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ORIGINAL ARTICLE

Farmers' attitudes towards common farming practices in northern Greece: implications for environmental pollution

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Abstract Common farming practices in intensive agriculture can be serious causes of water quality degradation, depending on the interaction between physical vulnerability of the farmland and farmers' behaviors in practicing farming. However, relevant information is highly limited in Greece. Farmers' attitudes and practices in the use of chemical fertilizers, pesticides, and irrigation water were explored in Serres region in northern Greece to understand behavior in practicing farming. The majority of the farmers considered that chemical fertilizers are harmful substances particularly to surface and groundwater and pesticides are highly harmful to human health. Most farmers showed high levels of awareness of the potential impact of farming practices on the environment, probably due to a combination of high experience in farming, adequate formal education, and valid sources of information. Farmers' compliance with most recommended practices showed high understanding of most components of conservation practices in fertilization, except from a void in the use of soil tests for better adjustment of the fertilization and in the use of organic fertilizers. Only a small fraction of farmers (4.4 %) were found to overuse fertilization, more often in sandy soils, but this practice was not accompanied by excessive use of irrigation water. As for pesticide use, farmers' compliance with most recommended practices showed high levels of rational use, except from the management of empty pesticide containers. None of the farmers overused soil pesticides with reference to application rates and frequency. Data provide key information for natural resource managers, relevant stakeholders, and local authorities to understand how farmers view their relationship to farming as well as how farmers practice farming. The collected evidence can serve as a valuable benchmark for future comparisons in Greece and possibly for comparisons with other areas of southern Europe. Tailored education programs that improve farmers' knowledge in fertilizing, pesticide use, and their impact on the environment can be a major step towards promoting sustainable farming and reducing potential environmental contamination.

Keywords Environmental awareness · Fertilization · Pesticide use · Survey

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Introduction

Modern agriculture was highly successful at increasing food production in the late twentieth century, with major increase of cereal yields in the USA and Europe for over 50 years, and also in Asia and Latin America since the 1970s (Pretty et al. 2001). However, increasing concerns over the impacts of modern farming practices on agricultural ecosystems and on the sustainability of arable systems have been evident, especially from the second half of the twentieth century (Stoate et al. 2001). Actually, farm management is a major driving force of land change and environmental degradation in the Mediterranean region, influencing ecosystem functions, processes and traits, especially through its impact on soil and water resources (Guerra and Pinto-Correia 2016). For example, the excessive application of both fertilizers and pesticides led to the frequent occurrence of nutrients and residues in water bodies, posing a potential threat to public health, increasing water infiltration costs, influencing fishery, and decreasing the perceived aesthetic value of water bodies (Tilman et al. 2002; Damalas and Eleftherohorinos 2011). The detrimental effects of modern agricultural practices on the ecosystem services underlie the necessity for more sustainable farming methods for food supply (Tilman et al. 2002).

The main impact of agriculture on the environment largely comes from the agricultural nutrients that pollute aquatic and terrestrial habitats as well as from pesticides, especially from highly persistent organic compounds. This kind of impact is commonly referred to as 'non-point' or 'diffuse' source pollution, because the pollutants have no obvious point of entry into receiving watercourses. Agricultural land use type has a direct impact on groundwater nitrogen (N) concentrations (Young and Briggs 2005). Globally, the application of N fertilizers has increased almost tenfold between 1950 and 2008 (Robertson and Vitousek 2009), but estimates showed that recovery in global cropping systems is around 50 % (Smil 1999). Nitrate leaching is an important N loss process in irrigated agriculture imposing cost both on the farmer and the environment (Quemada et al. 2013). The combination of coarse soil, shallow water table, humid climate, and irrigation leads to groundwater that is susceptible to NO_3–N pollution (Bruin et al. 2010). Moreover, some pesticide applications, especially the soil-applied treatments, contribute to chemical deposits in soil, which are carried through runoff and leaching into water bodies and groundwater (Guzzella et al. 2006).

At the field level, decisions for management practices are influenced by local factors, such as crop type and land management techniques, typically including the use of fertilizers and pesticides. Such decisions are normally meant to maximize the economic return to the farmers, given that the identity of many farmers is defined by high input and high output production systems for food, fibre, or fuel production (McGuire et al. 2013). However, other factors such as maximization or more long-term stabilization of the farm family income, long-term survival of the farm holding, and risk reduction have been reported among factors influencing farmers' decisions (Defrancesco et al. 2008; Lastra-Bravo et al. 2015). Many farmers hold strong views about maximising production from their land or are fearful of outside interference and loss of management control. This does not necessarily mean that conservation practices have to be profitable, but it is important that at least they do not cost anything to farmers. The importance of farmers' attitudes, beliefs, and perceptions, as well as personal values in promoting sustainable change of various forms has been widely recognized (Darnhofer et al. 2005; Damalas et al. 2006; Ajayi 2007; Stofferahn 2009; Damalas and Hashemi 2010; Hashemi and Damalas 2011).

Understanding factors that motivate farmers to perform conservation behaviors is seen as key to enhancing efforts addressing agri-environmental challenges. The complexity of farmers' decisions for being involved in conservation farming practices has been described as an internal analysis of the positive and negative impacts of participation in conservation efforts based on farmers' attitudes towards economic, environmental, social, and ethical aspects of the decisions (Schneider and Francis 2006). While the availability of financial incentives was identified as a factor in the adoption of conservation practices sponsored by federal programs, there is growing evidence that focusing solely on financial benefits fails to fully explain these decisions (Schneider and Francis 2006). Instead, efforts to model farmers' behavior are increasingly focused on understanding the role of farmers' values, beliefs, and attitudes that influence the decision making process (Sheeder and

Lynne 2011). Farmers' adoption of various agri-environmental measures in Greece has been studied since the 1990s (Vlahos and Beopoulos 2003) until recently (Kizos et al. 2010).

Obviously, farmers' attitudes and beliefs, as well as the local behavioural influences, have to be taken into account when designing and communicating agri-environmental measures. Most empirical studies provide insights into selected individual measures, but are incapable of providing results at a level relevant to decision-making, as they neglect the role of farmers (Uthes and Matzdorf 2013). However, an explicit understanding of farmers' values and perceptions of ecosystem services increases the likelihood of engaging their participation in behavioural change (Smith and Sullivan 2014). Moreover, farmers' willingness to participate in voluntary conservation programs is driven by psychological, financial and social factors and these need to be assessed on a case-by-case basis (Page and Bellotti 2015). However, policy-makers have a limited experience of farmers' response to environmental incentive schemes, particularly in the southern European Union member states (Defrancesco et al. 2008). Moreover, such information is rather limited in Greece. The specific objective of this study was to explore farmers' attitudes towards implementation of common farming practices (i.e., fertilization, pesticide use, and irrigation) and to provide some insights as to what farm and farmer characteristics may influence attitudes in common farming activities in the rural area of Serres. To the best of our knowledge, these issues have not been examined together by past research and therefore are worthy of consideration.

Materials and methods

Study area

The study was carried out in the rural area of Serres prefecture in northern Greece (Fig. 1). A considerable part (about 40 %) of the total land in this prefecture is arable, consisting of a big fertile plain crossed by the river Strymonas (Hellenic Statistical Authority 2011). The prefecture of Serres is a significant agricultural area of Greece and plays a key role in the agricultural sector of the country, with great advantage in producing agricultural products such as wheat, barley, corn, tobacco, cotton, rice, industrial tomato, and many others (Hellenic Statistical Authority 2011). As a result, the main occupation of most residents (about 55 % of the population) is related to agriculture and livestock farming (Hellenic Statistical Authority 2011).

Selection of sample

The study was carried out with 183 randomly selected farmers from the rural area of Serres in northern Greece. To cover a wide range of crops widely cultivated in the area and assure high representativeness of the sample, all municipalities of Serres region were purposively selected. These municipalities were: Serres, Amfipoli, Visaltia, Emmanouil Pappas, Irakleia, Nea Zichni, and Sintiki (Fig. 1). Thus, cluster sampling (municipalities) with small subsets (villages) was used to collect data. Members of the subset can be more easily identified, contributing to lower costs of the survey (Green et al. 2006). Potential participants for this project were approached independently considering their availability and their willingness to participate in the study. Participants were individuals who were engaged in agriculture and this was a necessary prerequisite for participation in the study. Overall, 300 farmers were enlisted from lists of farmers obtained from the local farm supplies stores in each studied area. Due to limited time for the project and total lack of financial support, a random sample of 200 farmers was drawn with replacement using an automatic random number generator in Microsoft Excel. Totally, 183 interviews were fully completed. The number of farmers interviewed in each municipality was: Serres (15), Amfipoli (20), Visaltia (41), Emmanouil Pappas (35), Irakleia (22), Nea Zichni (24), and Sintiki (26). Of the remaining names drawn, some farmers were unavailable at the time of the interview or some others provided incomplete information and were not included in the study. Based on the total number of the lists of farmers used in the areas surveyed, the sample of the study provided an error of 5.5 % [in estimation of percentages (%)] at 90 % level of significance, which was considered acceptable, taking into account the cost (e.g. budget limitations) and the available time (e.g. research deadlines) for this project. It should be noted, however, that the coverage of the survey is obviously low to allow a general estimation, e.g. at a national level, and therefore the

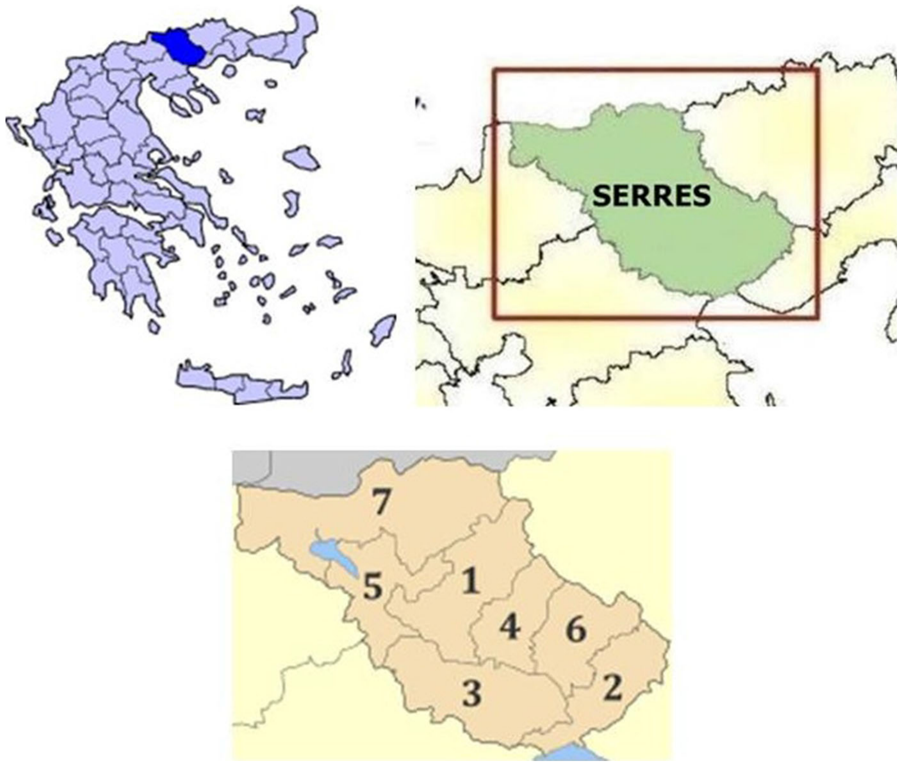

Fig. 1 Map showing the study area in northern Greece (municipalities: *1* Serres, *2* Amfipoli, *3* Visaltia, *4* Emmanouil Pappas, *5* Irakleia, *6* Nea Zichni, *7* Sintiki)

results cannot be considered representative of the country as a whole.

Data collection: process and instruments

The survey took place from October 2012 to April 2013. A four-page questionnaire was developed with 34 questions divided in five sections (Table 1). The first part included questions on the amount and application frequency of various fertilizer types as well as the source of information for fertilization practices; the second part included questions on the amount and frequency of pesticide applications in the soil (i.e., soil-applied herbicides, assuming much greater risk of contamination by herbicide application in bare soil than by foliar applications, where there is absorption by the existing vegetation), application rates used, criteria for selection of pesticides products,

Table 1 Overview of the questions from the questionnaire used

Data group	Description
1. Fertilization information	Types of fertilizers used; amount and application frequency; application method; sources of information about fertilization
2. Pesticide use and management	Pesticide products used in the soil; amount and application frequency; application rates; criteria for selection of pesticide products; sources of information about pesticide use
3. Irrigation information	Irrigation frequency; irrigation system; flow rate of irrigation pumps in hours per ha; source of irrigation water; sources of information about irrigation
4. Farm details and cropping systems	Type of crops; soil type of fields; cultivation techniques; cropping system (e.g. conventional farming, integrated crop management or organic farming)
5. Personal information	Gender; age; education; land ownership; hectares of land close to any type of water body; farm size; farming experience; main profession; professional satisfaction

and the source of information in relation to the application of plant protection products; the third part included questions regarding the number of irrigations (frequency) per growing season per crop, the irrigation system, the flow rate of irrigation pumps in hours per ha and finally the source of irrigation water. The specific types of fertilizers and pesticides used by farmers were recorded and the recommended rates of fertilizers and pesticides as well as the required (right) amount of irrigation water were calculated for each farmer based on the amounts of pesticide, fertilizer, and irrigation water used with respect to the cultivated crop and the soil type (also taking into account the irrigation system used). The fourth part of the questionnaire included questions on type of crops, soil type of fields, cultivation techniques and particular cropping systems (e.g. conventional farming, integrated crop management, or organic farming). The fifth and final part of the questionnaire included questions about the socio-demographic characteristics of farmers, such as gender, age, education, land tenure, arable land close to any type of water body, e.g. lake, river, stream or well, farm size, farming experience, main profession, and professional satisfaction. The questionnaire was designed based on published literature on related topics (Atari et al. 2009; Greiner et al. 2009), including also previous experience in the field from similar projects regarding the research methods and the particular research tools used (Damalas et al. 2006; Damalas and Hashemi 2010; Hashemi and Damalas 2011).

Data were collected through face-to-face interviews with each one of the growers from each household, usually at their farms. In few exceptional cases, there was a last minute cancellation of the scheduled appointment for interview by some growers. For not loosing additional participants, it was decided that these growers should be interviewed by phone. Validation of answers with the actual behaviour of those farmers was performed by contacting the local farm supplies stores in each studied area. No significant deviation was observed; thus, it was assumed that the interview of those farmers by phone did not affect the validity of the study. Although expensive, face-to-face interviews provide the highest response rates and are better suited to collecting complex information. To avoid any potential bias, it was made clear to the farmers that the study was only for academic research; in any case, an oral consent was obtained by each participant. The interviews were conducted in a friendly way and there was good cooperation with the growers without any refusals. With respect to awareness of practices regarding fertilization and pesticide use, farmers were asked to rate their level of implementation of common farming practices with 0 = no or 1 = yes. A percentage of compliance with recommended practices was then calculated for each examined practice. Validation of answers with the actual behaviour of farmers was performed by contacting the local farm supplies stores in each studied area to check about actual farming practices. In this context, the study was based on what farmers actually do and not only on what they say.

Data analysis

The raw data from the questionnaires were coded accordingly, entered into specially designed databases (Microsoft Access), and carefully checked for entry errors. Data were transferred to appropriate spreadsheets (Microsoft Excel) and SPSS for statistical analysis. Descriptive statistics (relative frequencies and means) were calculated for each categorical variable. Inferential statistics, i.e., Chi square (χ^2) for goodness-of-fit test and Spearman's rank correlation coefficient were additionally used (Norman and Streiner 2008). The Chi square for goodness-of-fit test is used for a single population and determines differences by comparing the observed frequency distribution (i.e., observed frequencies) with the frequency distribution of the null hypothesis (H_0) (i.e., expected frequencies), which assumes that the expected frequency distribution of all wards is the same (Norman and Streiner 2008). Differences were considered significant at $P < 0.05$.

Results

Basic demographic profile of farmers

The basic demographic background of the surveyed farmers is illustrated in Table 2. The majority of the farmers were men. Sixty-five percent of the farmers were in the age groups of high labor productivity up to 50 years. Thirty-five percent of the farmers were over 50 years of age. Based on educational attainment, farmers were grouped into five categories: illiterate or

Table 2 Basic demographic background of the farmers surveyed

Parameters	% of farmers
Gender	
Male	88.0
Female	12.0
Age (mean 46.6 years)	
Under 30 years	7.1
30–39 years	15.8
40–50 years	42.1
Over 50 years	35.0
Education (mean 9.7 years)	
No or primary education	28.4
Lower secondary education	23.5
Higher secondary education	41.0
Tertiary education (graduate)	5.5
Tertiary education (postgraduate)	1.6
Land tenure (mean 20.5 ha)	
Less than 1 ha	7.1
From 1 to less than 2 ha	4.4
From 2 to less than 4 ha	8.2
From 4 to less than 10 ha	26.8
From 10 to less than 20 ha	21.8
From 20 to less than 30 ha	6.6
From 30 to less than 40 ha	7.1
From 40 to less than 50 ha	8.7
From 50 ha and above	9.3
Farming experience (mean 21.9 years)	
Less than 10 years	14.8
From 10 to less than 20 years	30.6
From 20 to 30 years	27.3
More than 30 years	27.3
Main profession	
Agriculture	82.0
Other	18.0
Professional satisfaction	
Not satisfied	13.7
Hardly satisfied	25.1
Adequately satisfied	45.4
Considerably satisfied	10.9
Exceptionally satisfied	4.9
Cropping system	
Conventional agriculture	96.7
Alternative agriculture[a]	3.3

[a] Alternative agriculture: integrated crop management or organic agriculture

Table 3 Farmers' perceptions of the effects of chemical fertilizers and pesticides

Perception	% of farmers	
	Fertilizers	Pesticides
Harmful to water bodies	67.2	55.7
Harmful to commodities	18.6	30.6
Harmful to human health	47.0	71.6
No effect	14.8	14.2

Multiple answers were allowed; percentages of categories do not sum up to 100

primary school, lower secondary school, higher secondary school, tertiary education (degree from universities or technical institutes), and postgraduate education (Table 2). A great proportion of farmers (41.0 %) had received education at the level of higher secondary school, 23.5 % at the level of lower secondary school, whereas a solid fraction (28.4 %) reported that they were either illiterate or completed only the primary education. Some farmers (almost 7 %) had high levels of education (university degree or postgraduate diploma).

Most farmers were owners of the land under cultivation, whereas others were cultivating their own land along with some land under rental arrangement (data not shown). Farm sizes ranged largely from less than 1 to more than 50 ha per farmer, but most participants (almost 80 %) were professional farmers with quite large area under cultivation (Table 2). This is absolutely reasonable, given that the arable crops, which require large areas, override the orchards or the greenhouse crops in the area of Serres. Most participants were highly experienced farmers. Almost 85 % had at least 10 years of farming experience and a great proportion had more than 30 years of farming experience (Table 2). As for the main profession, the greatest part of the participants (82 %) was engaged in farming as their main occupation, whereas a sizeable proportion (18 %) was engaged in farming as a secondary occupation. With reference to professional satisfaction, most farmers (almost 61 %) were satisfied by their profession in agriculture with varying levels of satisfaction, whereas 39 % of farmers expressed low levels of professional satisfaction. Concerning cropping system, most farmers (96.7 %) were implementing conventional agriculture, whereas only a small fraction (3.3 %) was practicing alternative forms of agriculture, such as integrated crop management or organic agriculture (Table 2).

Farmers' perceptions, compliance, and sources of information

Most farmers had a negative perception of chemical fertilizers as well as of pesticides (Table 3). They felt that chemical fertilizers and pesticides are harmful to water bodies, commodities, and human health. In particular, the majority of the farmers supported that chemical fertilizers are harmful mostly to water bodies, whereas pesticides were perceived as highly harmful to human health. A countable proportion of farmers did not feel that chemical fertilizers and pesticides have any negative effect.

Farmers' compliance with most recommended practices showed high understanding of most components of conservation practices in fertilization (Table 4). The overall compliance for the tested fertilization practices was 63 %, showing that overall 63 % of the farmers had good knowledge about fertilization in their fields. The highest scores of compliance were found for the appropriate time of fertilization (100 %), the recommended amount of fertilizers used (96 %), the systematic crop rotation (95 %), and the incorporation of plant residues of previous crops into the soil (91 %). On the other hand, the lowest scores of compliance were found for the use of soil tests for better adjustment of the fertilization (4 %) and for the use of organic fertilizers (3 %).

As for pesticides, farmers' compliance with most recommended practices also showed high understanding of rational use (Table 4). The overall compliance for the reported pesticide use practices was 70 %, showing that overall 70 % of the farmers had good knowledge about pesticide use in their fields. The highest scores of compliance were found for pesticide application rates (100 %), the frequency of pesticide application (100 %), and the disposal of the surplus spray solution (92 %). Practically, almost all farmers were aware of the proper practices regarding these issues. On the other hand, the lowest scores of compliance were found for the collection of the empty containers of pesticides after use (3 %). Proper practices regarding this specific issue were unknown to most farmers.

Farmers reported various sources of information concerning fertilizers and pesticides (Table 5). The most important source for both farm supplies was the experts working in farm supplies stores. Also, a

Table 4 Farmers' compliance with recommended fertilization and pesticide use practices

Statement	Compliance (%)[a]
Fertilization	
Do you run a soil analysis (test) on a regular basis in your fields?	32
Do you consult a soil test for fertilization decisions in your crops?	4
Do you apply the recommended amounts of fertilizers in your crops?	96
Do you know of the appropriate time of fertilization in your crops?	100
Do you regularly check the status of fertilizer application equipment?	82
Do you use types of organic (non-synthetic) fertilizers in your fields?	3
Do you incorporate plant residues of previous crops into the soil?	91
Do you implement systematic crop rotation in your fields?	95
Overall compliance	63
Pesticide use	
Do you use soil-applied pesticides in your fields?	60
Do you apply the rates indicated on the product label?	100
Do you use the product with the frequency indicated on the label?	100
Do you dispose of properly any surplus of the spray solution?	92
Do you regularly check the status of the spraying equipment?	66
Do you collect the empty containers of pesticides after use?	3
Overall compliance	70

[a] Farmers were asked whether they implement (comply with) each practice (1 = yes) or not (0 = no)

Table 5 Sources of information for fertilization and pesticide use decisions

Source	% of farmers	
	Fertilizers	Pesticides
Agriculture offices of local authorities	1.1	0.5
Experts working in farm supplies stores	64.0	83.1
Private laboratories of soil analysis	4.5	0.0
Own experience	27.0	9.8
Other	3.4	6.6

χ^2 (fertilizers) = 142.9, $df = 4$, $P < 0.01$; χ^2 (pesticides) = 252.2, $df = 4$, $P < 0.01$

Table 6 Frequency of fertilization by method of application

Fertilization method/frequency	% of farmers
Soil-incorporated fertilization	
No soil-incorporated fertilization	8.7
Broadcast applied and soil-incorporated (once)	91.3
Broadcast applied and soil-incorporated (more than once)	0.0
Surface-applied fertilization	
No broadcast top-dressed fertilization	14.2
Broadcast top-dressed fertilization (once)	83.6
Broadcast top-dressed fertilization (twice)	1.6
Broadcast top-dressed fertilization (more than twice)	0.6

χ^2 (soil-incorporated fertilization) = 152.3, $df = 2$, $P < 0.01$; χ^2 (surface-applied fertilization) = 187.7, $df = 3$, $P < 0.01$

Table 7 Calculated extent of fertilization and irrigation overuse based on crop needs

Overuse extent	% of farmers
Fertilization	
Zero	95.6
From 1 to 10 %	0.0
From 11 to 20 %	1.1
From 21 to 30 %	1.1
Over 30 %	2.2
Irrigation	
Zero	89.7
From 1 to 10 %	1.8
From 11 to 20 %	4.3
From 21 to 30 %	2.4
Over 30 %	1.8

χ^2 (fertilizers) = 357.3, $df = 4$, $P < 0.01$; χ^2 (pesticides) = 303.8, $df = 4$, $P < 0.01$

sizeable proportion of farmers (27.0 %) relied on their own experience for the use of fertilizers, whereas a lower, but sizeable proportion (9.8 %) relied on their own experience for the use of pesticides. Other sources of information, especially the agriculture offices of local authorities, received much less attention.

Frequency of fertilization and extent of overuse

The majority of the farmers reported the usual practices of fertilization, consisting of broadcast spreading fertilizers on the soil surface and direct soil incorporation at the beginning of the growing season as well as broadcast spreading fertilizers on the soil surface during crop growth (Table 6). There were also some farmers that stated that they were not applying any fertilization in their fields. Concerning frequency, no significant deviation from the basic rules of fertilization was recorded.

When the fertilization was calculated based on the specific crop needs, it was revealed that the vast majority of the farmers (95.6 %) did not overuse fertilization in their fields (Table 7). Some cases of overuse in the fertilization amount were found by a small minority of farmers (4.4 %). Similarly, when the irrigation was calculated based on the specific crop needs, it was revealed that the greatest part of the farmers (89.7 %) did not overuse irrigation in their fields (Table 7). Some cases of overuse in the irrigation were found by a small minority of farmers (10.3 %). From the total cases of irrigation overuse, only one case was accompanied by simultaneous overuse of fertilization. This case concerned a conventional cropping system in a sandy soil near a river and the combination of overuse under these circumstances can be considered a potential case of significant water pollution.

Factors related to fertilization and irrigation overuse

There was a weak, but significant, relationship between farmers' age and overuse behavior both for fertilization as well as for irrigation (Table 8). The overuse behavior in fertilization was significantly correlated ($P < 0.05$) with advanced age (Table 8). However, the overuse behavior in irrigation was significantly correlated ($P < 0.01$) with young age (Table 8). Other factors such as education, land tenure, farming experience, and cropping system (i.e., conventional agriculture, integrated crop management, organic agriculture) did not show a significant correlation with the overuse behavior. Thus, excessive fertilization or irrigation by the farmers surveyed in this study could occur regardless of the level of education, the land tenure, the farming experience, and the cropping system.

Table 8 Factors related to fertilization and irrigation overuse

Factor	Spearman's rho	*P*	Significance
Fertilization overuse			
Age	0.157	0.034	*
Education	0.030	0.687	ns
Land tenure	−0.101	0.172	ns
Farming experience	0.009	0.905	ns
Cropping system	−0.039	0.597	ns
Irrigation overuse			
Age	−0.212	0.004	**
Education	0.071	0.338	ns
Land tenure	0.117	0.114	ns
Farming experience	−0.057	0.443	ns
Cropping system[a]	−0.059	0.428	ns

ns not significant

** Significant at $P < 0.01$; * significant at $P < 0.05$

[a] Cropping system: conventional agriculture, integrated crop management, organic agriculture

Discussion

Farmers of this study showed highly negative perceptions of fertilizers and pesticides with respect to their effects on water bodies, human health, and the environment. Similarly, Australian farmers clearly acknowledged that routine management activities that are inappropriately applied, e.g. agrochemicals, were the main drivers of ecosystem change (Smith and Sullivan 2014). The high environmental awareness of farmers or possibly the high levels of concern for public health issues and environmental quality derived by these negative perceptions appeared to be a discouraging factor for overusing fertilizers and pesticides by most farmers of the current study. The degree of trust to the industrial agricultural model may have played a role, but this issue was not examined in this study. Indeed, a sizeable part of farmers of the current study reported not using any fertilizers or pesticides in their fields, whereas most farmers reported using fertilizers and pesticides rationally, according to the standard agronomic practices. By contrast, a recent study of farmers' behavior in China (Yang and Fang 2015) revealed widespread fertilizer misapplication and highly variable application behaviours among farmers due to lack of knowledge on fertilizers and absence of guidance from extension services. Because farmers' perceptions may affect behavior (Damalas et al. 2006; Damalas and Hashemi 2010; Hashemi and Damalas 2011), lack of adequate information about farmers' perceptions has been a major constraint upon establishing effective approaches, principally for smallholder farmers. In the current study, a great proportion of farmers were aware that fertilizers can pose risk to water bodies and that pesticides can pose risk to their health. This evidence shows clearly that farmers' knowledge about the vulnerability of the environment to intensive use of fertilizers and of their health to intensive use of pesticides was high.

Farmers' compliance to most recommended practices showed high understanding of most components of conservation practices in fertilization and high understanding of rational use of soil applied pesticides. This could be attributed to a combination of high experience in farming, adequate formal education, and valid sources of information among the farmers surveyed that assured high environmental awareness of most farmers, without any financial incentives or participation to national conservation programs. Indeed, a great proportion of farmers (41.0 %) had received education at least up to the higher secondary school level, whereas some farmers (almost 7 %) had even higher levels of education. In addition, most participants were highly experienced farmers. Almost 85 % had at least 10 years of farming experience and a great proportion had more than 30 years of farming experience. Although a direct comparison is difficult, the results seem to support previous studies from southern Europe (Italy and Spain) regarding farmers' participation in agri-environmental schemes, where a tendency of participation was observed among elderly farmers (Borsotto et al. 2008; Defrancesco et al. 2008; Barreiro-Hurlé et al. 2010).

The most important source for both farm supplies (i.e., fertilizers and pesticides) was the experts working in farm supplies stores. Experience has shown that farmers prefer valid information about their management practices that can be easily and directly available to them when needed. Therefore, they preferred experts working in farm supplies stores as a common source of information that reflect both high validity and easy availability. This is not unusual, given that farm supplies stores in Greece are obliged by the current legislation to have scientists that are graduates of agricultural universities or technical institutes, a fact that assures an adequate level of knowledge about fertilizers and pesticides. However, this is may not be the case in other countries, where different sources of information, such as television, radio, neighbours, friends, and relatives, were reported as important sources of information for most farmers (Solano et al. 2003; Fawole 2008).

Farmers' compliance to most recommended practices showed a void in the use of soil tests for better adjustment of the fertilization and in the use of organic fertilizers as well as a void in the management of empty pesticide containers. Almost all farmers of this study were unaware of the proper practices related to these specific issues. Conservation farming practices are agronomically sound practices that protect water quality and are at least as profitable as the existing practices (Brouder and Gomez-Macpherson 2014). For example, newly designed alternative cropping systems have shown great potential to reduce N and water inputs and achieve sustainable use of groundwater, producing similar grain yields to the conventional double-cropping system (Gao et al. 2015). However, farmers' ignorance of their existence or possible misperceptions of their effectiveness may result in reduced adoption rates of these practices. An effective alternative is to implement programs that educate farmers. These programs are essentially informational incentives because they encourage adoption by revising farmers' perceptions of the cost effectiveness and usefulness of the new farming practices. Although fixed start-up costs are incurred, informational incentives may be less costly than financial incentives in the long run as information spreads throughout the farm. However, the various forms of education and training on relevant alternatives should be adjusted to growers' needs and preferences as suggested elsewhere (Hashemi et al. 2009).

Also, in the current study, overuse of irrigation by 10.3 % of farmers was revealed. Over-irrigation, in the case of surface irrigation, may trigger nutrient/chemical runoff, but can also cause perched water tables resulting in serious soil salinity problems (McKergow et al. 2003). It should be noted, however, that the percentage of overuse behavior in the current study was quite low for the fertilizers and zero for the pesticides; therefore, the possibility for nutrient/chemical runoff was indirectly estimated to be rather low. Only one case of over-irrigation was accompanied by simultaneous overuse of fertilization in a conventional cropping system in a sandy soil near a river, which can be considered a potential case of significant water pollution. With reference to factors that could affect the overuse behavior of farmers in fertilization and irrigation, several factors were taken into account. However, except from age, no other factors were significantly related with the overuse behavior. The overuse behavior in fertilization was significantly correlated with advanced age of farmers, probably because the elderly farmers have fewer sources of information for fertilization and tend to rely more on their own experience compared with the young farmers. A sizeable proportion of farmers of this study (27.0 %) relied on their own experience for the use of fertilizers. On the other hand, the overuse behavior in irrigation was significantly correlated with young age, probably because the young farmers are less experienced and tend to fear more of crop damage and yield losses by the lack of water compared with the elderly farmers. However, both these issues require further and more thorough investigation.

Adoption of innovative practices is influenced by the characteristics and circumstances of farmers as well as the characteristics of the practice, especially its relative advantage over existing practices and landholders' ability to trial the practice (Pannell et al. 2006). Farmers adopt an innovation if they expect that the practice will help them achieve their personal goals, which may include economic, social, and environmental goals. Farmers make land-use decisions not only in a business context (product prices and input costs), but also in a personal context. The personal context refers to intrinsic motivations for decision making (Ingram et al. 2013) and relates to individual and social conditions in which farmers operate, farmers' capabilities, such as knowledge, skills, and power, as well as psychological dimensions. Financial incentives, such as cost sharing or tax exemptions, where governments 'share' in the risk of adoption, are common methods for overcoming the negative perceptions. Normally, these types of incentives are costly, especially if the adoption depends primarily upon farmers' perceptions. Farmers can be motivated to adopt conservation practices by both financial and personal/attitudinal considerations that are not directly related to profit and financial capacity considerations (Sheeder and Lynne 2011). While financial motives appear as the primary driver of the adoption of conservation practices, there are works showing that other, non-financial, factors can play a role in the conservation decision made by farmers (Atari et al. 2009).

While it is well known that the river basin of Strymonas is classified as a vulnerable zone to nitrates (Mielach et al. 2012) and a local action plan is implemented, farmers in the current study did not participate in such plan and did not receive any financial assistance to use the specific farming practices. Therefore, farmers' behaviors of this study were not motivated by financial benefits. These results are consistent with previous studies that farmers' decisions can be affected by non-financial motivations when it comes to conserving the environment (Greiner and Gregg 2011). It seems that personal interest in environment and a sense of social responsibility of farmers played a role. Farmers feel strongly connected to nature, more than other population groups, because they often consider themselves as 'producers' of nature in the sense that they shape the landscape and make it productive (Kohler et al. 2014). Social responsibility refers to the responsibility of farmers for their impacts on the environment and the society, in which they are embedded, beyond their economic impacts (Mazur-Wierzbicka 2015). Because social responsibility could contribute to improving the image of farmers as perceived by stakeholders, as well as bringing notable economic, social, and environmental benefits (Mazur-Wierzbicka 2015), it could be consisdered as a possible explanation for farmers' attitudes of this study. Obviously, being a farmer is not simply a profession, but rather a way of life and thus money is not all that matters; quality of life and independence are also important. The findings of this study are in line with those of previous studies which suggest that farmers consider themselves as important stakeholders in the management of natural resources and generally perceive ecosystem services as important for productivity and sustainability (Smith and Sullivan 2014; Page and Belloti 2015).

This survey provides a view of farmers' attitudes towards implementation of common farming practices and the extent of their potential impact on water bodies in the rural area of Serres, based solely on information from farmers. Validation of answers with the actual behaviour of farmers through the local farm supplies stores in each studied area revealed no significant deviation, so the study captured what farmers actually do and not only what they say. The aim of the survey was primarily descriptive with a view to an assessment of farmers' environmental awareness in farming in the rural area of Serres. The sample was completely random and sufficient to be considered representative for the average farmer in the studied areas. Findings were not confirmed (cross-checked) by any pesticide, fertilizer, and irrigation water precise measurements or any published data from Greece. As with all site-specific studies, the variables that are significant in this study may not be replicable in other areas, given that few variables can be applied to all areas (Tosakana et al. 2010). This makes the task of policy management difficult. Thus, continuous assessment and review are of major importance to keep in touch with the intent and sensitivity of the farmers being targeted with conservation programs.

Farmers interact with a range of actors and multiple sources of information, so that no single approach or strategy for influencing their perceptions and behaviour is likely to be sufficient. Measures that could facilitate farmers' perception of ecological benefits and increase their energy for ecological conservation should be considered by policy makers. However, any attempts to influence farmers' behaviour need to take into account the development and communication of salient messages that farmers can easily to respond to. Most farming communities are usually heterogeneous and any advice needs to be tailored to farmers' different needs. On the other hand, most stakeholder processes tend to include 'farming' as a single category of interest, but it would be useful to explore which kinds of farmers are represented and how their attitudes influence farmer to farmer transmission of information and advice. It is important that policy recognizes that different policy tools can work quite differently for different farmers. Therefore, policy design can be effective when adapted well to local conditions, tries to identify a mix of complementary policies, and is targeted at key system variables that affect land-use practices. Existing knowledge gaps as well as decisions regarding who should mitigate these issues are still a matter of debate. Extension services could be highly effective, especially in case of new practices, although public agents need not be the exclusive providers of such services.

Conclusions

In this study, farmers' attitudes towards implementation of common farming practices and the extent of their potential impact on water bodies were explored in the rural area of Serres. Most farmers showed high levels of awareness of the potential impact of farming practices on the environment, high understanding of most components of conservation practices in fertilization, and high understanding of rational use of soil pesticides. This was probably due to a combination of high experience in farming, adequate formal education, and valid sources of information. None of the farmers received any financial assistance to use the specific farming practices. It seems that personal interest in environment and a sense of social responsibility of farmers played a role. Data capture general trends of farmers' behaviours in common farming practices in the area of Serres and identify gaps in farmers' knowledge relating to common farming practices.

Overall, the study provides key information for natural resource managers, relevant stakeholders, and local authorities to understand how farmers view their relationship to farming as well as how farmers practice farming. This information is critical for agricultural land operators whose actions greatly affect the health of both terrestrial and aquatic ecosystems. Also, this information provide policy makers with useful insights regarding farmers' orientation and behaviour in a specific environment as well as on the supporting or restraining role of the different regulations and policy measures on the effect of farmers' behaviour in future interventions. The collected evidence could be a valuable benchmark for future comparisons in Greece and possibly for comparisons with other areas of southern Europe.

Tailored education programs that improve farmers' knowledge in fertilizing, pesticide use, and their impact on the environment can be a major step towards enriching farmers' knowledge in practical issues of common farming practices and thus promoting sustainable farming as well as reducing potential environmental contamination. This could be accomplished by holding various classes or daily training courses on the field, especially tailored for young and inexperienced farmers to increase their knowledge of conservation farming practices. Creating and strengthening farmers' cooperative associations could be an effective step for increasing knowledge of conservation farming. Also, strengthening farmers' co-operation with agricultural offices of the local authorities could be another major step for further increasing the adoption of conservation farming practices in the study area.

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