Assess cotton growers' willingness to use coated cotton seeds with insecticides. A field research in the Region of Thessaly, Greece

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Abstract

Regarding cotton cultivation, the ban of use of coated cotton seeds with neonicotinoids leaves no other alternative but to apply granular insecticides during sowing. Due to the importance of cotton production for the Greek primary sector and national economy, a field research was conducted in August 2015 in the Region of Thessaly, central Greece, where half of Greek cotton is traditionally produced. The results prove that there is a significant environmental awareness from cotton producers, showing a strong preference in using coated cotton seeds instead of granular insecticides. This preference is more intense for younger farmers with large agricultural holdings. This is the first field research conducted for this issue, which verifies the need for further examination of farmers' beliefs, perceptions and attitudes on similar issues for different crops, like maize.

Keywords: *neonicotinoids; cotton, willingness to use.*

Résumé

Dans le cas de la culture du coton, l'interdiction des semences traitées aux néonicotinoïdes ne laisse aucune alternative sauf l'utilisation d'insecticides granulaires lors du semis. Vu l'importance de la production de coton pour le secteur primaire et l'économie nationale de la Grèce, une enquête sur le terrain a été réalisée en août 2015 dans la région de la Thessalie, en Grèce centrale, où est réalisée la moitié de la production traditionnelle de coton du pays. Les résultats révèlent une prise de conscience écologique considérable de la part des producteurs de coton qui manifestent une nette préférence pour les semences de coton enrobées au lieu des traitements aux insecticides granulaires. Cette préférence est plus forte chez les exploitants plus jeunes avec des exploitations de grande taille. Ce travail représente la première recherche réalisée en plein champ autour de cette question et il a mis en évidence la nécessité d'examiner davantage les convictions, les perceptions et les attitudes des exploitants à ce sujet en considérant, toutefois, des cultures différentes telles le maïs.

Mots-clés: néonicotinoïdes, coton, volonté d'utiliser.

Introduction

In many cases globally the adoption of cotton cultivation and production was the outcome of the implementation of agricultural policies aiming to exploit natural resources and provide to farmers, opportunities for significant increases of their income. Such changes though usually are being accompanied by serious environmental degradation due to soil depletion, and water contamination (Benjaminsen, 1999; Benjaminsen *et al.*, 2010). The continuous increasing demand for larger quantities of commodities for both food consumption and industrial use has intensified production, leading in many cases to soil and water fast degradation (Tappan and McGahuey, 2007; Kidron *et al.*, 2010). Another quite important issue is the loss of biodiversity being noticed in areas where intensive agriculture takes place, creating the need for the implementation of action plans aiming to restore this loss by increased biophysical resource use efficiency (Baudron *et al.*, 2009). Environmental issues related to cotton refer also to the use of agrochemicals, and more specifically to pesticides. It has been proven though that implementation of integrated pest-management systems can drastically reduce pesticides use, without negative impact on production yields (Sundaramurthy, 2002). Even though in many cases there is scepticism regarding pesticide use, it is highly admitted that there are serious constraints which do not allow them to be discarded, closely related with economic and food security issues (Devine and Furlong, 2007). More specifically, there is special concern about the use of a specific group of insecticides named neonicotinoids. Empirical studies claim that their use has a negative impact on beneficial insects, like honey bees, affecting negatively also the pollination service of food crops (Chagnon *et al.*, 2015). Such results though have been questioned by similar ones claiming quite the opposite (Jones and Turnbull, 2016). There is though serious scepticism from producers that this continuous trend of increasing limitations on crop protection possibilities jeopardise agricultural income as well as the stability of commodity markets, due to the increased risk agriculture is forced to take (Matyjaszczyk *et al.*, 2015). Newer research findings refer to the negative impact of neonicotinoids on honey bees, even when they are exposed to sublethal doses, claiming that this exposure is relevant to immunocompetence in worker bees (Brandt *et al.*, 2016). This debate focuses also on the topic that there is lack of information on field realistic levels of exposure as well as lack of knowledge regarding the synergist action with other Active Ingredients being used by farmers (David *et al.*, 2016). Beyond the agronomic and environmental perspective, the neonicotinoids issue has legal implications, with the EU to ban

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the use of them until this issue is permanently resolved, despite the fact that the scientific results are contradictory (McGrath, 2014).

Due to the importance of cotton cultivation for Greece, a field research was conducted during August 2015 in the Region of Thessaly, which is placed in central Greece. Traditionally, this region is the main cotton producing area of Greece for decades, with many major cotton processing facilities (cotton gin mills). Traditionally, Thessaly produces the majority of Greek cotton. During the last years in Thessaly approx. 100,000 Ha are being cultivated with cotton on average, while on a national basis this area is approx. 240,000 Ha. At the same time, in the majority of the cotton fields in this area, modern techniques are used, i.e. drip irrigation, etc. At a European level, Greece is by far the most important cotton-producing country; hence, Thessaly can be regarded as the most important cotton-producing area in Europe.

1. Background

Neonicotinoids are neurotoxic insecticides that act on a unique receptor of insects' nervous system (prosynaptic nicotinic acetylocholine receptor), and generally have low mammalian toxicity. This group of insecticides has a systemic activity, which means that it can easily translocate in different plant parts. Therefore, these insecticides used to be widely used for seed coat in various types of crops, such as cotton or maize, as they can easily translocate to stems and leaves providing a satisfactory level of protection in young plants from sucking insects, such as aphids and thrips. Nevertheless, in 2011, the United States Department of Agriculture (USDA) indicated that the application of imidacloprid which is one of the major neonicotinoids in use caused a reduction in bee populations, a phenomenon which was named colony collapse disorder (CCD). In this regard, the effect of neonicotinoids on bees was regarded as a result of chronic exposure and not as an immediate exposure effect. Nevertheless, in 2013, the European Food Safety Authority (EFSA) stated that neonicotinoids pose a high risk for bees, through drift that causes either direct insect exposure, or risks through toxic residues in nectar and pollen. In this context, EU decided restrictions to the use of three neocotinoids: imidacloprid, thiamethoxam and clothianidin. Indeed, neonicotinoids are toxic to bees, at a similar level with other novel insecticides with a different mode of action, such as spinosad, emamectin benzoate and fipronil, but most of the data until recently were focused on direct exposure and not chronic effects of sublethal doses.

Apparently, the withdrawal of these Active Ingredients (AIs) from seed coating (chiefly imidacloprid and thiamethoxam, which are the main AIs that are used for this purpose), created a serious gap for several crops, especially for cotton, for which there were not many alternatives for seed coating. Currently, this gap has been covered with other AIs that, obviously, have not systemic action, and thus, the risks of causing problems through sublethal or chronic effect on bees, is considered limited. One of these AIs is chlorpyrifos, which is toxic to mammals. At the same time, given that these AIs are not systemic, they can be effective against soil insects if they are used on seeding, but they cannot protect the plants from sucking insects. Moreover, at least in the case of cotton, these insecticides are currently applied in their granular (G) form and not in the form of seed coating, which questions users' safety and accurate application patterns. In Greece, practically, granular insecticides are either mixed with the seed or used separately at a different container, which is likely to increase operators' exposure during seeding. Nevertheless, apart from insect toxicity studies and environmental side effects, there is still inadequate information on the farmers' perception of this withdrawal, given that farmers are the users of insecticides during seeding, and any major change is expected to alter significantly some of the techniques used during the initial stage of cultivation.

In this context, the current questionnaire was developed in order to illustrate the impact of this withdrawal on the farmer's perception, by emphasizing to Greek cotton producers, in the main cotton producing area of Europe, Thessaly. This survey was performed during the 2015 growing season, and it is planned to be expanded in the next (2016) growing season for other crops, especially maize.

The questionnaire used for this field research was divided into three parts. In the first one, interviewees were asked to provide information regarding their socioeconomic characteristics, like age, gender, educational level, and annual payments of EU subsidies. In the second part there were questions aimed to collect information for the production plan of their agricultural holdings and their dependency from cotton production. At the same part, there was a question about the willingness to use cotton seeds coated with insecticides, instead of granular ones, which was used as the dependent variable in a MLR Model (see below). Finally, in the third part, farmers were called to assess a series of eight (8) proposals. These proposals are being presented in Table 1. In this part, it was targeted to assess the awareness of cotton producers as regards to the health hazards they are exposed to due to the use of insecticides, their environmentally-friendly consciousness, the difficulties during insecticidal applications (primarily during seeding), as well as their effectiveness and finally, their subjective impression about the possible increase of beneficial insect populations, after the ban of the use of neonicotinoid insecticides.

The sample consists of 607 questionnaires representing 6,767 Ha cultivated with cotton in 2014 and 6,965 Ha for the year 2015 respectively. This data series represents nearly 7% of the total cotton cultivated area in the region, and 3% of the total cultivated area with cotton on a national basis. The farmers' dependency from cotton remains stable for these two cultivating periods, with 51% and 52% of their land being cultivated with the specific crop, respectively. This can be considered as a data set that is solid enough to

Table 1 - *Descriptive statistics of FA statements.*			
Variables	Medium	95% Confidence Interval	
		Lower Limit	Upper Limit
Withdrawal of insecticides protects my health	2.90	2.76	3.05
Withdrawal of insecticides protecting cotton seeds protects the environment	1.65	1.44	1.87
Withdrawal of insecticides protecting cotton seeds protects my health	1.70	1.48	1.91
Granular insecticides being used for seeding cotton are easier to use	-0.32	-0.56	-0.07
I have realised that the use of new insecticides protects the beneficial insects, like bees, ladybirds, etc.	1.80	1.62	1.99
During the ongoing growing season period (2015) for cotton and maize I see more beneficial insects (bees etc.) compared to the previous one (2014)	1.42	1.25	1.60
After the emergence of cotton and maize I faced more problems this year (2015) compared to the previous ones due to sucking insects (aphids, thrips etc.)	0.59	0.37	0.81
After the emergence of cotton and maize I faced more problems this year (2015) compared with the previous ones due to soil insects (wireworms, cutworms etc.)	-0.12	-0.34	0.10
Source: Own calculation.			

draw conclusions regarding the farmers' perception from this withdrawal. Based on the above, the major aims of the specific survey was to a) assess the farmers' perception about the transition from seed coating to granular insecticides, b) to estimate farmers' opinion regarding efficacy of the granular insecticides and c) to illustrate farmers' awareness regarding health risks and environmental concerns regarding the use of granular insecticides. These variables were correlated with other parameters such as the financial support by EU, size of the crop, etc. For farmers in Thessaly, ban of the use of specific insecticides significantly protects their health and the environment (very positive values V1, V3, V2) and therefore they find it beneficial for both humans and the environment (V5, V6). Regarding the cotton cultivation problems, opinions differ remarkably. A relative balance appears between those who consider that in 2015 the germination problems increased compared to previous years (V7, V8) and those who strongly disagree. Surprisingly, the same results emerge regarding sowing when granular insecticides are being used, with farmers to express different points of view on an equal propensity (V4). The following Table presents the variables being used as statements, in order cotton producers to classify them by using a -4 to +4 Likert scale, with the -4 for the opinion "Strongly Disagree", 0 for the opinion "Neutral", and +4 for the opinion "Fully Agree".

2. Factor analysis

In order to approach the impact of insecticidal use in relation with the ban in seed coating, a Factor Analysis (FA) was performed to determine whether the collected data relative to farmers' perception (initial variables) allowed us to detect different categories of beliefs and attitudes. The major objective of the FA is to explore the likely underlying formation of a set of interrelated variables without imposing any fixed structure of the outcome. This method allows us to "identify the factor structure or model for a set of variables" (Bandalos, 1996). As stipulated by Tabachnick and Fidell (2007), factor analyses are "… *statistical techniques applied to a single set of variables when the researcher is interested in discovering which variables in the set form coherent subsets that are relatively independent of one another. Variables that are correlated with one another but largely independent of other subsets of variables are combined into factors"*.

The extraction method was in Principal Component Analysis (PCA), based on varimax rotation[1]. It was decided to use PCA because the objective was principally to explore what is the new insecticide application patterns emerging in cotton cultivation, after the ban of neonicotinoids, by reducing the number of initial variables. PCA represents a high-quality method when the purpose of the research is first of all, a reduction of variables (Conway and Huffcutt, 2003). Rotation of factor axes was implemented in order to identify "simple and interpretable" dimensions (Yaremko *et al.*, 1986).

When FA is being applied, several assumptions are being made (Brown, 2009a, 2009b): (i) the data are based on random sampling while variables are expressed through interval or ratio level, (ii) the relationship between the observed variables is linear while normality of variables is largely desirable. It is often mentioned that this 2nd assumption is not essential, especially if Principal Factor Analysis is used descriptively. The normality will just enhance the solution (Tabachnik and Fidell, 2007) and allows the generalization of the results of the analysis (Field, 2000).

If FA is a very useful method that has been implemented in various empirical studies, it almost presents some limitations:

(i) The correlations, the basis of factor analysis, describe relationships. No casual inferences can be made from correlations alone.

(ii) The choice of the initial variables is determining for the interpretation of the extracted factors. It is necessary to avoid sample specific variables.

(iii) The results are largely dependent of the sample selection and the sample size (larger sample leads to larger correlation). If it is recognized that EFA is a "large-sample" procedure (Osborne and Costello, 2009), it appears from

[1] As proposed by Yaremko *et al.* (1986), the rotation of the factor axes (dimensions) identified in the initial extraction of factors, allows us to obtain simple and interpretable factors. Due to the fact that the simple structure of the factor analysis was clear and respect the criteria proposed by Thurstone (1947) in order to identify simple structure, we used orthogonal rotation rather than oblique; more precisely the varimax rotation as suggested by different authors (Gorsuch, 1983; Tabachnik and Fiddell, 2007; Brown, 2009b).

Table 2 - *Pattern Matrix of Factor Analysis Results.*

		Communalities (h^2)	Id1 Prohibition of insecticides protects both humans and environment	Id2 Intensity of problems for the year 2015	Id3 Subjective assessment about beneficial insects
V3	Withdrawal of insecticides protecting cotton seeds protects my health	0.745	**.857**		
V2	Withdrawal of insecticides protecting cotton seeds protects the environment	0.698	**.832**		
V1	Withdrawal of insecticides protecting cotton seeds protects my health	0.544	**.695**		
V7	After the germination of cotton and maize I faced more problems this year (2015) compared with the previous ones due to phloem sucking insects (aphids, thrips etc)	0.729		**.849**	
V8	After the germination of cotton and maize I faced more problems this year (2015) compared with the previous ones due to soil insects like wireworms, cutworms etc.	0.724		**.847**	
V6	During the ongoing cultivation period (2015) for cotton and maize I see more beneficial insects (bees etc) compared with the previous one (2014)	0.813			**.813**
V5	I have realised that the use of new insecticides protects the beneficial insects, like bees etc., for both environment and humans	0.684			**.807**

Source: Own calculation.

the discussion, that mainly one criterion is finally adopted, based on the subjects – items ratio. The rule can be summarized as following: a ratio of 5 subjects per variable is a strict minimum while it is suggested to have "at least 10-15 subjects per variable" (Field, 2000). Nevertheless, this is not a strict rule because the accuracy of the analysis is in large part dependent of the nature of the variables (Fabrigar *et al.*, 1999) and their capacity to produce strong hyper-variables (factors).

(iv) The most important limitation concerns the reliability of the measurement, especially when measuring attitudes, behaviours and psychological attributes through Likert-type scales (Gliem and Gliem, 2003). The variables reflecting the change of insecticides application habits include themselves a psychological dimension. For this reason, the assessment of internal consistency reliability measures, through the calculation of Cronbach's alpha coefficients, is inescapable (Gliem and Gliem, 2003). This analysis aims to confirm or not the reliability of the variables initially selected, taking as rule of thumb that alpha coefficient higher than 0.70 is an acceptable level.

In order to evaluate the quality and the adequacy of the FA solution, two criteria are successively considered: the item communalities and the Kayser-Meyer-Olkin (KMO) measure for sampling accuracy. For each initial variable, communality is the proportion of its variance accounted for all extracted factors. A large communality value indicates a strong influence of the initial variable which is well reflected by the extracted factors. Following Kaiser (1974), we will also admit that a KMO greater than 0.70 is a significant threshold of sampling adequacy[2].

As regards the number of factors (hyper-variables) to be extracted, the "multiple criteria and reasoned reflection" was used, admitting that the alternative rules proposed in the literature "do not necessarily lead to the same decision" (Henson, Roberts, 2006). The first one is the *Kaiser's Criterion*, suggested by Guttman and adapted by Kaiser (Nunnally, 1978). Under this criterion, common factors are the ones with eigenvalue (amount of variance accounted for each factor) greater than one. The second one is the scree test of Cattell (1966)[3]. The third one concerns the total amount of variance explained by the extracted factors. If there is once again no absolute rule or precise threshold, it is generally admitted that the factors to be retained, are those which guaranty about 70-80% of the total variance.

The implementation of Factor Analysis allowed the extraction of three factors with the KMO Index up to 0.624, which is characterised as acceptable. As regards the interpretation of the three Factors, the results are summarized in Table 2.

- The first Factor (29.3%) consists of three variables and refers to the belief that the removal of pesticides contributes to the protection of Human health and the environment.
- The second Factor (22.5%) measures the "intensity of problems" faced by farmers this year compared to previous ones. The high positive value of the index means that the vast majority of farmers agree with the fact that they had more problems this year compared to previous ones. It is worth mentioning that the two original variables (V7 and V8) have almost the same weight (high load > 0.840).
- Finally, the third Factor (16.7%) is related to the subjective assessment of farmers with respect to this year's beneficial insect populations. In this case too, the two input variables have a considerable weight of about 0.810, indicating that the population of beneficial insects has been increased after the ban of coated cotton seed.

3. Willingness to use seed coated with neonicotinoids

The vast majority (over 80%) of the 605 farmers participated in this field research seem to prefer the use of cotton seed covered with neonicotinoid insecticides, regardless of gender and level of education (Table 3). On the contrary, age seems - to some extent - to differentiate their willingness to use such products, with young farmers to be more positive in using them, as compared to the older ones (60+). It is also worth mentioning that the adoption of cotton seed covered with neonicotinoid insecticides is associated with the annual income from subsidies. More specifically, 85%

[2] KMO takes values between 0 and 1. Kaiser (1994) considers that KM0 around 0.5 is miserable", while the sampling adequacy remains "mediocre" with KMO around 0.6. Above the value of 0.7, the solution is considered as satisfactory ("middling") while a KMO around 0.8 is "meritorious" and around 0.9 "marvelous".

[3] See Nelson (2005) for a detailed presentation of this test' implementation.

Table 3 - *Willingness to use cotton seed coated with neonicotinoids.*

Socio-economic Characteristics		(%) adoption of the product	Chi-Square	d.f.	p-value
Sample's Medium		81.2			
Gender	Male	80.8	3.987	2	0.136
	Female	85.1			
Age	≤ 40	85.1	4.987	2	0.075
	41-60	81.8			
	> 61	76.2			
Educational Level	Primary graduates	75.4	3.906	3	0.272
	High school graduates	80.2			
	Lyceum graduates	83.5			
	BSc graduates	83.0			
Subsidies payments	< 5000€	73.8	8.211	1	0.004
	≥ 5000€	84.0			

Source: Own calculation.

Table 4 - *MLR results.*

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
(a) Overall Assessment				
Constant	585.565			
Final model	547.440	38.127	6	.000
(b) Significance of Variables				
Age	550.733	3.293	1	.070
Id1. Withdrawal of insecticides protects both humans and environment	552.174	4.734	1	.030
Id2. Intensity of problems for the year 2015	551.262	3.822	1	.051
Id3. Subjective assessment about beneficial insects	547.441	.001	1	.976
Granular insecticides being used for seeding cotton are easier to use (V4)	559.212	11.772	1	.001
Income from subsidies	552.511	5.071	1	.024

of farmers receiving high subsidies (> 5,000 €) prefer such treatments, compared with 74% of the interviewees receiving subsidies below 5,000€. Financial support from EU is still partially tailored to the acreage being cultivated with cotton. This precondition was agreed back in the 1970s and it is referenced in Greece's accession Protocol in the EU. This is the main reason for the extension of this subsidy framework, because possible changes in the terms of this accession Protocol would jeopardise the whole cooperation agreement between Greece and the EU.

Based on these results, it is considered necessary to assess the actual impact of both major socio-economic characteristics of farmers and their attitudes towards pesticides as these were presented by the FA. To assess this, and given that the dependent variable is nominal, the assessment of the influence of the above explanatory variables is based on the use of Multinomial Logistic Regression (MLR).

The ratio between the number of observations and the number of explanatory variables is 100, which is higher than the desired limit of 20. Table 4 confirms the existence of a significant relationship between the explanatory variables and the willingness to use cotton seeds covered with insecticide (X^2 = 38.127 with p- value <0.001). This result ensures that all selected independent variables were statistically significant. In the same Table (2nd part), it is evident that the perception of usefulness as it was assessed by the FA, is not statistically significant (X^2 = 0.001 with p-value> 0.05) in contrast to the five remaining variables. Even when farmers have a high awareness about the utility of beneficial insects, it does not motivate them to use seeds coated with insecticide. This is indicative of the "praxis- orientation" of farmers' perception, at least in the case of cotton. Regarding age, apart from significant differences, farmers' opinions were notably varied. Conversely, the variable of income is highly significant. Finally, it is worth mentioning that the degree of simplicity of using granular insecticides affects the final farmers' decision about the use of coated cotton seeds.

The model summarized in Table 5 illustrates a number of significant results:

1. By increasing farmers' age by one year the possibility for using seeds coated cotton seeds is being decreased by 1.5% [1-exp (b) = 1-0.985]. The impact of age is limited, confirming that this variable is marginally significant.
2. The possibility to use seeds coated with insecticide (answer Yes) is being reduced by 0.597 for farmers with income from subsidies less than 5,000 € compared to farmers with higher income from the same source. This result confirms that farmers operating larger agricultural holdings are willing to use coated cotton seeds, compared to farmers with smaller farms.
3. The higher is their belief that the prohibition of using insecticides ensures the protection of humans and the environment, the lower is the probability to use coated cotton seed. By increasing the environmental awareness rate by one unit, the probability of use of coated cotton seed is reduced by 23.1% (exp (b) -1 = 0.769-1). The degree of awareness of the environment and human safety is therefore a determining factor.
4. The intensity of implementation problems they faced after emergence, motivate them to use coated cotton seed. For every point of increase of the degree of the problem, the possibility of using this type of seed is also increased by 23%. Hence, farmers acknowledge that the use of non-systemic insecticides may pose more risks for the cotton plants, early in the period, by sucking insects, and consider seed coating with a systemic compound a viable solution to this implication. In this regard, during the 2015 growing season, farmers, in general, faced more problems from infestations from these species than the previous year (2014).
5. Finally, as expected, farmers clearly reported that there are certain difficulties during the application of granular insecticides. In fact, the higher the impact of these difficulties, the higher the willingness to use the seeds coated with insecticide. One of the major risks that they recognize on the use of granular insecticides is the risks in human health, through handling of these insecticides during seeding.

Table 5 - *Assessment of the parameters of the Model.*

Dependent variable: willingness to use coated cotton seeds (a)	B	Std. Error	Wald	df	Sig.	Exp(B)
Constant	2.447	.451	29.449	1	.000	
Age	-.015	.008	3.270	1	.071	.985
Id1. Withdrawal of insecticides protects both humans and environment	-.263	.125	4.394	1	.036	.769
Id2. Intensity of problems for the year 2015	.208	.106	3.818	1	.051	1.230
Id3. Subjective assessment about beneficial insects	-.003	.110	.001	1	.976	.997
Granular insecticides being used for seeding cotton are easier to use (V4)	-.130	.038	11.424	1	.001	.878
Income from subsidies < 5000€	-.516	.227	5.187	1	.023	.597
Income from subsidies ≥ 5000€	0^b			0		

a. The reference category is 2 = No.
b. This parameter is set to zero because it is redundant.

Hence, indirectly, they do not see this risk in coated seed. This finding, in conjunction with (4) can be regarded as the willingness to use seed coated with systemic insecticide (not just an insecticide that is incorporated on the seed). Indicatively, an increase by one unit of the degree of convenience of using granular insecticide reduces the likelihood of turning to seed coated with an insecticide by 12% [exp (b) -1 = 0.878-1].

4. Conclusions

This survey illustrated the impact of the ban on neonicotinoids, particularly imidacloprid and thiamethoxam, in relation with the opinions about this ban of cotton growers in Central Greece. In the light of the present findings, there are serious concerns regarding the use of granular insecticides, which have been replaced seed coating during the last growing season. To our perspective, one of the most important findings of this study is that the farmers strongly believe that the application of granular insecticides endanger human health, and this belief was similarly expressed even from farmers' groups that have less environmental concerns. Moreover, during the last years, sowing machines in most cases were exclusively adjusted for use of coated seeds, and not for the application of granular insecticides during seeding. This may lead to possible failures during the application, in terms of both efficacy and safety.

Farmers strongly recognized a change in the problems arising from insect infestations on cotton. In this case, while they consider that granular insecticides are able to provide a satisfactory level of protection from soil insects, they consider that the same insecticides are not effective against sucking insects, such as aphids and thrips. Apparently, insecticides like chlorpyrifos are not able to control those insects early in the season, due to the fact that these AIs are not systemic. Moreover, practically, the cotton growers do not sufficiently see major changes in the beneficial insect fauna this season (2015), as compared to the previous season (2014). This is particularly important, as cotton growers in Thessaly, in their vast majority, are able to recognize the basic beneficial insect categories, i.e. bees, ladybirds etc., and, on some occasions, use their presence as an indicator to avoid leaf sprayings for sucking insects. Nevertheless, observations like this may not be reliable indicators of the actual presence of beneficials, including bees.

Interestingly, the perception of cotton growers in Thessaly regarding the use of coated seed is largely affected by other variables, such as the age of the farmer and the financial support that is received by EU. While the factors that affect this perception are poorly understood, there are hints that younger farmers tend to apply means that are easy to use, increasing in this way the efficiency of every application. This belief is strengthened when it is combined with the fact that larger agricultural holdings tend to prefer coated cotton seeds instead of granular insecticides, because the former are easier and safer to be applied in the existing sowing machines. On the other hand, environmental concerns are not analogous to the willingness to adopt coated seed. In general, farmers recognize that restrictions or even withdrawals of some AIs are compatible with environmental concerns, but they do not clearly relate these concerns with the withdrawal of neonicotinoids, as their willingness to use coated seed remains stable.

To our knowledge, this is the first report on the assessment of cotton growers' perception regarding the recent restrictions on the use of neonicotinoids as seed coating. Overall, the results of the present work clearly indicate that these restrictions did have an impact on farmers' opinion about the use of alternatives to neonicotinoids, especially in relation with human health and insecticidal efficacy aspects. While shaping the profile of this perception, we are unaware if the results from this survey, which was focused on one region, are transferable to other regions as well. Nevertheless, we estimate that some general conclusions regarding this perception can be drawn. Although this withdrawal also affects other crops that are cultivated in many parts of Europe, such as maize, we estimate that the impact is higher for Greece, given that the country is by far the major cotton producing area of EU, with considerable levels of annual exports of ginned cotton. Additional surveys are needed to estimate a wider variety of factors, such as other areas and crops. Finally, there is a need for implementing focused extension services, aiming to inform cotton producers about the pros and cons of the neonicotinoids use and present to them alternative ways of efficient and effective crop protection activities, having as targets to minimise their exposure to AIs and achieving satisfactory treatments of cotton pests.

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