations sometimes is significantly reduced food activity of the noxious invertebrates. Principal proposition which we have to accentuate lies in the fact that any pest in modern greenhouse is alien species and it is necessary to apply to it suitable control. As greenhouse biological community starts to include undesirable and noxious species which survive first active complex the control measures we have to stop to control for destruction and we have to start to use IPM strategy.

REFERENCES

1. Abd-Rabou, S. 2002. Parasitic hymenoptera in biological control of whiteflies. Scientific articles, Second International Conference of Plant Protection Research Institute, Vol. (2): 971-973.

2. Bohmont B. L. 1996. The standard pesticide user's guide. Prentice Hall Upper Saddle River. New Jersey, 443 p.

3. Cuperus G. W., G. V. Johnson and W. P. Morrison. 1993. Integrated wheat management. In: Successful implementation of IPM for agricultural crops (Ed. Leslie A., G.W. Cuperus). Lewis Publishers, pp. 33-56.
4. Greer L. and S. Diver. 1999. Integrated pest management for greenhouse crops. Pest management systems guide. Univ. of Massachusetts Coop. Ext. System publication, pp. 1-31.

5. Hall R. 1995. Challenges and prospects of IPM. In: Novel approaches to IPM. Ed.: Reuveni R., Lewis Publishers, pp. 1-20.

6. Pasqualini Edison. 2000. IPM: theory and practice in the pest control of pome fruit trees. Pflanzenschutz-Nachrichten Bayer 53, 2-3, pp. 154-176.

7. Pedigo L. G., L. G. Higley. 1996. Introduction to pest management and thresholds. In: Economic thresholds for IPM. Univ. of Nebraska Press, pp. 3-8.

8. Pundt L. and T. Smith. 2003. Pest management for herb bedding plants grown in the greenhouse. University of Connecticut and University of Massachusetts, pp. 1-12.

9. Rettke S. 2003. Primer on cyclamen mites. Greenhouse IPM notes. Publication from Cornell and Rutgers Cooperative Extension, vol. 13, N 8, pp. 3-4.

10. Reuveni R. 1995. Novel approaches to IPM. Lewis Publishers, 369 p.

11. Sanderson S.P.1990. Western flower thrips biology and control. Long Island Horticulture News. August, pp.1-3.

12. Van Lenteren, J.C. 2000. A greenhouse without pesticides: factor or fantasy?. Crop Protection, 19: 375-384.

مفهوم المكافحة المتكاملة للآفات فى المجتمعات البيولوجية المغلقة

شعبان عبدربه[١] ، فلاديمير جولى[٢]

١. *معهد بحوث وقاية النباتات، مركز البحوث الزراعية، الدقى ، جيزة، مصر*

٢. *جامعة فيرمونت ، فيرمونت، الولايات المتحدة الأمريكية*

تعتبر المكافحة المتكاملة للآفات من أهم طرق ادارة مكافحة الآفات فى المجتمعات البيولوجية المغلقة و قد تضمن هذا العمل مراجعة طرق المكافحة المتكاملة المختلفة للآفات داخل الصوب الزجاجية الى جانب قوائم للأفات الموجودة و أعدائها الحيوية و قد تطرق هذا العمل الى مفهوم أستراتيجية المكافحة المتكاملة داخل الصوب وذلك بعرض النماذج الناجحة لهذه المنظومة فى العديد من دول العالم المختلفة.