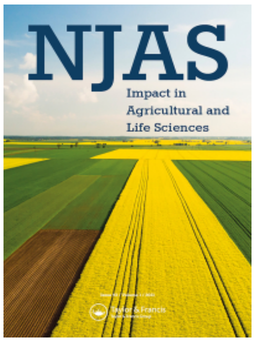

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A comparison of explicit and implicit attitudes towards crop protection methods in Costa Rica and Germany

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ABSTRACT
Crop protection technologies and their usage are critically discussed issues, both in the public discourse and within the agricultural sector. However, attitudes towards different methods of crop protection have been primarily investigated through surveys thus far. Thus, explicit attitudes can be biased. Furthermore, they can differ between countries. The study aims to contribute to the understanding of explicit and implicit attitudes of two crop protection methods (chemical and genetically modified crop protection) in Costa Rica and Germany. The implicit attitude was measured by a single-category implicit association test. The test was conducted with a total of 441 agricultural students: 208 from Costa Rica and 233 from Germany. The results argue for regional heterogeneity in attitudes towards crop protection methods as genetically modified crop protection is perceived more positive in Costa Rica than in Germany. This might impact the regional acceptance of multilateral policies. The results also highlight the importance of the method selection for the elicitation of attitudes.

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KEYWORD Agriculture; crop protection; implicit association; explicit association

1. Introduction

Managing pests is a nessecity in all types of arable farming. In the past decades, many advances were based on the usage of chemical crop proctection and genetically modified (GM) crop protection. Chemical crop protection refers to the direct application of chemically synthesized agents on the crop plants, while GM crop protection utilizes methods of genetic engineering in breeding, which induces (i) resistance against chemical agents (which enables the application of inexpensive herbicides) or (ii) the production of antibodies

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against insect infestations by the plant itself (Scursoni and Satorre, 2010; Tefera et al. 2016). While being widely applied in many countries and production contexts, both approaches have been subject to substantial debate.

Concerning chemical crop protection, critiques address environmental concerns and potential (human) health threads. An example for the environmental concern is the loss of biodiversity due to the usage of neonicotinoids (see Van der Sluijs et al. (2015) for a review). With respect to health concerns an intense debate exists about the carciogenic potential of glyphosate in the European Union (EU), which was stimulated by conflicting evaluations (cf. Mink et al. 2012; IARC 2017; ECHA 2017). Additionally, unsound usage of chemical plant protection can increase selective pressure on pests, leading to agronomic issues due to increased pesticide resistances (cf. Hawkins et al. 2019). GM crop protection is also part of a controversial debate, which originates not only in ethical concerns (Gregorowius et al. 2012) but also contradictory findings and evaluations in the literature (Hilbeck et al. 2013; Jacobsen et al. 2013; Klümper et al. 2011; Nicolia et al. 2014; Phipps and Park, 2002; Spök et al. 2005; Qaim et al. 2013).

As a result of these debates, many societal actors like environmental NGOs argue that farming practices need to change. Here, knowledge of the farmers' perspective is important. Policy makers can aim to influence practices through changes in incentive structures, but except in the case of explicit bans, the farmer remains the final decision maker. Thus, understanding factors influencing the decision-making process, like the attitudes towards the issue at stake, plays an important role to design efficient policies. Attitudes are generally assumed to influence an individuals intentions and subsequently their actions, e.g. in the theory of reasoned action (Ajzen and Fishbein, 1980) and theory of planned behaviour (Ajzen 1985). This role of attitudes (and other behaviour factors) have been acknowledged in the agricultural economics literature for a long time (e.g. Willock et al. 1999, see Dessart et al. (2019) for a recent review).

When studying farmers' attitudes towards different crop protection methods, previous research has primarily investigated attitudes using explicit attitude measurements (McNeil et al. 2010; Popek and Halagarda, 2017; Remoundou. et al. 2015). These explicit attitudes can be communicated directly and captured by surveys. Thus, they can also be controlled deliberately and adjusted or misreported due to perceived social desirability (Mather et al. 2012), which can bias the results of such surveys (Dimofte 2010; Echebarria Echabe 2013; Greenwald and Banaji, 1995). In contrast to explicit attitudes, it is possible to measure implicit, subconscious attitudes, which cannot be controlled by an individual and leaving them unaffected by potential social desirability biases (Greenwald et al. 1998). While implicit attitudes have been widely studied in the psychological literature (Nosek 2007), the literature with respect to agricultural practices is scarce. With respect to crop protection methods, Römer et al. (2019) study the implicit and explicit attitudes of students of agricultural sciences and the general public. The authors find differences between explicit and implicit attitudes. Also, these attitudes are either uncorrelated or only weakly correlated for the different crop protection methods, which indicates that the explicit attitudes have limited use as proxies for the implicit attitude. Still, this research was only focussing on one European country. As public debates, legal frameworks and production techniques differ worldwide, these results may not be generalizable to other (Non-European) contexts, especially in developing countries.

The objectives of this paper therefore are as follows: (i) to investigate the explicit and implicit attitudes towards different crop protection methods, (ii) to contrast the absolute attitudes in Costa Rica with Germany, and (iii) compare potential inter-country biases in reporting attitudes. Following Römer et al. (2019), this is done using an online test with agricultural science students from Costa Rica and Germany. The underlying methodology to estimate the implicit attitude is the single-category implicit association test (SC-IAT), a modified version of the original implicit association test (IAT) (Greenwald et al. 2003; Karpinski and Steinmann, 2006). The explicit attitude is measured using a standard survey technique.

By focussing on a comparison of the attitudes within the agricultural sectors of two countries, Costa Rica and Germany, this study aims to extent and complement previous research by Römer et al. (2019). Given the contextual differences with respect to the usage and legal restrictions of GM crop production as well as the usage of pesticides in the two countries (which can be at least partially generalized to Latin America and the EU), this comparison allows further insights into the relationship of farmers attitudes towards crop protection methods.

The structure of the remainder of this paper is as follows: the next section discusses differences between the situation around crop protection methods in Costa Rica and Germany, which lead to the hypotheses of the paper. This is followed by a description of the study design. The data as well as the approach for data analysis is presented in section 4. The results are presented and discussed in section 5. The paper ends with conclusions.

2. Chemical and GM crop protection: The situation in Costa Rica and Germany

The legal situation, adoption of, as well as public discourse around chemical and GM crop protection substantially differs between Costa Rica and Germany. Some important differences are outlined in the following.

While Costa Rica has a long history of sustainability protection policies and a green culture to protect the environment (OECD 2017), there is also an extensive use of agrochemicals. According to FAOSTAT (2017) data, Costa Rica ranks first worldwide for total applied amount per hectare of cropland (average of the years 2000 until 2015), which is around 7 times higher than in Germany. Glyphosate is the second most used chemical agent in the country (Pacheco-Rodríguez and García-González 2014). In this context, two species have been found to be resistant to glyphosate (Eleusine indica and Paspalum paniculatum) (Valverde 2010). In the period 1993–2005, there was an influential-social movement criticizing the methods of chemical crop protection in banana production. As a result, companies have incorporated good agricultural practices and now fulfil minimum standards, such as providence of personal protective equipment, while the applied amount of chemical agents remain similar. After the actions of the companies criticism is still present but on a smaller scale (Barraza et al., 2013). Still, farmers often use agrochemical which are inadequate and far from the optimal (PEN 2015). Overuse of agrochemicals is partly driven by limited access to new formulas, arising from difficult and lengthy registration processes. However, pressures from international importers in this regard limit the country's competitiveness in the international market. This situation leaves farmers in a problematic situation, since they cannot substitute obsolete agrochemicals for more efficient ones. In Germany and the EU, chemical plant protection (in particular glyphosate) and the admission of new chemical agents are critically discussed in public and political debates (Conrad et al. 2017; Damalas and Eleftherohorinos, 2011). Currently, the approval of glyphosate is under reconsideration (European Commission n.d.).

The introduction of GM crops took place without an adoption of a regulating legal framework in Costa Rica; a situation which is representative for most Latin American countries (Newell 2008; Otero 2008; Pacheco-Rodríguez and García-González 2014). Thus, with a few restrictions, GM crop protection is allowed in Costa Rica. Costa Rica produces GM seeds for the export market and imports GM products, such as cotton, rice and soybeans. However, marketed agricultural products do not specify whether they contain GM crops, which represents a lack of consumer information (Pacheco-Rodríguez, 2014). In contrast, legal hurdles for the introduction of GM crops in Germany (respectively the EU) are high, which lead to an effective ban of such crops (Lucht 2015). In addition, there labelling requirement for food products containing GM crops exists (based on Regulation (EC) No 1829/2003 of the EU).

Based on these considerations, hypotheses can be derived. For the Costa Rican agricultural students, we hypothesize that the explicit and implicit attitudes towards chemical crop protection are both indeed negative, since (i) perceived disadvantages are greater than advantages and (ii) no reasons for misreporting exist (low social pressure). Römer et al. (2019) report that German agricultural students are more likely to support the application of chemical crop protection, against the public opinion. This response might be strategic and regardless of their personal perception. Concerning GM crop protection, which is more commonly used in Latin America than Europe, we assume positive explicit and implicit attitudes towards GM crop protection in Costa Rica. Although GM crop protection is not available in Germany, an explicit supportive behaviour in contrast to the implicit negative attitude was reported by Römer et al. (2019). Therefore, our two hypotheses are as follows:

H1: “Chemical crop protection”: For Costa Rican agricultural students, the explicit and implicit associations towards chemical crop protection are both negative while for German agricultural students the associations are explicitly positive and implicitly negative.

H2: “GM crop protection”: For Costa Rican agricultural students, the explicit and implicit associations towards GM crop protection are both positive while for German agricultural students the associations are explicitly positive and implicitly negative.

3. Test setting and online-study outline

The IAT is a computer-based test developed by Greenwald et al. (1998) and is commonly applied in the field of social science to measure implicit attitudes (Greenwald et al. 2003; Karpinski and Steinmann, 2006). It measures the relative association or attitude of two target concepts with two attributes in the form of a semantic differential. In the following, the technical terms and the functionality of the IAT are outlined. The elaborations closely follow the presentation in Römer et al. (2019) and provide intuition based on the application of Greenwald et al. (1998). Assuming that one wants to investigate whether restrictions of one population group (e.g. the white population) against another population group (e.g. the black population, relative to the own group) exists, target concepts could be “black” and “white” and attributes could be “positive” and “negative”. By pressing a key on the keyboard participants are required to assign single terms of the target concepts, as well as the attributes, into two categories. Participants have to make multiple, consecutive decisions under time pressure. The categories and attributes are either compatible (e.g. “white and positive”; “black and negative”) or incompatible (e.g. “white and negative”; “black and positive”) with the participant’s attitude. The basic idea underlying the IAT is that the time required for processing the individual tasks differs between compatible and incompatible categories. Thus, a participant will require less time to assign a term to a compatible category than assigning it to an incompatible category. The resulting time differences can then be used to derive the relative implicit attitude (Greenwald et al. 1998).

The implicit attitude was measured using the SC-IAT (Karpinski and Steinmann, 2006), a modified version of the original IAT. In contrast to IAT, the SC-IAT uses only one target concept (instead of two). Assuming a positive implicit association towards white people, a participant would assign "white" and "positive" terms faster to one category than "white" and "negative" terms. This ability to measure the absolute implicit attitude towards one target concept represents the advantage of the SC-IAT (Karpinski and Steinmann, 2006).

With respect to the present study, the SC-IAT allows the investigation whether respondents prefer one target concept over another (e.g. chemical over GM crop protection), as well as whether the target concepts are perceived as negative, neutral or positive in absolute terms. Thus, two SC-IATs are required for the study, to investigate both crop protection methods. The SC-IATs were conducted as an online test on the participant's PC or Laptop (in German and Spanish for the German, respectively, Costa Rican agricultural students). A translated wordlist of the attributes and target concepts utilized in the test is shown in Table 1.

In the test,[1] participants were asked to use specific keys on their keyboards to assign terms appearing on the screen into groups. They were asked to act as fast as possible, avoiding errors at the same time. Examples of the screen are depicted in Figure 1. Wrong assignments were indicated on the screen and participants were asked to press the right key to move on. The test consist of two blocks, in which the target concept is either put in the same category with the positive (left side of Figure 1) or the negative terms (right side of Figure 1).

Instructions about the key assignment were provided before every block. The online test consisted of two SC-IATs, called sequences, and each sequence consisted of two blocks. The single appearance of a term is called

Table 1. Wordlist for the SC-IATs (translated to English).

		Wordlist
Attributes	Negative	Bad, brutal, disaster, disgusting, dreadful, painful, tragic, ugly
	Positive	Beautiful, celebration, joy, laugh, love, luck, outstanding, paradise
Concepts	Chemical crop protection	Fungicide, glyphosate, herbicide, insecticide, sprayer
	GM crop protection	Agro-genetic engineering, gene transfer, genetic modification, genetically modified organism, green genetic engineering

Source: Own depiction based on Römer et al. (2019)

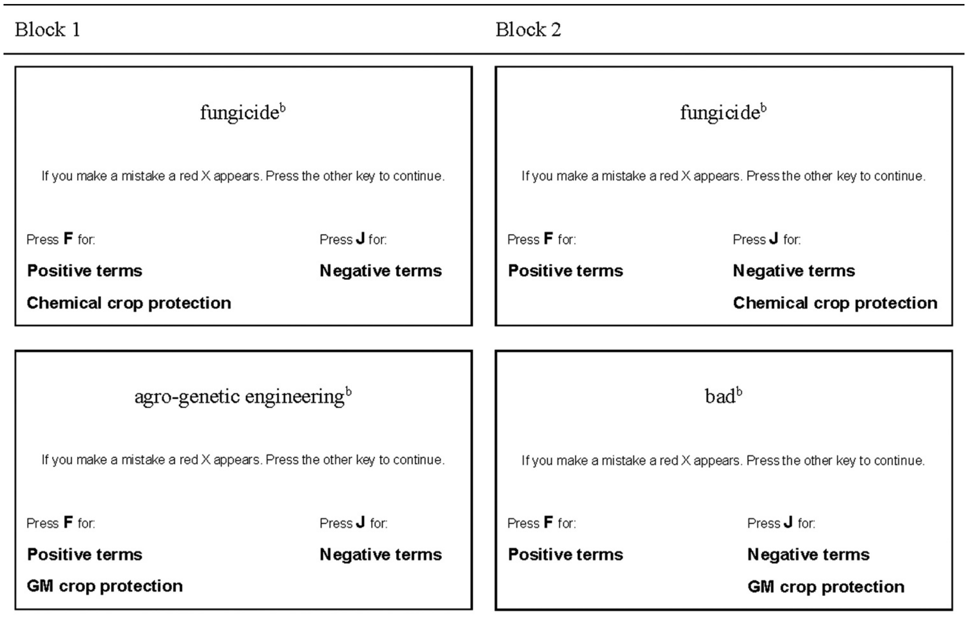

Figure 1. Exemplary visualization of the key assignment on the screen during the SC-IAT (chemical crop protection at the top and GM crop protection at the bottom)[a]. [a] The size representation is not true to scale. [b] Example of the concepts "fungicide", "agro-genetic engineering" and "bad" are shown; for the complete overview of concepts please see (Table 1). Source: own depiction based on Römer et al. (2019)

Table 2. Procedure of the SC-IATs.

Sequence[a]	Block[a]	Total Trials[a]	F-Key (Trials)	J-Key (Trials)
1	1	72	Positive terms (5·4 = 20) + chemical crop protection (5·4 = 20)	Negative terms (8·4 = 32)
	2	72	Positive terms (8·4 = 32)	Negative terms (5·4 = 20) + chemical crop protection (5·4 = 20)
2	1	72	Positive terms (5·4 = 20) + GM crop protection (5·4 = 20)	Negative terms (8·4 = 32)
	2	72	Positive terms (8·4 = 32)	Negative terms (5·4 = 20) + GM crop protection (5·4 = 20)

[a]The order is determined randomly, Source: Modified after Römer et al. (2019).

a trial. In total, there were 72 trials per block (Karpinski and Steinmann, 2006), see Table 2. The order of the sequences and blocks were randomly chosen to avoid order or learning-driven effects (Greenwald et al. 1998; Karpinski and Steinmann, 2006). Within each block, the attribute and concept terms shown on the screen were chosen randomly without replacement. Additionally, the usage of the response keys were balanced by presenting the words in a suitable ratio (see Table 2 for the absolute numbers).

Following the two SC-IATs, participants were asked for their attitude about chemical and GM crop protection by responding to the five-level Likert-items "How do you rate chemical crop protection?" and "How do you rate GM crop protection?" (both from "very positive" to "very negative"), followed by a questionnaire to collect socio-demographic characteristics. The personal results from the SC-IATs were provided to participants in the end.

4. Data and methodical approach for data analysis

4.1. Data collection

The online test and the survey were completed by 447 agricultural students – 211 from Costa Rica and 236 from Germany, of which 441 (208 from Costa Rica and 233 from Germany) were used in the analysis. Agricultural students were selected as they can be considered to be future producers and employees in the agricultural and related sectors. Furthermore, it can be expected that all students, regardless of their specialization are familiar with crop protection technologies and the accompanied controversies, as these are topics in the basic courses in the agricultural programmes of both universities. The sample of German students was collected at the Georg-August-University of Goettingen, Costa Rican sample at the University of Costa Rica. Students were invited by email. In return for their participation, study participants received either a € 10 voucher or CRC 5.000 (equivalent to € 7.39) cash payment in Germany and Costa Rica, respectively. The price difference in payout amounts takes into consideration the difference in living costs between the two countries. The data collection was carried out in August 2018 in Costa Rica. The data from the German students was collected in context of the study by Römer et al. (2019) during May–June 2017. The Costa Rican sample represents original data for the present study.[2]

The descriptive statistics of the participants are presented in Table 3. In the German sample, more students completed an apprenticeship – results, which are in line with the higher number of farm successors. 129 of 441 participants state that they will be working in primary production as farm successors in the near future. This suggest a high level of knowledge about different crop protection methods among the participants. It becomes apparent that the licentiate degree is only offered in Costa Rica, and accounts for one third of the Costa Rican students. However, the total number of master students from Costa Rica and Germany is closely matched. The share of female students is almost the same and both genders are well represented. The average response times for both online tests are comparable. While purchasing organic products is an unpopular opinion in the German sample, Costa Rican students show almost no preference.

Table 3. Descriptive statistics of Costa Rican and German students (N = 441).

		Mean/ Percentage	
Variable	Description	Costa Rica	Germany
Age	Age of the participant in years	21.36 (0.36)	22.53 (0.23)
Apprenticeship	Participant completed an agricultural apprenticeship	17.31%	29.18%
Enrolled: Bachelor	Participant is a bachelor student	27.40%	66.95%-
Licentiate	Participant is a licentiate student	36.06%	30.04%
Master	Participant is a master student	28.37%	3.00%
Other	Participant is neither a bachelor nor a master student	8.17%	
Evaluation of study	Personal evaluation of our online study on a five-level Likert-item. Range from −2 (very poor) to +2 (very good)	1.35 (0.05)	0.99 (0.06)
Farm successor	Participant is a farm successor	13.46%	43.35%
Gender	Share of female participants	46.63%	45.92%
Purchasing organic products	Frequency of purchasing organic products on a five-level Likert-item. Range from −2 (very rare) to +2 (very often)	−0.10 (0.09)	−0.94 (0.08)
Response time	Response time of participants in milliseconds, excluding errors	951.04 (690.38)	926.62 (698.10)
Rural origin	Participant grew up in a rural region	57.21%	81.55%
Semester	Number of semesters enrolled	4.33 (0.17)	4.20 (0.38)
Number of observations		208	233

For all means, standard deviation in parentheses.

4.2. Approach to data analysis

To analyse the result of the IAT as the implicit association, the raw measurements need to be cleaned and aggregated. In general, the present study follows the approach used by Römer et al. (2019), which is accordingly outlined in the following. The data was cleaned in following the specifications of the SC-IAT (Karpinski & Steinmann, 2006). Measured response times for wrong assignments were replaced by the block average of correct assignments plus a penalty of 400 ms. Further, responses with extreme reaction times (below 350 ms and over 10,000 ms), as well as participants with an error rate above 20 % were removed from the sample. This was the case for a total of six participants, three of each country. As suggested by Greenwald et al. (2003), we calculated a modified version of the original D-score to interpret the individual reaction times. It represents personal attitudes towards the target concept. The calculation of the modified D-score for a single participant is as follows:

$$\text{D-score} = (\mu_2 - \mu_1) \cdot \frac{1}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_{i(\text{correct assignment})} - \mu_{1+2}\right)^2}} \tag{1}$$

The personal D-score is calculated by first subtracting the average reaction time of block 2 (μ_2) from the average reaction time of block 1 (μ_1); and secondly, multiplying the result with one divided by the standard deviation of reaction times of correct assignments from block 1 and 2. n is the number of reaction times of correct assignments and $x_{i(\text{correct assignment})}$ stands for a single reaction time by correct assignment. For example, if one has an average reaction time of 750 ms and 850 ms in block 1 and 2, respectively, and a standard deviation (for correct assignments) of 500 ms for block 1 and 2 combined, the D-score is:

$$\text{D-score} = (850\text{ms} - 750\text{ms}) \cdot \frac{1}{500\text{ms}} = 0.2 \tag{2}$$

Since the range of the five-level Likert-item for explicit attitudes, −2 (very negative) to +2 (very positive) is not directly comparable to the range of the D-score for implicit attitudes, ≤−0.65 (strongly negative) and ≥0.65 (strongly positive), we adjust the range of the D-score accordingly (Phelan et al., 2014). Therefore, we divided the range of the Likert-item by the range of the D-score, i.e. 2 divided by 0.65, and multiplied the D-scores as well as its range by the outcome to reach comparability with the five-level Likert-item.

Differences between the explicit and implicit attitudes can be identified by considering the confidence intervals of their means. The association between the different measures can be assessed in terms of their correlation coefficients. To further cross-compare viewpoints between Costa Rican and German study participants while controlling for the influence of the individuals' characteristics, a set of equations was estimated using the seemingly unrelated regression approach (Zellner 1962). We consider the following set of equations:

$$Chemical\ explicit_l = \alpha_1 + \beta_1\ country_l + \boldsymbol{\gamma_1}\ \boldsymbol{c_l} + u_{l1} \quad (3)$$

$$Chemical\ implicit_l = \alpha_2 + \beta_2\ country_l + \boldsymbol{\gamma_2}\ \boldsymbol{c_l} + u_{l2} \quad (4)$$

$$GM\ explicit_l = \alpha_3 + \beta_3\ country_l + \boldsymbol{\gamma_3}\ \boldsymbol{c_l} + u_{l3} \quad (5)$$

$$GM\ implicit_l = \alpha_4 + \beta_4\ country_l + \boldsymbol{\gamma_4}\ \boldsymbol{c_l} + u_{l4} \quad (6)$$

The dependent variables $Chemical\ explicit_l$ and $Chemical\ implicit_l$ stand for the explicit and implicit attitudes of participant l towards chemical crop protection, respectively. Furthermore, $\alpha_{1\text{-}4}$ are the intercepts, $\beta_{1\text{-}4}$ the parameters for the dummy variable *country*, which is indicating whether the agricultural student is from Costa Rica or Germany. Additionally, $\boldsymbol{c_l}$ is a vector of the participant's characteristics, including age, apprenticeship, farm successor, gender, purchasing organic products, and rural origin, while $\boldsymbol{\gamma}$ is the parameter vector. Additionally, the dependent variables $GM\ explicit_l$ and $GM\ implicit_l$ represent the explicit and implicit attitudes towards GM crop protection, respectively. The error terms $u_{l1\text{-}4}$ are assumed to be correlated between the equations.

5. Results and discussion

The explicit and implicit attitudes towards chemical and GM crop protection are shown in Table 5. The table shows the mean as well as the 95% confidence intervals for explicit and implicit attitudes. Positive and negative attitudes are indicated by positive, respectively, negative values. The

Table 5. Mean and 95% confidence interval of the mean for the SC-IATs and Likert-items towards chemical and GM crop protection (N = 441).

	Costa Rica		Germany	
	95% confidence interval	Mean	95% confidence interval	Mean
Chemical crop protection				
Explicit:	−0.31; −0.02	−0.17	0.45; 0.70	0.57
Implicit:	−0.35; −0.15	−0.25	−0.37; −0.18	−0.28
GM crop protection				
Explicit:	0.84; 1.11	0.98	0.27; 0.54	0.40
Implicit:	−0.04; 0.18	0.07	−0.21; −0.03	−0.12
Number of observations	208		233	

distributions of the explicit and implicit associations for the plant protection methods are additionally shown in Figure 2. The top row shows the distributions for the pooled sample, the middle and lower row show the distributions of the German, respectively, Costa Rican sample.

The Costa Rican agricultural students' explicit and implicit attitudes towards chemical crop protection are both statistically significant negative as the 95% confidence interval shows. For German agricultural students, Table 5 indicates that explicit attitudes towards chemical crop protection are statistically significantly positive, while the implicit attitudes are statistically significantly negative. Therefore, we can accept our hypothesis H1. Regarding the attitudes for GM crop protection in Costa Rica, the explicit attitude is statistically significant positive, while the implicit does not prove to be statistically significant different from 0. In Germany, the explicit attitude for GM crop protection is statistically significant positive, whereas the implicit one is statistically significant negative. Thus, we have to reject our hypothesis H2.

The correlations between the different explicit and implicit attitude measures are presented in Table 6 for the Costa Rican students. The correlation between the explicit and implicit attitudes is 0.05 and 0.00 for the chemical and the GM crop protection, respectively, which both are not statistically significant. The correlations between the different explicit and implicit attitude measures are presented in Table 7 for the German students. The correlation between the explicit and implicit attitudes is 0.32 and 0.12 for the chemical and GM crop protection. Still, only the correlation for the chemical crop protection can be considered statistically significant.

Overall, the results show that Costa Rican agricultural students perceive chemical crop protection negatively while GM crop protection is explicitly perceived positively. This shows a clear preference for GM over chemical crop protection in Costa Rica. Concerning the attitudes of German agricultural students towards chemical crop protection, their explicit attitudes mismatch their implicit ones. This finding could indicate that German agricultural students potentially align their explicit attitudes with the values and viewpoints of the agricultural sector. Another possibility would be that despite an implicit dislike, German agricultural students report a positive attitude towards chemical crop protection if they perceive them as necessity for conventional agricultural production. However, it is noteworthy that this discrepancy between implicit vs. explicit cannot be observed for Costa Rican agricultural students. This argues for a higher social and public pressure towards the agricultural sector in Germany, which is also reflected in the legal situation in both countries (e.g. see Conrad et al. 2017; Pacheco-Rodríguez and García-González, 2014). Furthermore, particularly the results for the Costa Rican students are interesting, as at least the implicit and explicit attitudes towards chemical crop protection are both positive but not correlated (which

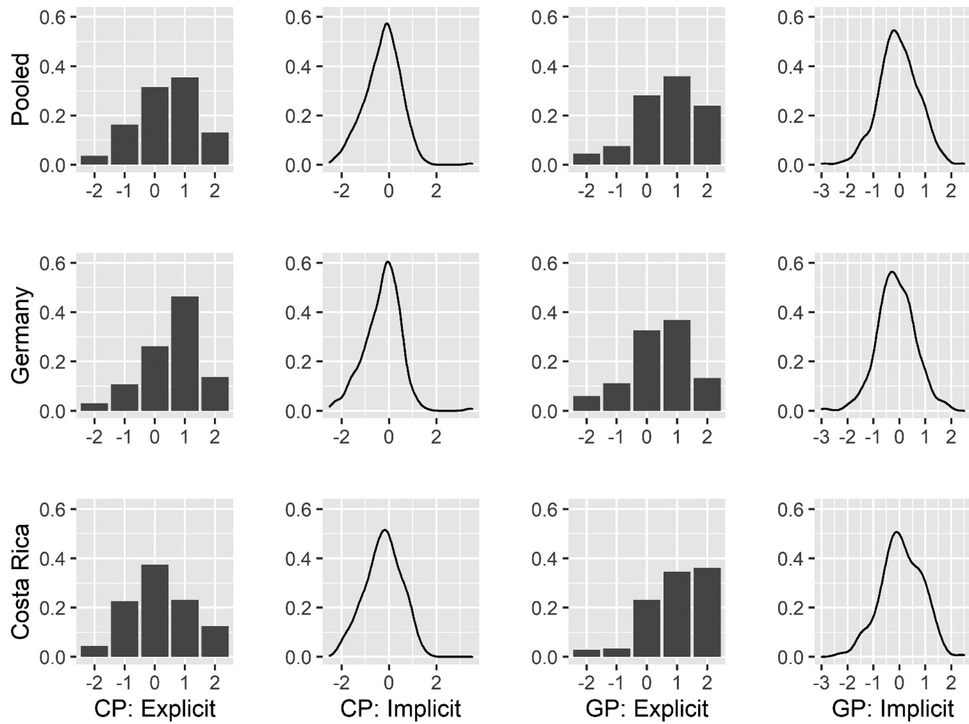

Figure 2. Distributions of the explicit and implicit associations (N = 441). Source: Own depiction; Notes: CP = Chemical crop protection, GP = GM crop protection

Table 6. Correlation analysis Costa Rican sample (n = 208).

	Chemical crop protection: explicit	Chemical crop protection: implicit	GM crop protection: explicit	GM crop protection: implicit
Chemical crop protection: explicit	1.00			
Chemical crop protection: implicit	**0.05**	1.00		
GM crop protection: explicit	0.29*	−0.06	1.00	
GM crop protection: implicit	−0.04	0.02	**0.00**	1.00

Pearson's correlation coefficient; * indicates a significance level of 1%, after applying the Holm–Bonferroni correction. Bold figures highlight the explicit-implicit correlation for each crop protection method.

Table 7. Correlation analysis German sample (n = 233).

	Chemical crop protection: explicit	Chemical crop protection: implicit	GM crop protection: explicit	GM crop protection: implicit
Chemical crop protection: explicit	1.00			
Chemical crop protection: implicit	**0.32***	1.00		
GM crop protection: explicit	0.45*	0.13	1.00	
GM crop protection: implicit	0.07	0.02	**0.12**	1.00

Pearson's correlation coefficient; *indicates a significance level of 1%, after applying the Holm–Bonferroni correction. Bold figures highlight the explicit–implicit correlation for each crop protection method.

is otherwise often reported in the literature, see Nosek 2007). Still, this result is in line with the findings of Römer et al. (2019) and an indication that explicit and implicit attitudes for crop protection may not have a bipolar structure (cf. Nosek 2007).

The results of the seemingly unrelated regressions are shown in Table 8. To avoid multiple comparison issues for the parameter-estimates of the explanatory variables, the significance levels for each variable were adjusted using the Holm–Bonferroni correction (Holm 1979). The dummy variable country allows a cross-comparison between the Costa Rican and German agricultural students with Costa Rica being the reference. Table 8 indicates no statistically significant differences for chemical crop protection between German and Costa Rican agricultural students when controlling for other variables, such as frequency of purchasing organic products and gender. This is found to be consistent for the explicit and implicit attitudes. Concerning GM crop

Table 8. Seemingly unrelated regressions: Results for chemical and GM crop protection (N = 441).

Independent Variables	Chemical crop protection: explicit	Chemical crop protection: implicit	GM crop protection: explicit	GM crop protection: implicit
Country: Germany	0.103	−0.119	−0.680***	−0.218**
	(0.098)	(0.080)	(0.108)	(0.080)
Age	−0.026**	0.002	0.009	0.001
	(0.010)	(0.008)	(0.011)	(0.008)
Apprenticeship	0.182	0.043	−0.006	0.037
	(0.110)	(0.090)	(0.121)	(0.090)
Farm successor	0.218	0.203*	−0.023	−0.163
	(0.108)	(0.088)	(0.119)	(0.089)
Frequency of purchasing organic products	−0.260***	−0.029	−0.102**	−0.053*
	(0.037)	(0.030)	(0.040)	(0.030)
Gender female	−0.183	−0.116	−0.202	0.027
	(0.090)	(0.074)	(0.099)	(0.074)
Rural region	0.092	0.001	0.067	0.073
	(0.105)	(0.086)	(0.116)	(0.086)
Constant	0.680**	−0.281	0.829***	0.010
	(0.236)	(0.193)	(0.260)	(0.193)
R^2	0.203	0.029	0.103	0.032

*, **,*** indicate a significance level at 10%, 5%, and 1% respectively, after applying the Holm–Bonferroni correction. For all coefficients standard errors in parentheses. A variance-inflation-factor test indicates that multicollinearity is low with a maximum value of 1.26 for farm successor.

protection, the implicit and explicit attitudes are statistically significantly lower for German students. This argues for the positive prevailing observations regarding GM crop protection in Costa Rica. The R^2-values indicate that the same set of explanatory sociodemographic variables explain a larger share of explicit attitude's variance than of the implicit attitude.

The initial situation in the two countries is fundamentally different. This comprises the legal framework but also the activity of social groups, e.g. see Lucht (2015). Against this background, it is not surprising that GM crop protection is perceived more positively in Costa Rica than in Germany. Furthermore, the social pressure in Germany, which places the agricultural industry in a defence position, is not prevailing, or is at least lower in Costa Rica. Therefore, social pressure could be seen as an indicator for misreporting in surveys and should be addressed by future research on controversial topics.

6. Conclusion

There is an ongoing global discussion about different crop protection methods and their negative externalities. Furthermore, this discussion has various country and regional specific dimensions. As advocators and opponents may respond strategically in this controversy, it is possible that the current body of the literature provides a biased view of how different crop protection methods are perceived in different countries. Against this background, this study extends to the understanding of the perception of crop protection in different countries by comparing the explicit and implicit attitudes towards chemical and GM (genetically modified) crop protection in Costa Rica and Germany. For the present study, a single-category implicit association test (SC-IAT) towards chemical and GM crop protection, as well as a questionnaire capturing the explicit association was carried out. Our sample consisted of 441 agricultural students in total, of which 208 are from Costa Rica and 233 from Germany.

The results show that in Costa Rica, GM crop protection is perceived more positive when compared with Germany. Furthermore, in Costa Rica, no discrepancy between explicit and implicit attitudes can be found, whereas in Germany, explicit attitudes mismatch their implicit ones for both crop protection methods, which argues for a reporting bias. This shows that no behaviour pattern exists which is suitable for all countries. Rather, regional heterogeneity can be assumed regarding the acceptance of different crop protection methods. While such a result may appear as unsurprising in itself, it points towards potential issues in the acceptance of policies targeting crop protection practices. If policies are country, respectively context-specific, these policies can account for relevant specificities, but if policies apply to different contexts (like e.g. trade agreements) this may not be possible. In this case, this could limit the acceptance of these policies.

Furthermore, the results can also be interpreted that attitudes towards crop protection methods may not have a bipolar (positive-negative) structure. Regardless of the actual reason, the results indicate that common surveys on controversial topics cannot always be regarded as a meaningful substitute for the measurement of implicit attitudes. Without the measurement of implicit attitudes, research may only provide an incomplete picture of the relevant behaviour factor to provide reasonable predictions for the acceptance of new policies. This is an important point of consideration for future policy impact assessments.

These findings have some implications for measuring attitudes on issues related to agricultural topics. Future research could build upon the study's findings and investigate whether they originate from a multidimensional structure of the attitudes or from misreporting, e.g. due to social pressure and a social desirability bias. In this regard, it would also be worth to study whether the exposure to discourses in different societal groups (for example, due to social media) changes the way in which crop protection is perceived. In general, additional research is needed to validate our results and provide a broader perspective in relation to cultural-driven attitudes.

Notes

1. See Römer et al. (2019), for a more detailed description of the procedure.
2. The data used by Römer et al. (2019) also contains a sample of agricultural science students from another University (University of Kassel). This data contains students enrolled in a programme specialized in organic agriculture. As this programme substantially differs from the ones the students considered in the present study, this data is not considered here. The datasets and the code used for the analysis are available from the authors upon request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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