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Cotton Production in the Presence of *Helicoverpa armigera* (Hb.) in Central Greece

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Abstract: The present study was conducted in 10 different communities of prefecture of Larissa, one of the main cotton-productive areas of Greece. Monitoring of *Helicoverpa armigera* lasted four years from 2002 to 2005. The monitoring system included four locations within each community and three traps in each location. Traps were of the funnel type, a reusable injection-moulded kind of plastic trap. Pheromone was z-11-hexadecenyl aldehyde 0.36% w/w. Insecticide (Vapona) was used for all the four years, but for years 2003 and 2004 double traps were used additionally, without the presence of insecticide (only with pheromone). Traps containing a pheromone and an insecticide had significantly greater number of insects trapped than those containing no insecticide. Fluctuation of insect population was different from year to year. Correlations on data between years (insect populations and cotton production across all communities) revealed that, when cotton production was low, the number of adult male insects of *H. armigera* captured in pheromone traps was high (r = -0.69). There were no statistically significant correlations between cotton production and number of trapped insects when data from all communities (across the four years) were used. Local conditions within each area have been proved important and these results were completely different compared to data concerning specific years. Prediction models must be used for average estimations within great areas that include data from many locations.

Key words: Cotton production, *Helicoverpa armigera*, population monitoring

INTRODUCTION

Cotton is one of the main cultivations in Greece and especially Central Greece where is well adapted, exhibiting high productivity, earliness and good quality. The development of cotton cultivation was based on extensive use of crop protection, especially when insecticides were used against insects harmful for the upper parts of the plant (thrips, European corn borer, white flies, acarea etc.). The positive impact of crop protection, lead to a negative side effect: the accumulation of pesticide residues, since about 20 kg of pesticides are applied in cotton cultivation per hectare (Giatropoulos, 2005). In the prefecture of Larissa especially, 1,300,000 kg of pesticides are applied in cotton cultivations (650,000 kg are granular insecticides) every year in the last decade.

Helicoverpa armigera (Hübner) (Lepidoptera: Noctuidae) is a major pest (also known as cotton bollworm) of a wide range of host plants, including crop plants. Several studies have been made on the development of *H. armigera* on plants and artificial diets. It was found that larvae require 5, 6 or 7 stadia to complete their development, resulting in a variation in duration of larval development. Such variation made the determination of the timing of control application difficult, as all stadia are not highly susceptible to the control means (Stavridis *et al*., 2004). It is essential to identify the various larval instars for better understanding insects' behavior, but larval instar could not easily be determined from observed feeding damage. This has widely been done for lepidopterous larvae on the basis of head capsule width (Gaines and Campbell, 1935; Frick and Wilson, 1981; Godin *et al*., 2002). Under optimal conditions, most lepidopterous larvae develop through a minimal number of stadia, growing at a nearly maximal growth rate. However, environmental conditions are seldom stable enough to support this maximum growth rate throughout the duration of larval development. Adult insects of the family Noctuidae are yellow-green moths about 2 cm long that are active during the night. Larvae are white to green and they may reach 5 cm in length. In Greece, four generations of *H. armigera* and other

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Noctuidae that are major pests of cotton, corn or tomato, were found (Giatropoulos, 2005). Second generation attacks cotton fields in middle June (when cotton tips and flowers appear). At that stage bolls and young flowers may be repaired and damages are very low (Tolis, 1999; Giatropoulos, 2005). Third generation causes great damages on cotton plants in middle July. Fourth generation appears in middle August and causes great damages in late cultivations, while early cultivations of cotton escape damages, because cotton plants are reaching maturity.

Although there are many enemies of *H. armigera,* damages on cotton plants are severe in specific years (1968 and 2003 in Greece), due to favorable environmental conditions (Giatropoulos, 2005). Chemical and biological formulations are used for controlling insect population, but it is not always easy to achieve a satisfying level of population control. In unmonitored and untreated fields damages of cotton bollworm on cotton production were sometimes found at 39-94%, but insect populations could be controlled by cultural techniques and biological and chemical applications (Sekulic *et al*., 2004). Damages on cotton production and methods of integrated control were also referred by Benedict *et al*. (1989). In Thessaly, there were many years without the presence of the insect, because population density was found very low. In specific years, high population densities cause severe damages on cotton production, but there are years that, although *H. armigera* is found in great numbers in cotton fields, damage level is far below economic threshold (Tolis, 1999; Giatropoulos, 2005). Additionally, chemical control of 4th or 5th instar larvae is not always successful. For this reason monitoring of populations is indispensable by using pheromone traps, 50-100 m apart (Walker and Cameron, 1990; Tolis, 1999; Giatropoulos, 2005). Monitoring starts in middle May until middle September and data are recorded every 2 or 3 days, for best surveillance of insect population during the cultivation period of cotton.

The aim of this study was to study fluctuation of populations of *H. armigera* in various areas in the Prefecture of Larissa. Population densities of the insect and cotton production were studied under correlation analysis and year effect was additionally studied.

MATERIALS AND METHODS

The present study was conducted in 10 different communities of prefecture of Larissa, one of the main cotton-productive areas of Greece. Monitoring of *H. armigera* lasted four years from 2002-2005. The monitoring system included four locations within each community and three traps in each location, at a distance between traps of 50 m (on the corners of a equilateral triangle). Traps were of the funnel type, a reusable injection-moulded kind of plastic trap, suitable for dusty locations. Pheromone was z-11-hexadecenyl aldehyde 0.36% w/w (Produced by Russell Fine Chemicals Ltd). Vapona (transfluthrin, 0.4% w/w, distributed by Sara Lee Hellas) is a fumigant insecticide used as standard moth-papers. It was applied in the traps for all the four years, but for years 2003 and 2004 double traps were used additionally, without the presence of insecticide (only with pheromone). Three cotton varieties cover over 80% of the cultivated fields: Celia and Carmen (Fibermax-Bayer) and Sandra (Veterin Hellas).

Data from traps recorded fluctuation of insect population within each community and for the whole Prefecture of Larissa. Environmental conditions (rainfall, relative humidity, temperature) were also recorded. Cotton mean production in kg ha^{-1} was also calculated from harvesting data within each community. Correlations between cotton mean production and number of male adult insects were performed. Data transformations, ANOVA and correlations were based on the standard procedures described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Table 1 presents environmental data of Larissa for years 2002-2005. Year 2002 was warmer (mean temperature) and relatively wet compared to other years. Year 2005 was also warm but with very low rainfall. Table 2 presents mean cotton production and adult male insects of *H. armigera* captured in the 10 communities of Larissa, for years 2002-2005.

In years 2002, 2003 and 2004, the presence of the insect might contributed in lower cotton production. Statistically significant differences between the two types of traps (with or without insecticide application) were found, due to greater number of insects trapped when Vapona was used. The presence of the insecticide obviously contributed in higher number of male catches, because insects were affected by the insecticide and thus, they could not fly away.

Figure 1 presents insect populations monitored within the ten different areas (communities) for *H. armigera* (traps with or without insecticide application) and *Pectinophora gossypiella* (Stavridis *et al*., 2008), according means of years 2003-2004. Fluctuation of insect population was different from year to year. Insect population fluctuations showed statistically significant differences and this phenomenon was described by Deligeorgidis *et al*. (2008).

Table 1: Environmental data of Larissa for years 2002-2005

Year	Month	Min temperature (°C)	Max temperature (°C)	Mean temperature (°C)	Rain (mm)	RH (%)
2002	March	5.1	18.0	10.1	41.0	81.0
	April	12.0	25.0	19.0	47.0	72.0
	May	12.2	26.0	19.0	55.0	80.0
	June	17.0	32.0	22.0	22.0	78.0
	July	17.0	36.1	27.0	12.0	58.0
	August	18.0	34.0	26.0	2.0	60.0
	September	14.0	27.0	20.0	47.0	80.0
	October	11.0	25.0	17.0	88.0	82.0
	Mean	13.3	27.9	20.0	314.0	73.9
2003	March	2.2	17.0	8.0	26.0	86.0
	April	5.0	18.0	10.0	41.0	81.0
	May	12.0	30.0	21.0	67.0	67.0
	June	20.0	33.2	24.1	18.0	61.0
	July	20.1	38.0	26.0	16.0	48.0
	August	20.0	33.0	25.0	28.0	70.0
	September	14.0	30.0	22.0	39.0	75.0
	October	11.0	29.0	18.0	98.0	84.0
	Mean	13.0	28.5	19.3	333.0	71.5
2004	March	7.0	20.0	13.0	15.0	89.0
	April	10.1	24.0	16.0	58.0	82.0
	May	11.0	26.0	18.0	65.0	80.0
	June	17.0	32.0	22.0	36.0	78.0
	July	17.2	36.0	26.3	20.0	58.0
	August	18.0	34.0	26.1	2.0	60.0
	September	14.0	30.0	20.0	8.0	70.0
	October	12.0	28.0	17.0	21.0	82.0
	Mean	13.3	28.8	19.8	225.0	74.9
2005	March	9.0	20.0	14.0	10.0	87.0
	April	11.0	24.0	17.0	45.0	80.0
	May	11.2	26.0	18.0	45.0	80.0
	June	17.0	32.0	22.0	17.0	74.0
	July	19.0	36.0	27.0	2.0	60.0
	August	20.0	33.0	27.0	42.0	68.0
	September	14.0	30.0	22.0	17.0	70.0
	October	11.0	25.0	18.0	10.0	72.0
	Mean	14.0	28.3	20.6	188.0	73.9

Min: Minimum, Max: Maximum, RH: Relative Humidity

Table 2: Mean cotton production and adult male insects of *Helicoverpa armigera* in the 10 communities (C1-C10) of Larissa, for years 2002-2005 and monitoring traps without insecticide application or with insecticide application

Year	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Mean
Cotton production (kg ha^{-1})											
2002	3700	4000	4300	4000	3700	3700	4400	4000	3800	4000	3960†
2003	3000	4500	4500	4200	3800	3400	4500	3800	4000	2600	3830†
2004	3500	4000	4400	4600	3800	3500	3600	1800	4800	4000	3800†
2005	3950	5000	4700	4800	3740	3500	3800	3800	4700	4700	4270†
Mean	3540	4380	4480	4400	3760	3530	4080	3350	4330	3830	3960†
Mean No. of male insects trapped (traps without insecticide application)											
2003	13.5	38	27	16.3	115.3	26.7	9.7	11	7	12.7	27.7±2.9
2004	13.0	15.6	15	9.4	43.1	10.6	6.2	19.2	9.3	11.1	15.3±2.9
Mean	13.3	26.8	21.0	12.9	79.2	18.7	8.0	15.1	8.2	11.9	21.5±2.9
Mean No. of male insects trapped (traps with insecticide application)											
2002	22.0	13.7	14	10	62	1	2.5	2.7	5.3	12.7	14.6±4.1
2003	95.0	39	30	130	150	30	45	35	11	35	60.0±4.1
2004	70.0	12.1	4	20	100	44	4	15.2	12	32	31.3±4.1
2005	30.0	6.5	1.5	6	5	7	10	11	5	33	11.5±4.1
Mean	54.3	17.8	12.4	41.5	79.3	20.5	15.4	16.0	8.3	28.2	29.4±4.1

†: Harvesting data without replications, All interactions (recording period×year×location) were statistically significant at $p<0.05$

Local conditions within each area have been proved important for population fluctuations and these results were completely different compared to data concerning years (Table 2). The specific conditions within each area determine the balance between the insect population and level of damage on cotton production. There were areas where the insect showed increased populations (and possibly low populations of its enemies) resulting in low cotton production. Warm years with light rainfall seem not to favor *H. armigera* activity (or favor natural enemies of the pest), resulting in lower damages (Table 1, 2). The distinct seasonal fluctuations in insect populations

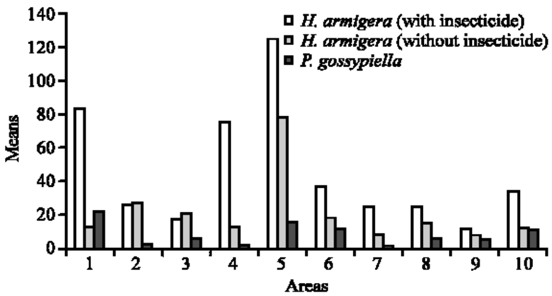

Fig. 1: Insect populations monitored within the ten different areas (communities) for *Helicoverpa armigera* (traps with or without insecticide application) and *Pectinophora gossypiella* (data adopted from Stavridis *et al.* (2008)), according means of years 2003-2004

(Walker and Cameron, 1990) have provided opportunities to restrict the application of insecticides to periods when they are necessary for control of the pest. Identifying these periods requires knowledge of economic thresholds and widespread pest monitoring systems. An approach for insect population fluctuations was stated by Sequeira and Playford (2002). Within and between-season patterns of *Helicoverpa* egg and larval abundance on commercial cotton in central Queensland were analysed using crop scouting data for five farms over nine consecutive growing seasons. Within seasons, analysis of mean weekly egg density profiles for individual farms revealed asynchronous oviposition activity among farms for approximately the first 8 weeks of the growing season. Beyond 8 weeks oviposition activity appeared to be well synchronised among farms. Weekly egg density profiles differed significantly between seasons. The ecological significance of oviposition activity and larval survival patterns on cotton were connected to pesticide application and control strategies.

Correlations on data between years (insect populations and cotton production across all communities) revealed that, when cotton production was low, the number of adult male insects of *H. armigera* captured in pheromone traps was high (r = -0.62 to -0.69). The opposite was found for *P. gossypiella* (Stavridis *et al.*, 2008), where correlations were positive. The present study showed that *H. armigera* populations negatively affected cotton production, requiring monitoring and subsequently, insect population control below damage levels. Statistically significant correlations were not found between cotton production and number of trapped insects when data from all communities (across the four years) were used.

Although correlation data must be handled with care because of the particular biological phenomenon of interaction of insect populations with year conditions (Deligeorgidis *et al.*, 2008) leading in a misfit of insect catches and damage levels and in agreement to the findings of Stavridis *et al.* (2008) studying populations of *P. gossypiella*, damage predictions maybe performed from data between years (insect populations and cotton production across all communities). These predictions will refer to the average of damages that will be expected in all communities studied for specific years. The models proposed here, derived from correlations of present study and data adopted from Stavridis *et al.* (2008). For *H. armigera* proposed model is hyperbolic $y = 3E+42x^{-11.415}$ ($r^2 = 0.65$) and for *P. gossypiella*, model is linear $y = 0.0192x-65.462$ ($r^2 = 0.87$), after best line fit test. Cotton production (y) and subsequently damage levels depend on the total male catches (x), but data are also depended on year conditions estimated by recordings from all communities. Modeling and estimations of *Helicoverpa* damages on various crops were attempted previously (Chilcutt *et al.*, 2003; Nibouche *et al.*, 2007). Chilcutt *et al.* (2003) referred that high *H. zea* (Boddie) densities had no effect on cotton yield unless they occurred late in the season. In particular, this was true for artificial *H. zea* damage. They also stated that, with the exception of late in the season, the model for simulating *H. zea* damage to cotton through removal of fruiting structures resulted in similar yields as real *H. zea* larvae damage to cotton. According to the model by Nibouche *et al.* (2007), the relative organ (food) availability in the field and the larval instar were found to be significant factors. Chaturvedi (2007) described how monitoring system and preliminary studies of egg and larval distributions and damage assessment trials could be used to develop an initial estimate of a threshold that would maintain damage below the 5% commercially acceptable level for pest *H. armigera* on *Cicer arietinum*.

Concluding, correlations on data between years revealed that, when cotton production was low, the number of adult male insects of *H. armigera* captured in pheromone traps was high. Present study showed that *H. armigera* populations negatively affected cotton production, requiring monitoring and subsequently, insect population control below damage levels. There were not found statistically significant correlations between cotton production and number of trapped insects when data from all communities (across the four years) were used. Prediction models and practices proposed must be performed with care, because of the year-to-year interactions. We propose only to be used for average estimations within great areas that include data from many locations.

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REFERENCES

Benedict, J.H., K.M. El-Zik, L.R. Oliver, P.A. Roberts and L.T. Wilson, 1989. Economic Injury Levels and Thresholds for Pests of Cotton. In: Integrated Pest Management Systems and Cotton Production, Frisbie, R.E., K.M. El-Zik and L.T. Wilson (Eds.). John Wiley and Sons, New York, ISBN 04-718-17821, pp: 121-153.

Chaturvedi, I., 2007. Economic threshold level and monitoring systems: Reality and practicality in *Helicoverpa armigera* (Lepidoptera: Noctuidae). Electr. J. Envir.. Agric. Food Chem., 6: 2199-2206.

Chilcutt, C.F., L.T. Wilson and R.J. Lascano, 2003. Field evaluation of a *Helicoverpa zea* (Lepidoptera: Noctuidae) damage simulation model: Effects of irrigation, *H. zea* density and time of damage on cotton yield. J. Econ. Entomol., 96: 1174-1183.

Deligeorgidis, N.P., C.G. Ipsilandis, G. Sidiropoulos, V. Greveniotis, L. Giakalis and P.N. Deligeorgidis, 2008. Population fluctuations of *Tingis sideritis* Štusák (Heteroptera, Tingidae) on wild mountain tea *Sideritis scardica* Griseb. (Lamiaceae) of Mount Vermion in Greece. J. Entomol.

Frick, K.E. and R.F. Wilson, 1981. Head capsule measurements of *Bactra verutana* larvae reared on an artificial diet. Environ. Entomol., 10: 237-239.

Gaines, J.C. and F.L. Campbell, 1935. Dyar's rule as related to the number of instars of the corn earworm, *Heliothis obsoleta* (Fab.), collected in the field. Ann. Entomol. Soc. Am., 28: 445-461.

Giatropoulos, C., 2005. Integrated Cotton Production. 1st Edn., Larissa, Greek, pp: 53.

Godin, J., P. Maltais and S. Gaudet, 2002. Head capsule width as an instar indicator for larvae of the cranberry fruitworm (Lepidoptera: Pyralidae) in southeastern New Brunswick. J. Econ. Entomol., 95: 1308-1313.

Nibouche, S., E. Gozé, R. Babin, J. Beyo and T. Brévault, 2007. Modeling *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) damages on cotton. Environ. Entomol., 36: 151-156.

Sekulic, R., K. Tatjana, S. Maširevic, D. Vajgand, F. Gordana and S. Radojèic, 2004. Incidence and damage of cotton bollworm (*Helicoverpa armigera* Hbn.) in vojvodina province in 2003. Biljni Lekar, 32: 113-124.

Sequeira, R.V. and C.L. Playford, 2002. Trends in *Helicoverpa* spp. (Lepidoptera: Noctuidae) abundance on commercial cotton in central queensland: Implications for pest management. Crop. Protect., 21: 439-447.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Edn., The Iowa State University Press, Ames, IA., ISBN: 0-81381560-6, pp: 507.

Stavridis, D.G., C.G. Ipsilantis, P.C. Katarachias, P.G. Milonas, A.A. Ifoulis and M. Savopoulou-Soultani, 2004. Determination of *Helicoverpa armigera* (Lepidoptera: Tortricidae) larval instars and age based on head capsule width and larval weight. Entomol. Hellenica, 15: 53-61.

Stavridis, D.G., P.N. Deligeorgidis, A. Gliatis, C. Giatropoulos, E. Mola, C. Fotiadou and C.G. Ipsilandis, 2008. Cotton production in the presence of *Pectinophora gossypiella* (Saund.) in Central Greece. J. Entomol. (In Press).

Tolis, I.D., 1999. Cotton: Enemies, Diseases and Weeds. 1st Edn. A. Stamoulis Publications, Greece, Greek, pp: 734.

Walker, G.P. and P.J. Cameron, 1990. Pheromone trapping and field scouting for tomato fruitworm in tomatoes and sweet corn. Proc. N. Zealand Weed Pest Cont. Conf., 43: 17-20.