Understanding Pesticide-Use Decisions. Case study: European apple production

Wie erklären sich Entscheidungsverfahren des Pestizideinsatzes im Europäischen Apfelanbau

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Zusammenfassung

Mit der Erklärung von Entscheidungsverfahren des Pestizideinsatzes können die Bestimmungsgründe verschiedener Pflanzenschutz-Strategien, die in Europäischen Anbausystemen angewendet werden, identifiziert werden. Der dynamische Kontext (Motivationen und Kenntnisse) der Pflanzenschutzstrategien wird beschrieben, sozioökonomische Faktoren, welche die Entscheidungen zum Pestizideinsatz beeinflussen, werden identifiziert und Bestimmungsgründe des Pestizideinsatzes werden festgestellt. Unsere Ergebnisse weisen darauf hin, dass sozioökonomische Faktoren, welche die Pflanzenschutzstrategien beeinflussen, an Produktsicherheit ausgerichtet sind. So ist das Konsumentenrisiko für Pestizidrückstände geringer. Außerdem wird begründet, dass klimatische Bedingungen und die Verfügbarkeit von effektiven Instrumenten für die direkte Bekämpfung der Krankheiten und Schädlingen die Bestimmungsgründe verschiedener Pestizideinsatztendenzen sind. Für die Umsetzung der neuen Europäischen Richtlinie über die nachhaltige Nutzung der Pflanzenschutzmittel wurden zwei politische Möglichkeiten festgestellt.

Schlagworte: Sozioökonomische Bestimmungsgründe der Pflanzenschutzstrategien, Nachhaltige Nutzung der Pflanzenschutzmittel, Institutionalismus

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Summary

Understanding pesticide-use decisions is a study intended to explain different patterns of farming systems utilised in European agriculture, which are defined in terms of pesticide use attributes. In this investigation motivational and knowledge systems related to crop protection are described, socio-economic factors affecting decisions about the use of pesticides are identified, and driving forces behind pesticide-use attributes are drawn. Our research shows that socio-economic factors affecting crop protection strategies are mainly oriented to guarantee reduction of consumers' risks from pesticide residues; while, climatic conditions and availability of effective technical options are explanatory factors for the different pesticide use patterns. Two policy options for the implementation of the New Framework Directive on Sustainable Use of Pesticides are elucidated.

Keywords: socio-economic driving forces in crop protection, sustainable use of pesticides, institutional economics

1. Introduction

Crop protection strategies are aimed at preventing crop losses generated by the action of pests, diseases and weeds (STRUIK and KROPFF, 2003). Given the increased demand for agricultural produce and the need to maintain levels of productivity (VON WITZKE et al., 2008), crop protection strategies are essential for the practice of agriculture today. The use of pesticides is an effective tool of crop protection strategies; however, it is subject of much debate due to its potential externalities (e.g. human toxicity, environmental impacts).

The evaluation of alternative methods and new technologies of crop protection has demonstrated the viability of innovative strategies which are less reliant on pesticide use (ENDURE[1], 2009). Besides developing such strategies, however, scientific research should furnish instruments supporting their implementation. The analysis of socio-economic driving forces of crop protection therefore becomes relevant.

[1] European Network for the Durable Exploitation of Crop Protection Strategies. http://www.endure-network.eu

In our research, a theoretical framework related to the decision-making process is utilised to describe the dynamic context of crop protection strategies (i.e. motivational and knowledge systems); socio-economic factors affecting pesticide-use decisions are identified; and explanatory reasons behind the patterns of two pesticide use attributes are drawn.

2. Theoretical Framework

According with the precepts of the New Institutional Economics school of thought, rational decision-making requires knowledge and a choice between alternatives, and is influenced by motivations (KASPER and STREIT, 1998). Institutional analyses may be focused on understanding the role of rules in shaping human behaviour. In particular, a set of elements (i.e. rules in use, nature of the community, physical world) should be identified to explain a human action (OSTROM, 1998)
The attributes of crop protection strategies are empirically investigated through examining the logic of the growers' decisions about when a pesticide treatment is needed, which product should be applied and its dosage. The incentives created with regulations implemented in the fruit growing sector are also explored.

3. Material and Methods

3.1 Data collection

Four apple-growing regions are selected from a classification of agricultural systems implemented in the European production of fruit trees. In this classification, crop protection strategies are defined by two pesticide use attributes: the quantity and the type of pesticides applied. The former is expressed in terms of active ingredients applied per hectare. The later indicates the average hazardousness of those active ingredients; for that, ratings are assigned to their intrinsic properties (e.g. toxicity for humans) (HERNANDEZ and MANN, 2008). Each case-study region represents one particular type of crop protection strategy. The case-study regions are listed in the Table 1.

Tab. 1: Case-study regions

Pesticide Use	Low Innovation	High Innovation
High Intensity	Emilia-Romagna (Italy)	Lake Constance (Germany)
Low Intensity	Lerida (Spain)	Kent (United Kingdom)

Empirical material was collected via semi-structured interviews with stakeholders influencing pesticide use decisions (i.e. farmers, public and private advisers, pesticide dealers, representatives of certification agencies, growers' associations, fruit retailers, public agencies and agricultural research centers). The interviews, which were recorded, covered the following topics: who makes pesticide use decisions, motivations behind pesticide use, knowledge and perceptions about pesticide use, choosing pesticide products, non-chemical strategies of crop protection. In 32 interviews, 40 stakeholders were interviewed: 16 in Spain, nine in England, eight in Italy and seven in Germany.

3.2 Data analysis

With the purpose of drawing conclusions or generalising the empirical material into a higher level of abstraction (FLICK, 2006), techniques of qualitative analysis such as clustering, summarising, and building a logical chain of evidences are carried out. The concepts developed from the empirical material are continuously assessed against the data and modified where necessary (MAYRING, 2004). The empirical findings are confronted to the issue of validity. In particular, the empirical material' representativeness is checked and the empirical inferences are confirmed. The quality of the findings is also judged. For that, the consistence of the research process is verified, the dependence of the conclusions on the subjects and conditions of the inquiry is evaluated, the logic of the concepts is proofed, and the theoretical transferability of the concepts is confirmed (MILES and HUBERMAN, 1994).

4. Results

4.1 Dynamic context of crop protection strategies

It was found that the motivational aspects related to crop protection strategies and subsequently to pesticide of pesticide-use decisions are guided at the operational (farm) level by economic aims (i.e. to make a profit). At the collective-choice level, the endeavour of the fruit growing industry is related to guarantee food safety (i.e. to reduce levels of reportable pesticide residues).

It was recognised that apple growers own well developed knowledge of pest and disease problems for the design of crop protection strategies. In particular, public authorities and the fruit growing industry foment the use of thresholds of treatment for the control of key insects and the use of prognosis models for the protection against the most common diseases. It implies that the design of crop protection strategies takes into account specific characteristics and conditions of each fruit-growing region. Indeed, the use of decision support systems and the coverage of the advisory networks are significant in all case-study regions[2].

4.2 Socio-economic factors affecting pesticide-use decisions

Strategic choices of apple growers are one factor affecting pesticide-use decisions. Apple growers are likely to apply pesticide products that are recognised for being effective in avoiding crop losses, do not generate problems for fruit trade (e.g. due to pesticide residues in fruits), and represent a competitive advantage in terms of costs.

Conditions for the trade of fresh apples are other factor affecting pesticide use decisions. The strategic choices of apple growers should fit with specific standards of fruit quality (e.g. size, shape, colour and tolerable levels of damage) and market access requirements (i.e. implementation of good agricultural practices in crop production and compliance with maximum pesticide residue levels in fruits).

In the case-study regions, retailing apples through supermarkets corresponds to the largest channel of trade[3]. In this case, the implementation of good agricultural practices is certified by means of private schemes or standards (e.g. GlobalGAP, the most widespread standard in Europe). Tests of pesticide residues in fruits are carried out

[2] An indicator of the coverage of advisory networks may be associated to the area under fruit production being assisted, which corresponds to 66% in Lerida, 60-65% in Emilia-Romagna, circa 84% in Lake Constance, and at least 85% in Kent.

[3] In the Lake Constance region, 84% of the area under apple production is directly linked to supermarkets and their commercialisation chains. While in the United Kingdom, 85% of the apple production is traded through supermarkets.

by regional authorities (officially in charge of monitoring plans), fruit retailers (i.e. supermarkets), food industry companies, marketing organisations, and growers' associations. The participation of several actors in the control of pesticide residues indicates the importance of guaranteeing safety for fruit consumers. Some supermarkets have established stricter limitations to pesticide residues in fruits than those allowed by law (see Regulation EC no. 394/2005). These restrictions include[4]: acceptable residue levels between 33 and 80% below to the maximum pesticide residue levels legally tolerated, restriction to the number of different active substances detected in fruits (between 3 and 5), non excess of the acceptable daily intake and the acute reference dose and prohibition for the use of certain products.

The implementation of instruments of agricultural policies (e.g. cross compliance and rural development) is another factor affecting pesticide use decisions. The apple production is supported with these instruments by enhancing the competitiveness of growers and also by addressing the sustainability of farming systems. These instruments include investments in machinery, financial support for labour and advice as well as stimulus to producers' organisations and thereby reinforcement of the fruit supply.

4.3 Driving forces of pesticide-use attributes

The high vulnerability to diseases together with the logic behind tactical choices explains the higher intensity in the use of pesticides. According to the opinion of the stakeholders interviewed, in Emilia-Romagna and Lake Constance, in addition to apple scab (*Venturia inequalis*), the most common disease in European apple production, the potential occurrence of fire blight (*Erwinia amylovora*) is of high significance because of the climatic conditions. In crop protection, the tactical logic is grounded on the common understanding that diseases are prevented and pests are controlled. A treatment with fungicides is recommended when the potential risk of disease infestation is forecasted. That potential risk is estimated with help of models that simulate the epidemiology of the disease in function of the

[4] According to information published by the pesticide Action Network Europe http://www.pan-europe.info/Resources/Factsheets/Supermarkets.pdf

temperature, humidity and precipitation, and field inspections in which the presence (or not) of disease inoculums is observed. Applications with insecticides are recommended once, it is verified that the pest occurrence exceeds a pre-established threshold (e.g. number of captures of male insects in pheromone traps) and the conditions of temperature and moisture are ideal for the reproduction of that specific insect (GARCIA DE OTAZO et al., 1992). It implies that in a growing season, the average number of treatments with fungicides is larger than the number of treatments with insecticides[5].

The low innovation in the use of pesticides is explained with the high pressure of insects, technical limitations in the use of non-chemical mechanisms of control and restrictions to the use of chemical products. Due to the climatic conditions, in Emilia-Romagna and Lerida the relevance of the codling moth (*Cydia pomonella*)[6], the most common pest in European apple production, is high. Three technical limitations in the use of non-chemical mechanisms of codling moth (*Cydia pomonella*) control were identified in Lerida. The use of matting disruption devices is an effective technique to control the first generation of the insect, but the use of synthetically derived insecticides is still required for the control of the second and third generations of the insect. The applications of granulose virus are negatively affected by the high temperatures and the strong solar radiation (in hours of exposure and intensity), since the product is easily evaporated. The massive (communal) implementation of sexual confusion techniques and field borders' controls is discouraged by the structural attributes of the factors of production (i.e. small orchards located away from each other), as the pest control effectiveness declines. Given that the use of non-chemical methods of control is limited, the dependence on pesticides (chemical control) increases. This dependence and the fact

[5] According to data collected in the Network of Excellence ENDURE, experts on crop protection estimated the following average number of treatments per growing season in apple production: 26 with fungicides and 9 with insecticides in Lake Constance; 24 with fungicides and 10 with insecticides in Emilia-Romagna; 10 with fungicides and 8 with insecticides in Lerida; and 14 with fungicides and 6 with insecticides in Kent.

[6] Experts on crop protection estimate that the average number of generations of codling moth (*cydia pomonella*) in an apple growing season is of: 3 in Lerida, 2-3 in Emilia-Romagna, 2 in Kent, and 1-2 in Lake Constance.

that the fewer approved insecticides should be alternated to avoid problems of pest resistance constrain the selection of pesticides. In particular, negative externalities for human health and the environment can be hardly taken into account. In the last two decades, the amount of active substances authorised in the European Union has been markedly reduced as a result of a review programme included in the Directive 91/414/EEC. Although this review encourages the development of pesticides with fewer toxic effects (OLLINGER and FERNANDEZ-CORNEJO, 1998), a strict criterion on toxicity and environmental hazard triggers has been included for the approval of active substances in the New Framework Directive on Sustainable Use of Pesticides. Experts on crop protection have identified potential negative consequences of implementing that cut-off criterion. For instances, the Pesticide Safety Directorate of the United Kingdom calculated that 68% of the insecticides, 31-34% of the fungicides and 25-31% of the herbicides could fail in the re-approval. According to information published by the IRAC[7], one strategy to avoid insecticide resistance problems is to alternate the chemical classes of insecticide that are applied.

5. Conclusions

In what the apple production respects, a homogeneous institutional framework affecting the decisions about the use of pesticides is in force at European level. The norms-in-use shaping the design of crop protection strategies give priority to fruit safety standards (i.e. to reduce the level of reportable pesticide residues in fruit) over using all available tools and techniques of crop protection. For instances, the apple varieties cultivated to the largest extent[8] in the case-study regions are characterised by high susceptibility to apple scab (*Venturia inequalis*) in .contradiction to the basic recommendation of technical

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[7] Insecticide Resistance Action Committee. http://www.irac-online.org

[8] Golden Delicious in Lerida, Gala in Kent, Jonagold in Lake Constace, and Fuji in Emilia-Romagna.

guidelines of integrated fruit production (e.g. IOBC[9]) to grow apple varieties with resistance to common diseases and pests.

Considering that in the New Directive for Sustainable Use of Pesticides (Com 373/2006/EC) is established that from the year 2014 all the agricultural production in the European Union should be performed under principles of integrated production and Member States should define the objectives and mechanisms of control, two options for policy-makers are identified. One option is to set as main objective of integrated production the reduction of pesticide residues on fruit, as the self-regulation system of the apple-chain does; it would imply that the role of public institutions is to verify that barriers of trade are not implemented and also that the information is trustful. The other option is to set other objectives (different than reduction of pesticide residues in fruit), as for instance the reduction of pesticide load; then, the role of public authorities would be to guarantee the implementation of the basic principles, which means a similar task as that performed by fruit-traders in the self-regulation of the apple-chain; this process may be expensive and demanding in terms of institutional capacity.

Local knowledge is a key element in the design of crop protection strategies. In particular, regional adapted information is useful to manage the incidence of these physical and material factors that at the end determine the differences in pesticide use attributes levels. In fact, the pest control is improved when the effectiveness of chemical products under the regional conditions is known; thresholds of treatments for emerging pests are calculated; the activity of beneficial organisms is fomented (e.g. in Kent the *Typhlodromus pyri* is employed to control the rose aphid (*Disaphis plantaginea*)). Likewise, better efficacy in the use of pesticides is attained with improvements in techniques and equipments of application (e.g. in Kent dosages are adjusted according with the structure of the orchard (i.e. plant density or plant high) and the characteristics of the sprayer[10]).

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[9] International Organisation for Biological and Integrated Control of Noxious Animals and Plants. http://www.iobc.ch

[10] Under the PACE programme (Pesticide dose Adjustment to the Crop Environment) reductions of even 75% of the recommended dosage have been reached without putting in risk the production of commercially accepted fruit http://pjwrc.co.uk/DoseRateCalculator.aspx

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