XVII[th] World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

A UNIFIED PEST SCOUTING FOR AREA-WIDE IPM

A. HETZRONI[1], L. SHEALTIEL-HARPAZ[2], Y. COHEN[1]

1 A. Hetzroni, Volcani Center, P.O.B. 6 Bet-Dagan, 50250 Israel, amots@volcani.agri.gov.il
1 Y. Cohen, yafitush@volcani.agri.gov.il
2 L. Shealtiel-Harpaz, Northern R&D, P.O. Box 831 Kiryat Shmona, 11016, Israel, lioraamit@bezeqint.net

CSBE100633 – Presented at Section VII: Information Systems Conference

ABSTRACT The determination of pest populations is an essential part of area-wide integrated pest management to wisely respond to a variety of threats. Information regarding wide area population trends, previous control measures and other environmental parameters could improve decision making, reduce pesticide use and delay the acquired pest resistance to applications. As of now, dozens of scouts are employed by individuals or organizations to monitor pests in field crops plantations and controlled greenhouses. Pest control decisions are based on observations that are often translated into recommendations to the growers and then lost. A working data collection system was developed in collaboration with pest scouts, to create a common language among the solitary scouts. This system was implemented to enable the collection of data from field scouts in wide areas into a central database. The system employed cellular phones and the Internet to transmit data mainly from field scouts to a central data base, with a limited feedback. For reliable wide area IPM is required to establish quantification of pest population which takes into account the differences in estimation not only among scouts but also among crops. The severity of pest population is not necessarily similar when evaluating the population in one crop compared to another. Therefore, there is a need to establish and assimilate standardized estimates of pest populations. A unified measure was developed to allow estimation of pest infestation across crops thus making it possible to evaluate the situation and its dynamics over a wide area. The calculation of the measure is done on the data server, and takes into account the crop stand, the pest and method of scouting. The measure of pest population is now being used to evaluate the method and its benefits.

Keywords: wide-area IPM, pest-scouting, standardization, pest-yield.

INTRODUCTION Agriculture faces constant threats of plant diseases, insects, weeds and invasion by new pests. Such threats cause extensive annual yield and financial losses. For example it is estimated that the US suffer annual crop losses worth $9.1 billion due to diseases, $7.7 billion to insects, and $6.2 billion to weeds (Agrios, 1997). In Israel, about 5% of the cotton crop is lost due to insects, damage valued at approximately $2 million (Ariela Niv, Cotton board, Israel, personal communication). Vegetable production in Israel suffers crop losses valued at $10 million due to diseases, $10 million due to insects and $20 million due to weeds (Shaul Graf, extension services, Israel, personal communication).

Pest and disease distribution is dynamic in time and space, reacting to multiple biotic and abiotic conditions and the agro-ecosystem heterogeneity (Stinner et al., 1983; Carriere et al., 2006). Spatial and temporal monitoring of pest and disease infestations is therefore essential to any sustainable pest management paradigm (Pasiecznik et al., 2005).

However, the objective of pest management is not only to reduce pest numbers and the potential for crop damage but also to conserve environmental quality and furnish sustainable production systems. Applying map-based pest monitoring can enhance a pest management program. One significant outcome is a reduction in pesticide use. For example, in replicated trials in potato fields, precision pest management was directly compared to 'conventional' pest management (in which sprays were applied to entire fields when means exceeded thresholds). Precision pest management led to a 30 to 40% reduction in the amount of insecticides applied for Colorado potato beetle control across a range of colonization pressures. It also reduced the amount of pesticides needed for green peach aphid control (Weisz et al., 1996).

Trends toward regulations that require more traceability for products between the farm and consumers compel the farmers to use targeted IPM practices to reduce pesticide use. Because knowledge and information are keys to correct pest management decisions (Bajwa et al., 2003), there is an increasing demand for tools that enable efficient data collection on a broad spectrum of pests over a wide spatial scale (Magarey et al., 2002).

IPM approach considers agricultural modality as an ecosystem created and maintained by human actions. Ideally, this view imposes a holistic approach to pest management, addressing all the potential pests and diseases at an area-wide scale. Dispersal of pests and diseases is temporally and spatially dynamic, responding to a variety of biotic and abiotic conditions. Pest management practices on one crop or field affects whether directly or indirectly it's neighbouring hosts. Therefore, measuring and understanding temporal and spatial dynamics of pests is a fundamental component of such management. Pest dynamics such as invasion, long range migration, local movement, and population fluctuations that are documented through pest surveillance gathering the information and turning it into a useful decision management tool remains a challenge (Magarey et al. 2002). Several techniques exist to assist in data collection, such as insect trapping, but these are limited to a relatively small number of pest species, and thus direct population assessments by scouts cannot yet be replaced (Xia et al., 2007).

The main obstacle in this approach is that gathering sufficient information on pest location in time and space is labour-intensive and expensive, and is thus seldom achieved. The availability of geospatial information technologies is a significant opportunity for wide area data collection and the management of temporal and spatial dynamics of the agricultural environment.

Field crops, orchards and greenhouses are being continuously monitored for pests, by dozens of scouts employed by individuals or organizations. A typical cotton field, for example, is visited by a professional scout twice a week, monitoring pests in, at least, two locations within the field. The information gathered is shared with the grower to determine if and what measure to apply. Pest control decision is thus based on professional observations that are often translated into recommendations to the growers and then vanish. The data collected is volatile: no records are kept or habitually shared with neighbouring growers. This valuable data, if accumulated and shared, would enhance pest management programs.

Standard data collection and unified reporting is required in order to effectively accumulate data from numerous agents. Scouting protocols do not exist for most crops, for others – protocols exist but are loosely implemented. Many scouts have adopted their own methods for estimating and reporting insect population levels. In some cases regional climatic differences and crop variability require different measures for the same pests. For example *Bemisia tabaci* is considered an significant pest of tomatoes in the Hullah valley, Israel, while in the Bet-Shean valley the tomato season draws to an end by the time that the *B. tabaci* appears, therefore scouts in the Bet-Shean region seldom encounter this pest and do not include it in their protocols. Pests that migrate from crop to crop may have a varied impact on each crop leading to dissimilar monitoring. The same *B. tabaci* is also a major cotton pest thus the practice exercised by cotton pest scouts is to count the nymphal stages. The same pest is considered minor for industrial tomatoes thus pest scouts qualitatively monitor adults only.

A working data collection system was developed, in collaboration with pest scouts, which includes a recording device and two-way communication with a central database. The system was developed to bear the scouts' personal working methods and habits. The system is lightweight, portable, and relatively weatherproof at an affordable price. This system has been operational and systematically used by eight pest scouts for over two years, within a pilot study, in two regions in the northern valleys of Israel (Hetzroni et al., 2009). The scouts are currently collecting infestation data in field crops, mainly in cotton, corn and tomato in these three regions, backed by the entomology staff of the Cotton Board and the proponents of the project. The selected crops are important in these regions and often share the same pests. The primary objective of the pilot was to convert manual methods to technology assisted data collection methods, and gain the acceptance of the field staff.

For reliable wide area IPM it is required to establish quantification of pest population which takes into account the differences in estimation not only among scouts but also among crops. The severity of pest population is not necessarily similar when evaluating a population in one crop compared to another.

OBJECTIVES The objective of the current work was to establish and assimilate a standard estimation of pest populations among the solitary scouts inspecting various crops.

METHODS Scouting protocols were revised and unified. It was a collaborative work of grower's organizations, entomologists, experienced scouts from different regions, and engineers. The protocols are still undergoing some revisions.

Cotton Bollworm (*Helicoverpa armigera*) is one of the major polyphagous pests in field crops in the northern valleys of Israel. The larvae damage the tomato crop during the growth from ripeness through color change (Torres-Vila et al., 2003). Scouts are compelled, according to the protocol, to sample a few runs of 1 m each, and to report their findings as the number of eggs and larvae per meter.

Corn becomes susceptible to *H. Armigera* at the initiation of the tassel primordia (Fefelova et al. 2008, Dömötör et al., 2009). The protocol requires scouts to sample a group of plants. The total number of tassels or ears in the group is recorded. Each tassel / ear is inspected for infestation with *H. Armigera* and the total count of infested parts in recorded.

In cotton, eggs and larvae of cotton *H. Armigera* are searched as soon as the bolls appear (Lu et al., 2008). The scouting protocol requires the scouts to arbitrarily select several sections of rows, each of 1 m in length. In each section the scout should count the total number of eggs, small and large larvae. The average of infestations per meter is recorded.

Pest-Yield At this stage, after close follow up, we are certain that the scouts have assimilated and are complying with the scouting protocols. While the scouts continue to monitor pest populations and data is being accumulated, on the server side the data is converted from estimates and counts to a new quantity: the ‘pest-yield’. The calculation of the measure takes into account the crop stand, the pest and method of quantification. Calculations are performed on the data server and the information is exploited to evaluate the approach and its benefits in evaluating the pest infestation dynamics over a wide area.

RESULTS A model to estimate pest counts of pest was developed. It is based on a sampling protocol, and estimation of crop load (counts of plants and phenological stage). To estimate the count of cotton bollworms in tomatoes we assume plant density of 3 plants per meter in a row, or 30,000 plants per hectare. Therefore, having a count of eggs/larvae per meter we are able to calculate the count per hectare. Scouts might take shortcuts and use descriptive estimations such as ‘low’, ‘medium’, or ‘high’, or even threshold such as ‘yes’/‘no’, rather than counts, to report the infestations. This shortcut is commonly used for other pests/crops as well. For cotton bollworm in tomatoes ‘low’ is translated to 0.65 larvae per meter or 6,500 per hectare. ‘Medium’ is translated to 21,500 larvae per hectare, and ‘high’ is estimated as 181,500 larvae per hectare. Cotton plots bear 100,000 plants per hectare while corn is planted in density of 70,000 plants per hectare.

The concept of using a regional spread of pest that is based on sporadic information is still in its early stages of development. The validity of future conclusions that could be deduced from the data is yet to be confirmed. So far, 4400 records of cotton bollworm that were accumulated during 2009 in 96 cotton, tomato, and corn plots in the Hullah valley, Israel (approx. 35’36”E 33’07”N) have been examined.

The counts of cotton bollworm were aggregated weekly and plotted by crop (Figure 1). The increase of cotton bollworm population in the beginning of May and the slow decrease as the tomatoes began to ripen (mid June) is evident. The cotton bolls appeared around mid-July at which time the bollworm started to migrate from the ripening tomato to the cotton plots where the bolls were appearing. Similarly, the bollworms migrated from the cotton plots to corn as soon as the tassels appeared (approx. mid August).

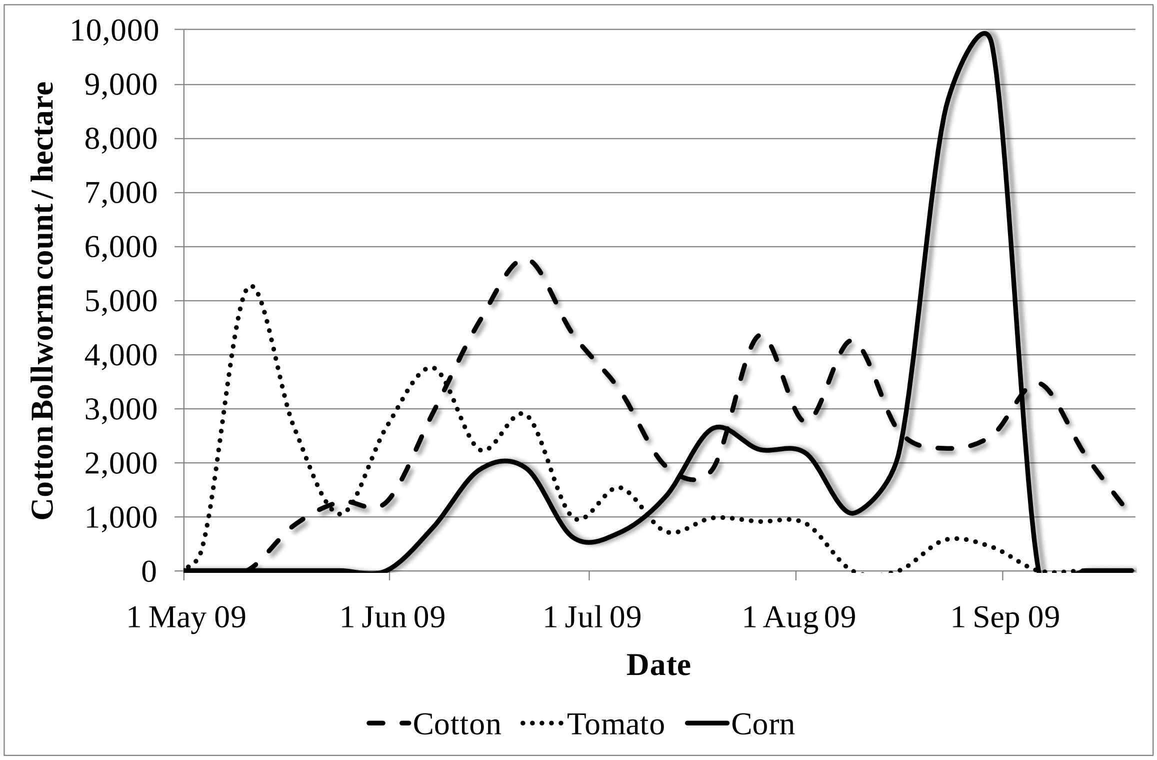

Figure 1.Variation of *Helicoverpa armigera* counts in time, by crop. Data was recorded from May to October 2009 in 96 plots in the Hullah valley.

CONCLUSION It is common to determine pest control measures based on local and immediate measurements of pest infestation taking into account ambience, treatments, and observations from previous visits. Regional decisions are often based on meticulous data collection such as regular visits to fixed traps. The concept of basing decisions on sporadic data is not common. This work is another step to validate this approach.

The results of cotton bollworm counts that are presented here correspond with our knowledge on pest-crop relationship. The counts of cotton bollworm in tomatoes reduced and respectively rose in cotton as anticipated. Thus, although the data flow is sporadic, the information is valid and portrays a valid description of the pest status in the region.

The polyphagous behaviour of the cotton bollworm was also derived from the 2009 data described here. While the pest population was reduced in one crop, it increased in another crop. Future study should focus on the specific migration such as preferred targets and distances of the affected neighbouring plots.

REFERENCES

Agrios, G. N. 1997. *Plant Pathology*, 4th Edition, Academic Press. pp. 25-33.

Bajwa, W.I., L. Coop, and M. Kogan. 2003. Integrated pest management (IPM) and Internet-based information delivery systems. Neotropical Entomology 32:373-383.

Carriere, Y., P.C. Ellsworth, P. Dutilleul, C. Ellers-Kirk, V. Barkley and L. Antilla 2006. A GIS-based approach for area wide pest management: the scales of *Lygus hesperus* movements to cotton from alfalfa, weeds, and cotton. Entomologia Experimentalis et Applicata 118(3): 203-210.

Dömötör I., J. Kiss, and G. Szőcs. 2009. Coincidence of silking time of corn, *Zea mays* and flight period of cotton bollworm, *Helicoverpa armigera* Hbn.: How does it affect follow-up abundancy of larvae on cobs and grain damage in various corn hybrids? Acta Phytopathologica et Entomologica Hungarica. 44(2): 315-326.

Fefelova Yu. A., and A. N. Frolov. 2008. Distribution and mortality of corn earworm (*Helicoverpa armigera*, *Lepidoptera*, *Noctuidae*) on maize plants in Krasnodar Territory. Entomological Review 88(4): 480-484

Hetzroni A., M. Meron, I. Fraier, Y. Magrisso, O. Mendelsohn. 2009. Data collection and two-way communication to support decision making by pest scouts. Proceedings of the Joint International Agricultural Conference. Wageningen, Netherlands

Lu Y.H., F. Qiu, H.Q. Feng, H.B. Li, Z.C. Yang, K.A.G. Wyckhuys, and K.M. Wu. 2008. Species composition and seasonal abundance of pestiferous plant bugs (*Hemiptera: Miridae*) on Bt Cotton in China, Crop Protection, 27(3-5): 465-472

Magarey, R.D., J.W. Travis, J.M. Russo, R.C. Seem and P. A. Magarey. 2002. Decision support systems: quenching the thirst. Plant Disease 86(1): 5.

Pasiecznik, N.M., I.M. Smith, G.W. Watson, A.A. Brunt, B. Ritchie and L.M.F. Charles (2005). CABI/EPPO distribution maps of plant pests and plant diseases and their important role in plant quarantine. EPPO Bulletin 35(1): 1-7.

Stinner, R. E., C. S. Barfield, J. L. Stimac and L. Dohse. 1983. Dispersal and movement of insect pests. Annual Review of Entomology 28: 319-335.

Torres-Vila L. M., M.C. Rodríguez-Molina and A. Lacasa-Plasencia. 2003. Impact of *Helicoverpa armigera* larval density and crop phenology on yield and quality losses in processing tomato: developing fruit count-based damage thresholds for IPM decision-making. Crop Protection 22(3): 521-532

Weisz, R., S. Fleischer and Z. Smilowitz. 1996. Site-specific integrated pest management for high-value crops: Impact on potato pest management. Journal of economic entomology 89(2): 501-509.

Xia, Y., R. Magarey, K. Suiter and R. Stinner. 2007. Applications of information technology in IPM. General concepts in integrated pest and disease management. Ciancio, A. & Mukerji, KG (Eds.). Springer, The Netherlands: 205-222.