AGRICULTURAL ENTOMOLOGY

CHAPTER 1: INTRODUCTION TO ENTOMOLOGY

1.1. Introduction

The subject of interest "economic or applied entomology" is the study of all cost-effective insects. A subdivision of economic entomology is agricultural entomology, they are advantageous as they possess (e.g., silk, honey, lacquer); support the development of crop production (e.g., pollinators); makes the harm cause financial loss to plants grown for feed, food, landscaping, or fiber; harmful for farm animals; or they destroy agricultural pests this is why they are committed to the study of insects concerned in agriculture (Hinton, 1960; Common, 1954; Furunishi et al., 1982). Agricultural entomology includes analysis of all basic angles of life history, ecology, and insect's nature towards farm animals and agricultural crops. The application of integrated pest management (IPM) programs and the basis for the design are specified by these courses (Abivardi, 2001; Kirby & Spence, 1857; Clark, 2006).

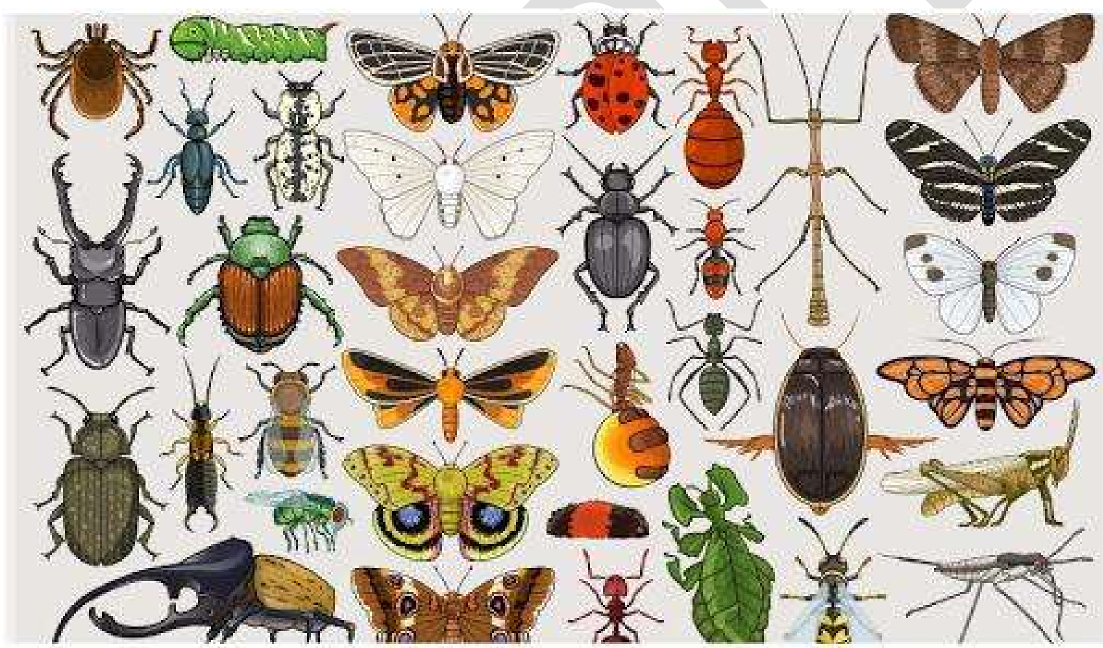

Figure 1.1. Different classes of infects

[Source: http://www.justscienc]e.in/articles/what-is-entomology-all-about/2017/07/10

1.2. Economic Entomology

Insects influence earth equally as humans so that is why they are viewed as the major challenges of humans. Humans are based on insects for extraction of silk and honey, for numerous different essential ecological roles, for the decay of organic matter and the renewing of carbon, and pollination of numerous crops (Wolff et al., 2001; Amendt et al., 2007; Hall & Huntington, 2009). But it is the harmful effects of insect pests that have been the extreme involvement of humans. There are no dependable forecasts of aggregate damages provoked by insects as agents triggering straight devastation to dwellings and different artificial structures, as farm animals and pests of crop plants, and as parasites of humans and domestic animals and vectors of pathogens, but the numbers run to possibly hundreds of billions of dollars per year. The evaluation at $90.5 billion between 1988 and 1990 resulted in shortfalls in the generation of just eight primary cash crops and food (cotton, coffee, potato, maize, rice, wheat, soybean, and barley) by insects and vertebrate pests all over the world (Moutia & Mamet, 1946; Forbes & Hart, 1900).

Entomology became organized in the late 1800s and early 1900s, as a course of the same importance as zoology and botany in various research and academic institutions. This ranking of the discipline of a category of animals (Insecta) is because of the variety of insects and their financial significance, therefore, they are comparable to the study of animals and plants i.e. two kingdoms of organisms. Basic and applied (or economic) entomology were separated through the first half of the twentieth century (Matthée, 1951; Zalucki et al., 2012; Masaki, 1980). Main branches, like forest entomology, agricultural entomology, medical and veterinary entomology, and urban entomology are commonly preferred terms since then, where the general use of the term "economic entomology " has demolished. An account of few notable sights in the growth of agricultural entomology is given in Table 1.1 through the ages, however, a complete historical note is outside the limits of this article (DeBach, 1964; Borror et al., 1992; Tauber et al., 1986).

The kingdom of agricultural entomology is linked with farm animals and agricultural crops and contains all fundamental studies of helpful and pest insects. Crops are chiefly focused in this article, however, the common precepts and principles are correspondingly useful to farm animals. Biosystematics is comparable to the science in which the initial point of such courses is a true description of the insect species (Leconte, 1873; Lounsbury, 1940; Schabel et al., 1999).

1.3. Biosystematics

To get the information related to the fundamental biology of species within a genus that is firmly associated, scientific nomenclature is an effective tool. Inferring the reports to other adjacent connected species of that genus is generally doable when precise information on host records, geographic distribution, and biology of one or more species in a genus are included in the orderly analysis and have been continued after the naming of species (taxonomy) (Mitter et al., 1993; Reinert, 1990). When handling a new pest, a blueprint to pursue is proposed by biosystematics, despite that for every individual species, the analysis of the biology must be determined. E.g, 10 – 12 species dispersed from southern Brazil to the northeastern United States are included in the genus *Cerotoma* (Coleoptera: Chrysomelidae). It looks like all are related to the herbaceous plants in the family Fabaceae (bean family). The biology of two species that have been considered mostly is *C. arcuata* in

South America and *C. trifurcata* in North America (Fig. 1.3) (Kimani & Overholt, 1995; Teal & Byers, 1980). The other species in the genus contribute few of the following characteristics, this can be concluded from the information for these two species: pupate in the soil inside pupal cases and nitrogen-fixing root nodules are consumed by larvae; close to growing leguminous plants, eggs are laid in the soil; when seedlings emerge, first-generation adults emerge and when plants are in full vegetative growth, second-generation adults emerge, first is fed on foliage and then, developing pods are used to feed. Within their specific agroecosystem, students of agricultural entomology in Central, South or North America perceive in common terms, the aspect of any other species of *Cerotoma* with the help of the biosystematic information on the genus (Booij, 1982; Braby & Williams, 2016).

The twist in this concept is the awareness that the structure of species is almost similar (sibling) which means that they are strictly linked with each other but species may have numerous significant biological characteristics. In the biological operate literature, the illustrations of the critical requirement for dependable biosystematics studies are set up.

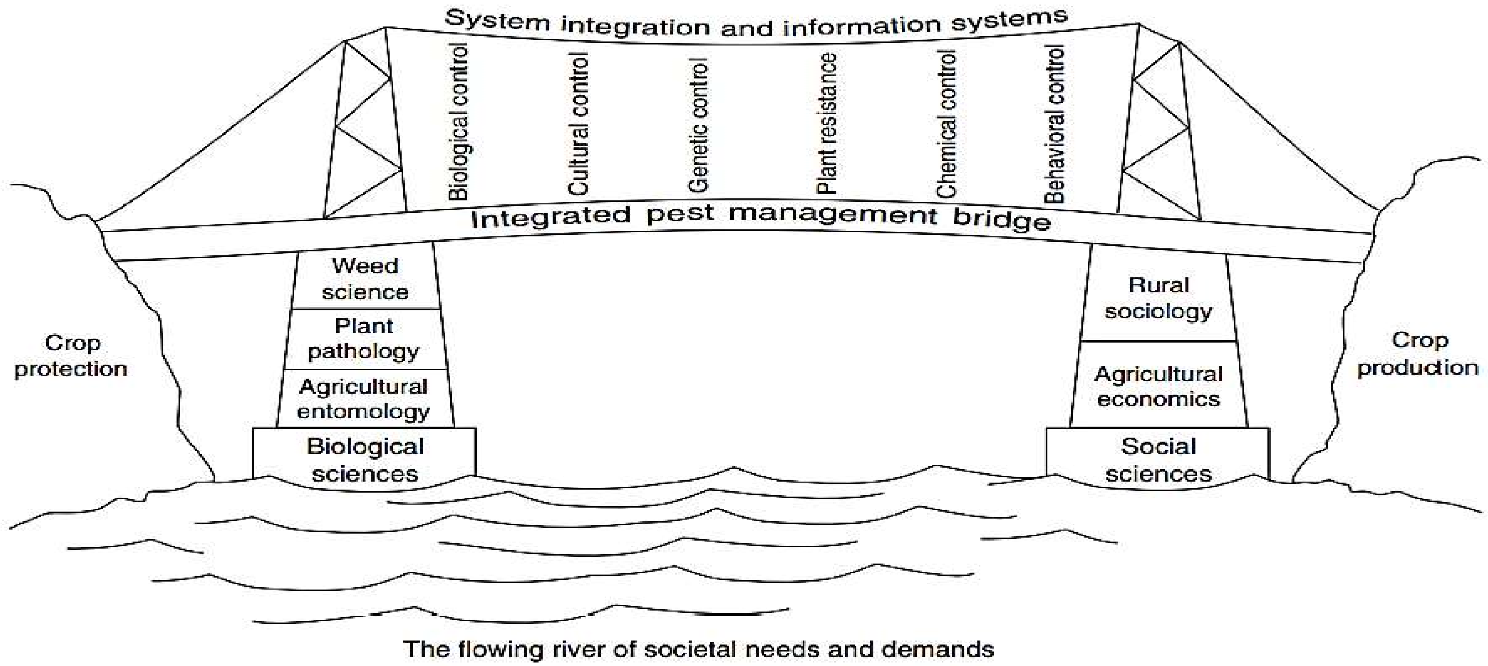

Figure 1.2. A bridge analogy: agricultural entomology is assumed as one of the major poles, collectively with weed science and plant pathology, assisting the " integrated pest management bridge."

[Source: https://kundoc.com/pdf-agricultural-entomology-.html]

Note:

two-way transportation between crop protection and crop production is through a bridge. Sociology and social sciences of economics made the other pillar. Information systems and system integration are the central tension cables, these are IPM's strategic components that give support to the vertical lines that further make the bridge stable. The "river" of always changing societal requirements is running under this bridge.

Table 1.1. Few Indicators in the Former Development of Agricultural Entomology (Schowalter, 2000; Norris et al., 2003).

Significant Events	***Years ago from 2000***	***Date***
Release of Bt transgenic collection of corn, potato, and cotton	5	1990s
Expression " integrated pest management " first shows up in the press swift development of molecular biology	20	1980s
First edition of Rachel Carson's *Silent Spring*	32	1968
First report of insect resistance to DDT	45	1959
Terminology " pheromone " invented by P. Butenandt and P. Karlson, who recognized first such substance in the silkworm moth	48	1962
First edition of W. P. Flint's and C. L. Metcalf *Destructive and Useful Insects* Discovery of DDT and beginning of the insecticide era	54	1946
First record of an insect-resistant to an insecticide	106	1894
First record of extensive loss of cotton in Texas through the cotton boll weevil	112	1888
First fruitful case of biological control: the cottony cushion scale, on citrus, by the vedalia beetle, in California	142	1858
Alfred Wallace and Charles Darwin mutually raised up with a paper on the theory of evolution	169	1831
Beginning of scientific nomenclature — 10th edition of Linnaeus, *Systema Naturae* Burgeoning descriptions of insects	242	1758
First record of plant resistance to an insect	100 – 200	1750-1899
Soaps utilized to control insects in China	900	1100
First descriptions of insect pests	3,500	1500 B.C.E.
First evidence of insecticide use	4,500	2500 B.C.E.
Beginnings of agriculture	10,000	8000 B.C.E.

The current report is based on surveys examined by Paul DeBa ch. He is one of the main biological control consultants of a misunderstanding of the twentieth century but he skipped chances because of misinterpretation. The *Aonidiella aurantia* is a seri-its parasitoids which is the California red scale (Oerke, 1994; Price, 1997; Norris et al., 2003). In California, the red scale parasitoid *Aphytis chrysomphali* had been ous pest of citrus-generating areas and also another citrus of the identified to happen in California. However, it was not regarded to be very effecworld. Biological operation of the red scale had a lengthy history tive control representation (Evans, 1984; Jones, 1973; Huffaker & Gutierrez, 1999).

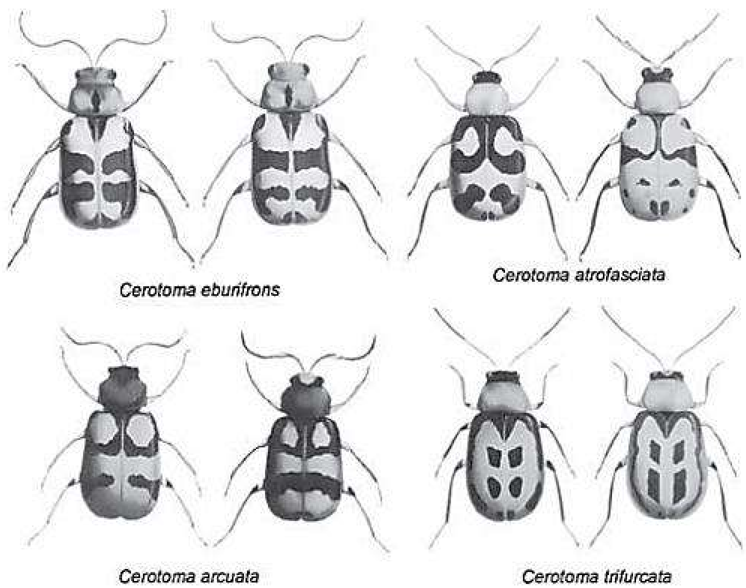

Figure 1.3. Biological resemblance and morphological variety in the genus Cerotoma: male and female specimens are highlighted by four of the twelve familiar species. The morphological characters can help us to identify dissimilar species, but they have undistinguishable life behaviors and histories

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The parasitoids were not imported into California as they were baffled by *A. chrysomphali* when during the foreign investigation, entomologists found parasitized scales. It was later revealed that as compared to *A. chrysomphali, A. melinus* and *A. lingnanensis* are more effective natural enemies of the California red scale, they were, in fact, two different species. In California, *A. melinus* and *A. lingnanensis* are the main red scale parasitoids now. *A. chrysomphali* were unexpectedly developed in California and were considered as single species, parasitic on the California red scale in the familiarize and elsewhere, but biosystematics studies revealed that it is a complicated involving seven species minimum having different biological adaptations but morphologically almost indistinguishable.

Nonetheless, knowledge of the terms of a species is not the expression of the correct possible pest condition or economic affect. Species that induce the evaluation of shortfalls or advantages is the next significant stage in agricultural entomology.

1.4. Pest Impact Assessment

The insect species are not a pest of that animal or crop in which they are found. Monetary losses would result from it being a pest. The studies are associated with the evaluation of economic losses from pests, and the situation under which the animals are nurtured or the crop is developed commercially is very similar to the circumstances under which these studies are conducted (Soliman et al., 2010; Erdle & MacLean, 1999). As a way to research works and set up budget allocations, the sponsorship of the Food and Agriculture Organization (FAO) of the United Nations has organized enough methodology used in crop loss evaluation. The assurance of the yield potential of the crop is associated with the key data for these investigations. When the adverse environmental factors are not present, its maximum yield, called the attainable yield, is evaluated by the genetic design of a crop variety. The crop that is prepared under normal farming conditions results in actual yield, however, the crop is developed under almost ideal conditions for examining the attainable yield. The amount of crop loss is the difference between the actual yield and attainable yield (Fig. 1.4).

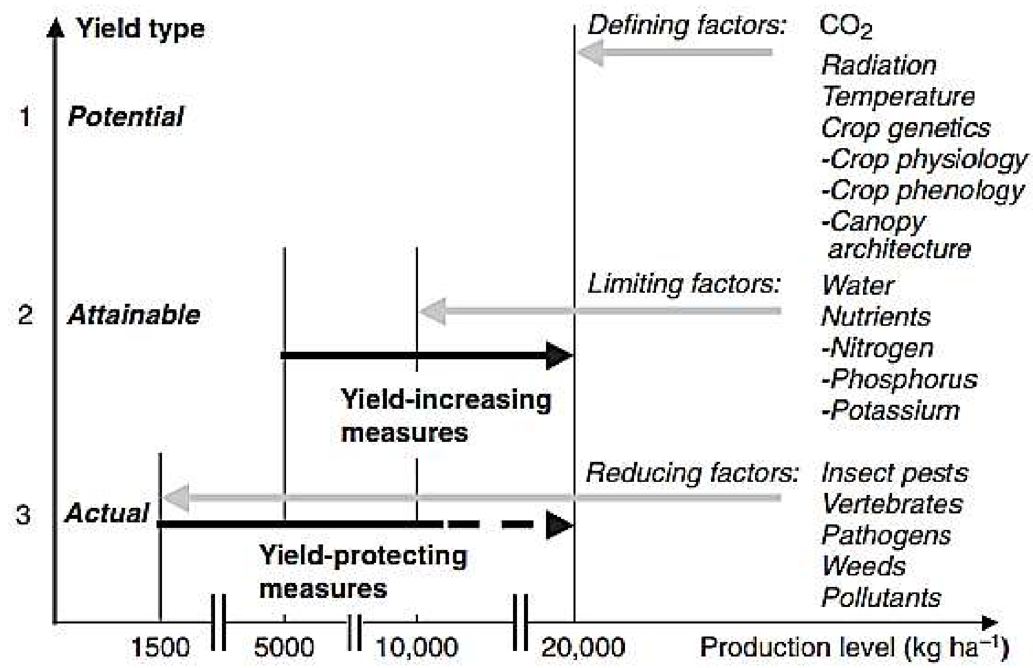

Figure 1.4. Elements showing a generic crop that is affected by the yield.

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To set apart the impact of the pest from all different limitations it involves putting up practicals to estimate crop damages and assign the shortfalls to a particular reason (e.g., the attack of a pest). Pest category is changed by techniques — for instance, whether the pests are vertebrates, insects, weeds, or plant pathogens. The fundamental relationship for calculating the economic downfall measure for the pest is the significant relationship between pest population measures and crop shortfalls. The significant notion in IPM is basically the economic downfall measure (Muriithi et al., 2012).

1.5. Life History and Habits

Expanding the informational foundation on the life history and habits of the species to the situations under which the crop is developed has become very important when the pest update and existence of a species have been well prepared. Information on temperature-dependent developmental rates and developmental threshold temperatures are also contained by the financially important life-history aspects. The phenology of pest is modeled by utilizing these data (Welch, 1914; Teskey, 1960). The feeding, arrangement, sexual behavior of the species and selection of the host are added in other important researches. For the preparation of target-specific control strategy and for a plan of action in IPM, the base is supplied by most of these studies. E.g, the description of the recognition of those pheromones and the act of pheromones in mating are related to the study of sexual behavior. Consecutively, these may be utilized for beneficial IPM systems components for various crops, in the mating disruption or abundance and monitoring pest incidence. Another evenly valuable identification in IPM advancement is of kairomones, which is resulted from investigating host selection behavior (Klostermeyer, 1942; McLintock & Depner, 1954).

1.6. Phenology

All insects go through the fundamental phases of growth from egg to generative adult (or imago), however, the life wheel of other insect species differs immensely. A fact in which there is an appreciable deviation in the list of spawnings annually is termed as voltinism. It is based on the period of the life wheel. A multivoltine species may have many spawnings annually whereas a univoltine species has only one spawning annually (Pilcher et al., 2005). The extend of versions in the Insecta is obvious when one thinks that mosquitoes or whiteflies may end one spawning in around 21 days, on another hand, the 17-year periodical cicada has a spawning every 17 years. Under hot subtropical circumstances, spawnings regularly overlap but in the process of temperate climate circumstances, they frequently are detached. A phenomenon called phenology defines the temporal periodicity in the growth cycle of an organism. Agricultural entomology is concerned with the relationship between the phenology of the crop and the phenologies of its different pests. A case of a similar relationship for soybean developed under regular circumstances for the midwestern United States is illustrated in Fig. 4 (Bartomeus et al., 2013; Welch et al., 1978).

1.7. Population and Community Ecology

Insect ecology also includes the study of the population and community levels. It is vital to have knowledge of the community and population-level actions for management reasons, even though, for agricultural entomology, the species is the focal biological body. In a described geographical area, (e.g., a river valley, a crop field, a mountain chain) populations are gathering of indifferent entities. Most insects have the great regenerative ability. Triplehorn, Borror, and Johnson took the example of fruit flies (*Drosophila*), and calculated that they generate 100 workable eggs, almost 50 produce females and each will further lay 100 eggs and the cycle continues, producing 25 generations in 1 year; the last generation of one year would have 1.192 $\times 10^{41}$ flies, if they are collected together tightly i.e. 60,000 of them to a liter, a ball of flies would be made of about 155 million kilometers in diameter, approximately a distance from the earth to the sun. But for obvious reasons, such unlimited population growth is not realistic. The coupled processes of both biological (biotic) and physical (abiotic) aspects of the environment, generally, control the populations. In agricultural entomology, the principle aspects that control insect populations are very active areas of exploration (Knausenberger et al., 1996; Naranjo, 2001).

An ecological community is defined as the group of species living together in a region and engaging to differing degrees form what. The main manufacturers are the weeds and the crop plants that remain inside the crop field or develop along the edges in a crop community. Active trophic relationships are retained by the animals inside the crop community: few eat the decomposing plants, and remaining eat existing plants, and yet others eat animals. Primary consumers or herbivores are those that eat the plants. Primary consumers on the crop plants are pests. Secondary consumers are predators and parasitoids. Natural attackers are helpful because they eat pests. Eventually, decaying organic matter is eaten by detritivores and decomposers. " Food webs " interlink entire biotic components of the community. In crop communities, it is significant to comprehend about trophic linkages and food webs because it offers a fundament for illustrating the distraction of nature in crop ecosystems. Pandemics of pest organisms may cause distractions in trophic relations. Due to which a need to control actions will arise. (Orr & Ritchie, 2004).

1.8. Links to IPM Systems Development

It has become hard to disconnect IPM and agricultural entomology because of the arrival and success of IPM in the last third of the twentieth century. The two fields of aim are inseparably related to entomology. Ways to form and compose IPM methods are specified by a trustworthy database of biological information. E.g. in strategies of increasing biological control by habitat management, the interest is developing. In the shape of field hedges and cover crops, the facts on source-sink relationships among common enemies and pests are needed by the method across neighboring crops, crop plants especially managed vegetation and natural vegetation.

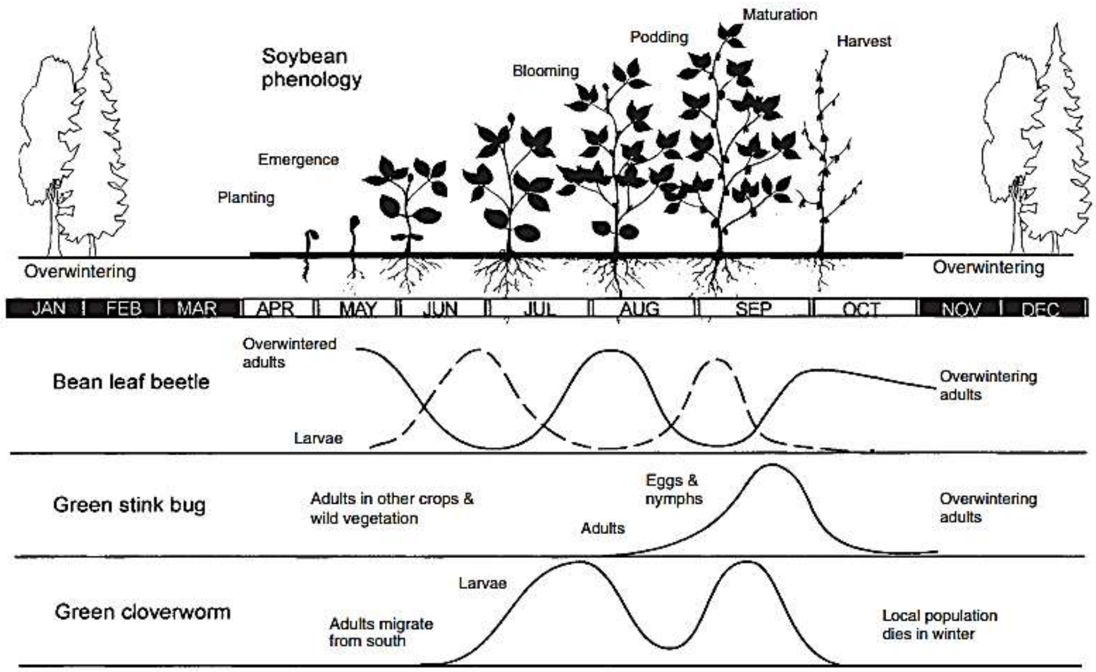

Figure 1.5. Pest phenology and crop phenology: the relation between the three of its nearly ordinary insect pests and phenology of soybean in the midwestern United States, C. trifurcata (Coleoptera: Chrysomelidae), the bean leaf beetle; Acrosternum hilare (Hemiptera: Pentatomidae), the green stink bug; Hypena scabra (Lepidoptera: Noctuidae) and the green cloverworm.

[Source: https://kundoc.com/pdf-agricultural-entomology-.html]

As per the theory, more stability of the system and an increment in universal enemies have resulted from the diversification of the crop ecosystem. Nonetheless, it is not easy to explain conflicting results of experiments planned to test working hypotheses by the complication of interactions. Knowledgebase elements that are important to establish advanced IPM systems are the study of inter-field movement and within-field, entomophagous insects and the host selection manner of phytophagous, dynamics of populations, and the multitrophic interactions among community members, all under the discipline of agricultural entomology (Heinrichs, 2005).

For the approachability to fundamental information on agricultural entomology, the arrival of the World Wide Web has had a vital effect. Web pages have been started by most well known agricultural research centers that arrange details and facts so that it is accessible to the students all over the world. Most chiefly, the dynamic nature of the Web provides population dynamics and usability of surveys about the phenology and also provides the chance to offer weather-driven modeling capacities that immensely raise the scope of major pest organisms. Such capacities are provided by two sites http://pnwpest.org/wea/ and http://www. ipm.ucdavis.edu/PHENOLOGY/models.html .

In the late 1800s and early 1900s, the biology of insect pests was investigated by entomologists in vast detail. Monographs and articles are still of great importance that was published during those times. Information valuable for managing agricultural and other pests can be supplied by thorough knowledge of the behavior and life history of an insect as identified by the early entomologists. In the mid-1940s, a fantasy that problems of pests could be solved forever is presented by organosynthetic insecticides. Various entomologists alter their attempts to neglect basic insect biology studies and examine new chemicals. To destroy the environmental difficulties by the wrong application of these pests and chemicals, the lack of success of insecticides resulted in the establishment of IPM. Entomologists have had to target again their aims of insect biology and move back to the basics for making IPM a success. As entomologists these days attempt to achieve the civilized knowledge of the group of animals that are deliberate adversaries of humans, the agricultural entomology has come full circle.

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