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Perceptions and sociocultural factors underlying adoption of conservation agriculture in the Mediterranean

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Abstract

The Mediterranean region is facing major challenges for soil conservation and sustainable agriculture. Conservation agriculture (CA), including reduced soil disturbance, can help conserve soils and improve soil fertility, but its adoption in the Mediterranean region is limited. Examining farmers' perceptions of soil and underlying sociocultural factors can help shed light on adoption of soil management practices. In this paper, we conducted a survey with 590 farmers across Morocco, Spain and Tunisia to explore concepts that are cognitively associated with soil and perceptions of tillage. We also evaluated differences in perceptions of innovation, community, adaptive capacity, and responsibility for soil. We found that farmers' cognitive associations with soil show awareness of soil as a living resource, go beyond agriculture and livelihoods to reveal cultural ties, and link to multiple levels of human needs. Beliefs about the benefits of tillage for water availability and yield persist among the surveyed farmers. We found that openness towards innovation, perceived adaptive capacity and responsibility for soil were associated with minimum tillage, whereas community integration was not. Education, age and farm lifestyle were also associated with differences in these perceptions. CA promotion in the Mediterranean should emphasize the multiple values of soil, should demonstrate how sufficient yields may be achieved alongside resilience to drought, and be tailored to differing levels of environmental awareness and economic needs across north and south.

Keywords Conservation agriculture · Farmer attitudes · Landscape value · Soil disturbance · Agricultural intensification · Tillage

Abbreviations

CA Conservation agriculture
TPB Theory of Planned Behavior
DOI Diffusion of Innovation

Introduction

Healthy soils are crucial for global agriculture, yet agricultural intensification and widespread agricultural

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management practices are some of the main contributors to soil loss and degradation worldwide (FAO, 2020). This degradation can limit the capacity of soils to provide crucial ecosystem services, including food production, and hamper the capacity of farmers to sustain their livelihoods. The Mediterranean region is particularly vulnerable to soil degradation, with high erosion rates, low levels of soil organic matter, and strong human pressures (Aguilera et al. 2013; Panagos et al. 2020; Ferreira et al. 2022). These trends, in conjunction with climate change, pose serious challenges for farmers.

In order to face these challenges, improve their soil, and secure their livelihoods, many farmers worldwide practice the principles of 'Conservation Agriculture' (CA). These principles include minimal soil disturbance, permanent soil cover, and crop diversification, including crop rotations (FAO 2017). Across Europe, CA has been shown to promote ecosystem multifunctionality (Wittwer et al. 2021). In Mediterranean dryland agriculture, CA practices have been shown to mitigate land degradation caused by conventional tillage and to improve soil organic matter content, water retention, and other ecosystem functions and services (Kassam et al. 2009; Laghrour et al. 2016; Lee et al. 2019). Additional incentives for implementing CA include reductions in fuel and labor costs, as farmers do not need to perform tillage operations, but perform seeding operations only.

Despite these benefits, the adoption of CA practices among farmers in Mediterranean dryland agriculture is limited. One reason is that CA represents a fundamental shift in thinking from conventional agriculture that includes tillage (Kassam et al. 2009). This shift also requires specific knowledge and technology to implement and to deal with challenges such as weed and pest management (Lahmar 2010). Some Mediterranean farmers perceive practices for soil cover, such as mulching, as negative, due to higher costs compared to traditional tillage (Cerdà et al. 2017). These economic factors, as well as other socioeconomic and biophysical conditions, have been shown to explain limited CA adoption among farmers (Knowler 2015; Bijttebier et al. 2018).

Sociocultural factors may further explain farmers' adoption of CA practices (Knowler and Bradshaw 2007; Wuepper 2019; Rust et al. 2020), particularly of minimizing soil disturbance, which is arguably the cornerstone of CA. In general, farmers' perceptions of their landscapes and related practices can influence their land management decisions, including soil conservation (Kessler 2006; Vuillot et al. 2016; Wartenberg et al. 2018). One aspect is the perception of the soil itself, including how it is viewed as a resource, its uses and perceived value. Different meanings and attachment to specific landscape elements can be revealed by assessing stakeholders' cognitive associations to these elements (Gottwald et al. 2021). Farmers have been found to associate soil conservation with social values and symbolic meanings, including how soil conservation measures fit into everyday life; that are, in turn, related to their decision to till soil (Schneider et al. 2010).

Reluctance to implement alternative agricultural practices can be linked to farmers' adherence to traditional practices, long-term (often inter-generational) knowledge and beliefs, and the role of conventional practices in routine farming (Schneider et al. 2010). In the Mediterranean region, traditional agricultural practices may be maintained over long time periods and provide multiple ecosystem services, and they are closely linked to local peoples' cultural identities (Quintas-Soriano et al. 2019; García-Martín et al. 2021). These traditions create a foundation for familiar agricultural practices that farmers are often unlikely to deviate from. In contrast, the adoption of new practices has been related to the capacity for innovative thinking and openness to change among farmers (Rust et al. 2020). These qualities have been associated with young farmers with a more vocational view on farming and greater flexibility (Schmitzberger et al. 2005; Koutsou et al. 2014). Perceptions of innovation and tradition are therefore tied to farmers' implementation of new practices. In addition, the degree of farmers' integration into their local community, their social capital, and attitudes towards development and collaboration with others, can also affect their choice to implement alternative farming practices (Kessler 2006; Willy and Holm-Müller 2013; Rust et al. 2020). For example, higher involvement in communal activities and better social networks helped farming families with land degradation issues in northwest Tunisia to implement sustainable land planning (Jendoubi et al. 2020).

Collectively, these perceptions, attitudes and knowledge sources may relate to each other and play an important role in farmers' decision-making (Dhehibi et al. 2019). One relevant theory that incorporates these elements is the Theory of Planned Behavior (TPB) (Ajzen 1991). In this theory, social expectations to adopt particular behaviors are known as "subjective norms", and can influence intent to adopt, along with people's confidence in their ability to do so. This theory has been widely used in investigations of decisions and behaviors of farmers (e.g. Borges et al. 2014; Sutherland and Holstead 2014; Yazdanpanah et al. 2014; Tama et al. 2021). Lang and Rabotyagov (2022) combined the TPB with the Diffusion of Innovation (DOI) theory to study landowners' adoption of best management practices, and found environmental awareness and attitudes significantly affected adoption.

Farmers' perception of their own capacity to adapt and change is an important determinant for their choice of practices, especially in the context of climate change (Hyland et al. 2016; Talanow et al. 2021). Farmers with higher

perceived adaptive capacity are more likely to consider changing practices than those who perceive their capacity to adapt to be low. Capacity to adapt can also be associated with perceived responsibility for landscape elements such as soil. While farmers may be aware of adverse impacts of certain practices, they may not attribute these impacts to their own individual management, but rather seek to shift or share responsibility (Ingram et al. 2010). Recognizing responsibility to land, and the connections among land management and broader society, is increasingly viewed as an essential part of effective land stewardship (Quartuch and Beckley 2013; West et al. 2018). This perceived responsibility is particularly relevant to soil, given that its management can have effects on ecosystem health and productivity at both local and regional scales.

Managing soil as a resource to ensure its healthy functioning is particularly crucial in the face of both land degradation and ongoing environmental change, including climate change, which will alter Mediterranean agriculture (Cramer et al. 2018; Montsant et al. 2021). Given these acute challenges, the Mediterranean region has been found to benefit from CA (Devkota et al. 2022). To support this management, it is important to understand Mediterranean farmers' perceptions of and relations to soil and the sociocultural determinants of Mediterranean farmers' uptake of CA practices. Investigating farmers' perceptions of soil is especially important as their perspectives on land management policy may differ from scientists and policy-makers (De Souza Mello Bicalho and Dos Guimarães Peixoto 2016; Petrescu-Mag et al. 2020). It is of particular interest to compare these perceptions across different Mediterranean countries, given the contrasting agricultural contexts in northern and southern Mediterranean regions.

The aim of our study is to investigate the perceptions of Mediterranean dryland arable farmers in relation to soil and soil management, and to compare these perceptions among those practicing CA and conventional agriculture. We recognize that psychological and cultural factors motivate farmers alongside socio-economic factors. We thus designed a survey to investigate perceptions related to soil, tillage, and the following sociocultural aspects of soil management: innovation, community integration, perceived adaptive capacity and responsibility. These aspects relate to the subjective norms and moral values of the TPB and DOI theory (Yazdanpanah et al. 2014; Lang and Rabotyagov 2022). We aimed to understand the differences in these perceptions and how this may relate to tillage practices and additional sociodemographic variables.

The main research questions for our study were:

i) What do Mediterranean arable farmers cognitively associate with soil?
ii) How do Mediterranean arable farmers perceive tillage and sociocultural aspects of soil management?
iii) What is the difference in the above perceptions among countries and between farmers practicing CA and conventional agriculture?

We hypothesized that Mediterranean farmers who practice CA, if compared to those farmers who are tilling, have (1) different perceptions of soil as a resource, and (2) different perceptions of sociocultural aspects of soil management. Specifically, CA farmers may be more aware of soil as a living resource or of its multiple roles in society; they may be more open to innovation and less attached to traditional practices or routines that could include conventional tillage; they may be more engaged in their farming community; and perceive they have a greater capacity to manage and take responsibility for soil, than those tilling.

In this paper, we identify the materials and methods, including survey design, that we employed to address our research questions. We then present the results of the survey, followed by discussion of the main findings, including the differences of perceptions among groups and how regional agricultural traditions relate to soil management in the study regions. Finally, we present study limitations and conclusions.

Fig. 1 Conservation agriculture practices in each of the study regions. From left to right: Sheep grazing in fallow fields, Morocco; a CA wheat field, Spain; Direct seeding rows, Tunisia. Photos: Harun Cicek

Materials and methods

Study regions

Our study areas were located in three agricultural landscapes of varying rainfall gradients in Morocco, Spain and Tunisia, where research partners including extension agencies and research institutes have previously conducted studies and developed outreach programs related to agronomy and CA (Fig. 1). These sites cover both Northern and Southern Mediterranean farmlands with different biophysical, socio-economic and cultural characteristics.

Morocco

The three principal agricultural regions of Meknes, Oued Zem and Settat cover a rainfall gradient across cereals-based system regions of Morocco. The semi-arid regions of Oued Zem and Settat receive limited rainfall (< 300 mm/year). Here cereal crops, primarily wheat, durum, and barley, and forages are grown as annual crops. Small ruminants are an essential component of the production system. The region of Meknes receives higher rainfall (approximately 400 mm/year). Cereal, food legumes and forage crops are the main crops grown in the region. Plantations of olive trees, apples, pears, prunes, and almonds are grown under supplement irrigation where available. All regions have limited irrigation and the majority of arable lands is rainfed. Livestock grazing, primarily sheep, takes place after harvest freely and there is no fencing to prevent herders from allowing livestock to graze on stubble. These regions have a network of regional and local agricultural advisory services and farmers practicing both no-till and conventional practices. An estimated 10,500 ha of farmland are under CA (Kassam et al. 2020; Mrabet et al. 2022).

Spain

Some of the main cereal and legume producing areas in Catalonia include the protected rural area of Gallecs and its surroundings, the counties of La Noguera and La Segarra in the west of the territory, and the counties of Alt Urgell and Cerdanya in the Catalan Pyrenees. The protected rural area of Gallecs is northwest of Barcelona. It is a dryland arable area with a low annual rainfall (approximately 600 mm/year). The major crops are wheat, barley, oat, with some legumes, vegetable and olive production. Most of the farmers in this territory practice certified organic agriculture or some other type of sustainable agricultural production. The regions of La Noguera and La Segarra are located in the west of the Catalan territory, in the province of Lleida. The region's climate is dry continental, with hot, dry summers and cold, wet, foggy winters. Cereal and legume production in this region are often destined for the production of animal feed, and most of the farmers in the survey (especially those in Artesa de Segre and surrounding area, in the district of La Noguera) produce pork and poultry. The counties of La Cerdanya and Alt Urgell are located in the north of the Catalan territory, in the Pyrenees, also in the province of Lleida. The main agricultural activity in the region is extensive cattle production; most of the farmers also produce fodder (mainly alfalfa, vetch, sainfoins and cereals for fodder) and some grain (barley, rye and wheat). Approximately 10–15% of farmers across Catalonia are practicing some form of CA.

Tunisia

The Northern Tunisian agricultural regions of Zaghouan, Siliana, Béjà, Jendouba, Kef and Bizerte are located in two bioclimatic settings: sub-humid and semi-arid. The semi-arid region is marked by hot summers and cold winters, and low annual rainfall (from 200 to 400 mm per year). The sub-humid region has approximate average rainfall of 600 mm/year and is more favorable for agriculture than the semi-arid region. Production systems in the northern regions of Tunisia are mainly based on cereals production, primarily wheat and barley, combined with ruminant livestock. These six regions have agricultural extension networks and links to agricultural research institutes. Most farmers practice conventional tillage, whereas approximately 14, 000 hectares are under CA (Kassam et al. 2020; Mrabet et al. 2022).

Survey design and data collection

We designed a questionnaire to contain both open and closed question types to obtain both qualitative and quantitative data for analysis. The questionnaire included the following thematic sections: soil and land management; traditional and cultural practices; community, identity and adaptive capacity; and sociodemographic information (Supplementary Material 1). The first question was a free association question to derive the concepts that farmers associate with soil. Statements were devised on tillage and on sociocultural aspects of management including tradition, community, management capacity, and responsibility for soil. Respondents were asked to score their agreement with each statement on a 5-point Likert scale (1 – strongly disagree to 5 - strongly agree). One limitation of surveys is acquiescence bias, where respondents tend to agree with statements (Bartling et al. 2022). In order to overcome this potential bias, we included both positive and negative statements into the Likert scales (Billiet and McClendon 2000). Respondents were also asked to identify any practices that they considered traditional to their region in an open question, in order

to identify regional cultural practices that may be linked to soil and soil management. Questions on sociodemographic information, such as age, gender and level of education were asked at the end of the questionnaire and were framed as open or multiple-choice questions.

Questionnaires were developed in English and translated into Arabic, Catalan and French. Questions were pre-tested with three to five farmers in each country to determine level of understanding and improve clarity. Interviewers were trained by project researchers in Morocco, Spain and Tunisia to conduct the surveys using both paper copies and tablets. The surveys were conducted face-to-face in the respective local language between May 2021 and January 2022. We aimed to reach 200 farmers in each country that cover a range of farm sizes and of conventional and conservation agriculture practices, including conventional and minimum or no-tillage. We aimed to gather enough responses to enable comparisons among farmer groups while keeping the data collection feasible, but recognize that this is not fully representative of the population of each region, similar to Fagerholm et al. (2019) and Casagrande et al. (2016). The understanding of minimum tillage can vary according to farmer, farming system, and country; some farmers may refrain from tilling in general but practice limited tillage operations for specific goals such as weed removal. For the purposes of comparison, we considered minimum tillage to consist of tilling once a year or less (including no-tillage), and conventional tillage to consist of tilling more than once a year.

Farmers were initially targeted in each country through existing extension networks and through lists of farmers who have previously participated in research and development projects. Farmers participated in the survey either when attending training workshops, were visited by researchers at their farm, or met at the location of a regional association. Neighboring farmers to those initially contacted were also visited and asked if they would like to participate. Free, prior and informed consent was obtained from all individual participants before beginning surveys. Due to local regulations for the Covid-19 pandemic, meeting many farmers face-to-face in Spain was not possible, and therefore an online version of the questionnaire was created using LimeSurvey software. The online questionnaire was active between September 2021 and December 2021. A link to this online version was sent to farmers contacted via email or telephone by researchers. As we sought to interview the farmers that were conducting on-field activities, who in our study regions were mostly male, we did not seek a gender-balanced sample. Responses from all three regions were collected, cleaned and checked for clarity, translated to English and placed into a central database for analysis.

Table 1 Profile of respondents

		Morocco (n = 188)	Spain (n = 185)	Tunisia (n = 189)	Overall (n = 562)
Age	18–35	30 (16%)	31 (17%)	15 (8%)	76 (14%)
	36–50	75 (40%)	78 (42%)	77 (40%)	230 (41%)
	51–65	53 (28%)	61 (33%)	73 (39%)	187 (33%)
	> 65	30 (16%)	15 (8%)	24 (13%)	69 (12%)
Gender	Female	0 (0%)	24 (13%)	10 (5%)	34 (6%)
	Male	188 (100%)	158 (85%)	179 (95%)	525 (93%)
	Prefer not to say	0 (0%)	3 (2%)	0 (0%)	(1%)
Education	No formal schooling	29 (15%)	3 (2%)	13 (7%)	45 (8%)
	Primary education	51 (27%)	19 (10%)	48 (25%)	118 (21%)
	Secondary education	84 (45%)	38 (20%)	49 (26%)	171 (30%)
	Technical training	4 (2%)	70 (38%)	16 (9%)	90 (16%)
	Bachelor degree	13 (7%)	34 (18%)	33 (18%)	80 (14%)
	Master degree or higher	0 (0%)	21 (11%)	30 (16%)	51 (9%)
Ownership	Sole or family-owned	154 (82%)	138 (78%)	146 (78%)	438 (78%)
	Other	34 (18%)	38 (22%)	42 (22%)	114 (22%)
Role of farm for income	Sole income	155 (82%)	124 (67%)	134 (71%)	413 (73%)
	Second job	28 (15%)	44 (24%)	45 (24%)	117 (21%)
	Hobby	5 (1%)	17 (3%)	10 (2%)	32 (6%)
Median time spent farming		26 years	23 years	24 years	25 years
Median farm size		20 ha	36 ha	44 ha	30 ha
Union membership		139 (74%)	111 (60%)	103 (55%)	353 (63%)
Organic farming		0	92 (50%)	0	92 (16%)
Minimum tillage		100 (54%)	140 (77%)	71 (38%)	311 (55%)

Statistical analysis

We synthesized the sociodemographic information of 590 participating farmers into a table and removed rows with missing values. This resulted in a dataset of 562 responses (Morocco, n = 188, Spain, n = 185, Tunisia, n = 189). The respondent profile is shown in Table 1.

To analyze the responses to the free association question on cognitive associations with soil, we first cleaned the raw data by correcting spellings, removing common words, and grouping together similar concepts. Where multiple concepts were expressed in a single item, these were "separated into multiple" items (Keddem et al. 2021, p3). We then calculated the cumulative cognitive salience of each term using the AnthroTools package in R (Purzycki and Jamieson-Lane 2017; Fremout et al. 2021). Cognitive salience is a measure that considers the frequency and the mean rank of a free-listed term, i.e. how often it is mentioned and whether it is mentioned first or subsequently in a list (Sutrop 2001). It is calculated as S = F/(NR) where F is term frequency, N is the number of participants, and R is the mean rank. Terms closer to the value of 1 are mentioned more frequently and towards the beginning of a free-list, whereas those closer to the value of 0 are mentioned less frequently and towards the end of a free-list (Wartmann and Purves 2018). We compared cumulative cognitive salience of terms among countries and among respondents implementing minimum tillage and those tilling conventionally.

To analyze the Likert item responses on tillage and sociocultural aspects, we first calculated the quality of the dataset with Cronbach's Alpha, a statistic that represents the equivalence across a set of items and suggests data reliability (Taber 2018). We then synthesized the responses to the individual Likert items, then compared them by tillage type and country visually using the 'likert' and 'HH' packages, and checked for association among responses and tillage practice with bivariate statistics (Fogarty 2019). For the statements on agricultural tradition, innovation, community, and adaptive capacity with relation to soil, we checked the correlations among these Likert item responses with Spearman's rank correlation. We then created scales of agricultural tradition, community integration, adaptive capacity, and responsibility for soil by taking the mean of the responses to related Likert items (Booysen 2002; Becker et al. 2017; Greco et al. 2019). For example, for the mean of preference for "agricultural innovation", we combined the Likert item responses for the following statements: "It is important to me to follow what my ancestors did on the land"; "It is important to me to follow international farming trends"; "Innovation is more important to me than tradition" and "There is no need to change farming practices that have been in place for a long time." For negative statements, we reversed the response to facilitate the positive scale.

To investigate the associations among these responses and the farmer characteristics, we used the resulting means as response variables in linear regression models, with age, education level, country, farming lifestyle, farm ownership, farm size, union membership, tillage practice, and organic farming as explanatory variables. We checked variable distributions for normality and log transformed farm size as this variable was highly skewed. We checked for homoscedasticity with the studentized Breusch-Pagan test, and when confirmed, ran the models using robust standard errors using the coeftest function from the 'sandwich' package. We checked diagnostic plots and tested the models for fit and overdispersion with the 'Dharma' package.

For the open question on traditional farming practices, we analyzed the responses by reviewing and coding the responses into different categories, then aggregating the identified practices by country. We then considered how these practices may be related to soil management and to the theme of tradition and innovation in Mediterranean landscapes. All analyses were performed in R Version 1.3.1093 and MaxQDA Version 2022.

Results

Concepts associated with soil

The free association exercise resulted in 131 concepts listed by respondents that they cognitively relate with soil. The most frequent and most salient term was "life" (F = 170) followed by "livelihood" (F = 117) and "agriculture" (F = 97). The salience of listed terms varied by country and tillage practice (Fig. 2). For example, "biodiversity", "nature" and "land" were more salient among those practicing minimum tillage (S = 0.05, S = 0.04 and S = 0.09, respectively) than those practicing conventional (S = 0.02, S = 0.02 and S = 0.04, respectively). Conversely, "inheritance" and "future" were more salient among those practicing conventional tillage (S = 0.05 and S = 0.04) compared to those practicing minimum tillage (S = 0.01 and S = 0.01, respectively). When comparing these terms by country, it is clear that the term "biodiversity" was more salient among farmers in Spain (S = 0.1) than Morocco and Tunisia (S = 0 and S = 0.01, respectively), whereas "inheritance" was only salient among farmers in Tunisia (S = 0.12) and "future" was mostly salient among farmers in Tunisia (S = 0.10).

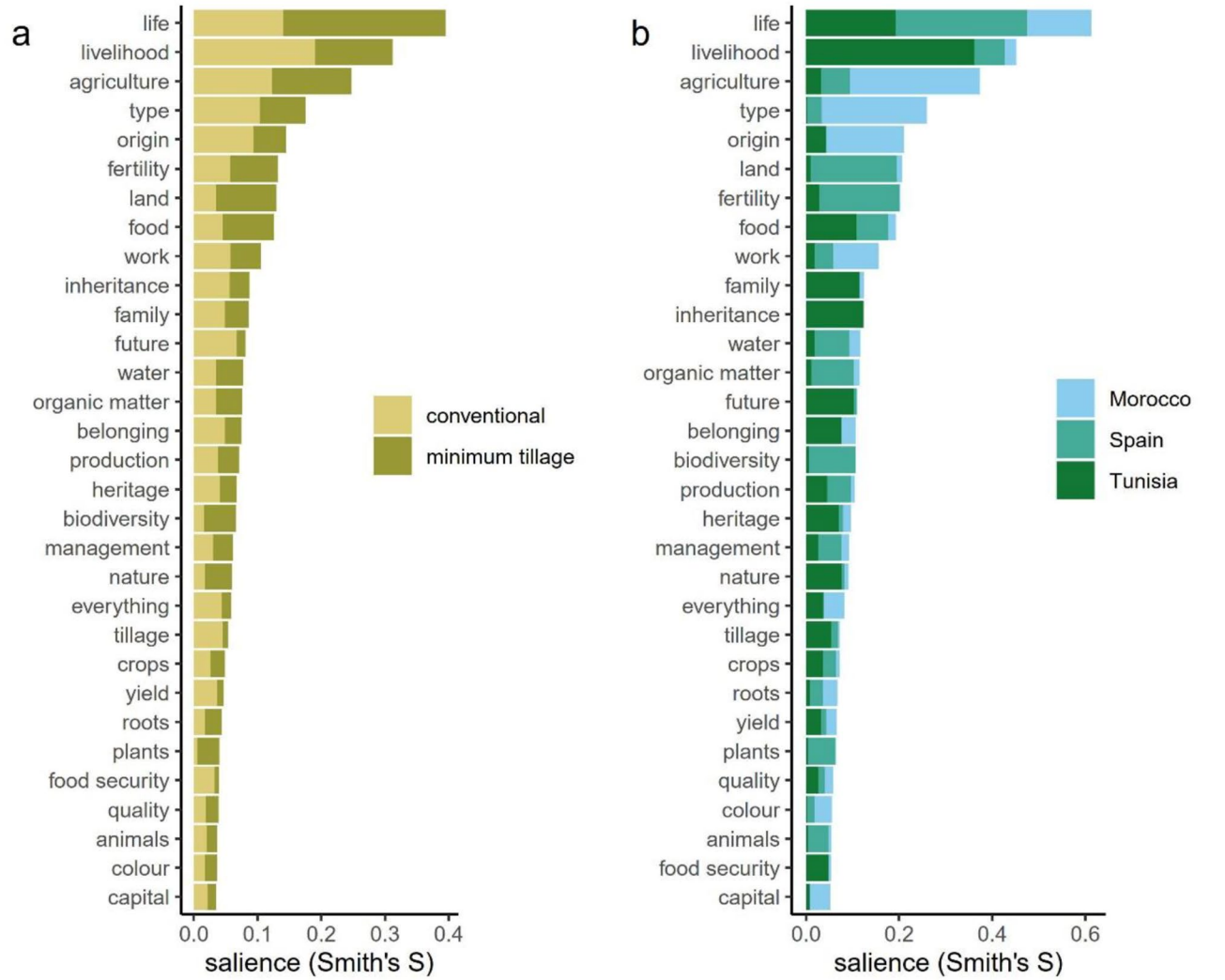

Fig. 2 Salience scores of terms identified by respondents as related to the concept of soil through the free association survey question, separated by tillage practice (**2a**, left) and country (**2b**, right). Salience scores are calculated based on within-group sample sizes

Perceptions of tillage

The reliability testing of the dataset resulted in a Cronbach's Alpha of 0.68. The widely applied "rule-of-thumb" threshold measure of acceptable data reliability is an alpha of 0.7 (Taber 2018). In comparing responses to statements about tillage between farmers practicing conventional and minimum tillage, we found that the greatest difference of opinion was related to yield (Cramer's V 0.39, Fig. 3), where more farmers practicing conventional tillage agreed with the notion of a positive relationship between tillage and yield. In contrast, the majority of respondents from both groups disagreed that tillage and water availability are unrelated (Cramer's V 0.16).

Sociocultural aspects of soil management

Responses to statements on sociocultural aspects were organized into four thematic groups: tradition and innovation, community integration, perceived adaptive capacity, and responsibility for soil management. Overall, respondents perceived innovation to be more important than tradition (73.8%), and disagreed with the notion that farming practices should be kept in place if they have been practiced for a long time (78.1%, Fig. 4). Respondents generally felt they had the capacity to improve the soils on their farm, and perceived themselves to be adaptable. In terms of community integration, respondents generally perceived themselves to be active in their farming community. The majority of respondents expressed that responsibility for soil on their farm was their own (93.4%), but that in general,

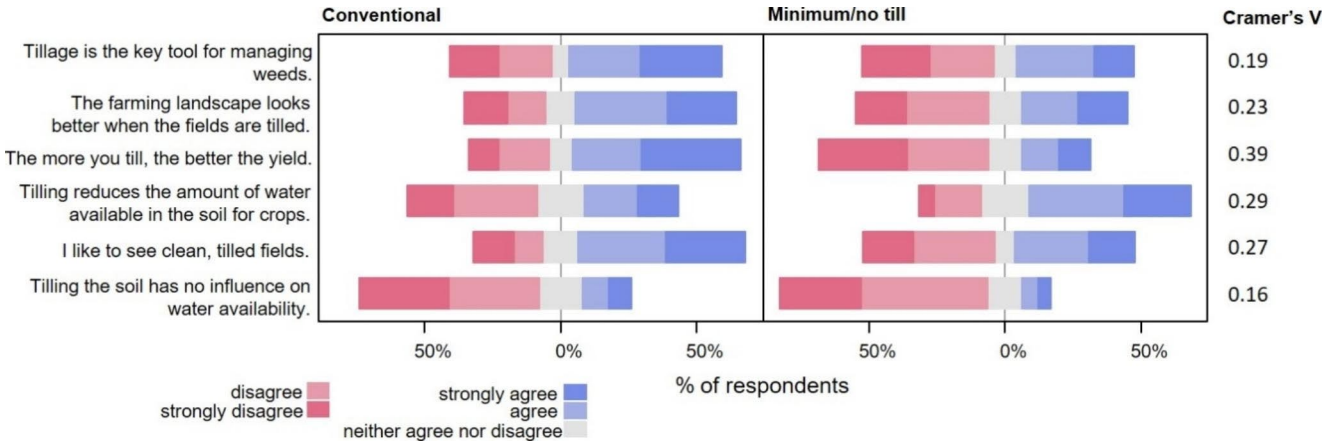

Fig. 3 Responses to the Likert scale statements on tillage. Bars show responses from respondents separated by tillage practice (conventional tillage, n = 245, minimum tillage, n = 311)

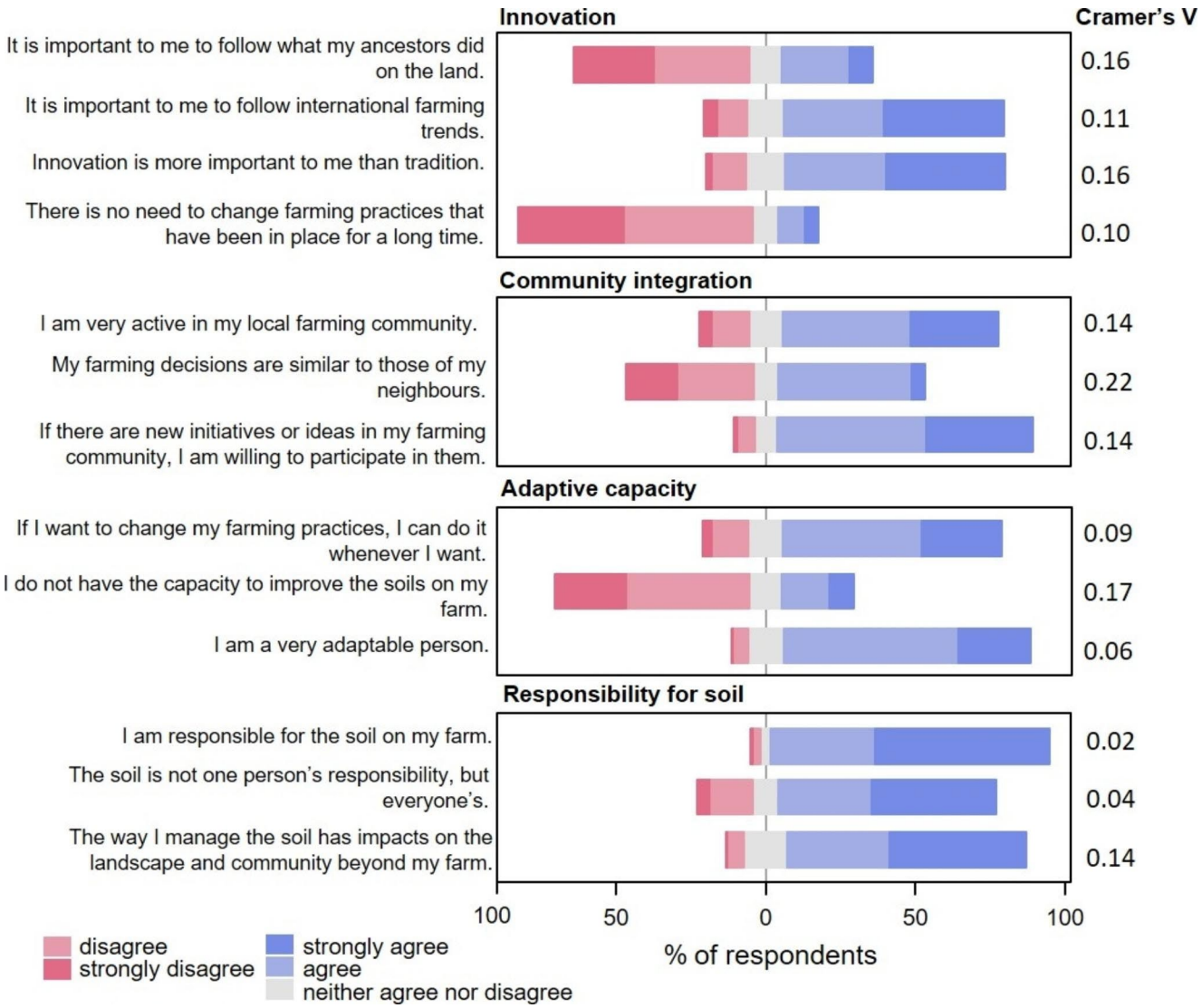

Fig. 4 Responses to the Likert scale statements on four themes related to soil management; innovation, community integration, adaptive capacity, and responsibility for soil. Bars show responses from all farmers grouped together (n = 562)

responsibility for soil should be shared (73.1%). In terms of the differences among conventional and CA farmers, the strongest difference was for the perceived similarity of farming decisions to those of their neighbors, where more conventional farmers than CA farmers agreed with this statement (Cramer's V 0.22).

Relationships among sociocultural aspects and farmer characteristics

The results of the multiple linear regression models show that sociocultural aspects are associated with sociodemographic variables and tillage practice of respondents. We report here the results that were statistically significant ($p < 0.1$). Age was negatively associated with innovation, suggesting that older respondents are less likely to value innovation over tradition (Table 2; Fig. 5). Innovation, adaptive capacity and responsibility for soil were positively associated with education. However, education was negatively associated with community integration, suggesting that respondents with a higher level of education perceive less integration in their community, including less similarity to their neighbors' decisions (Fig. 5).

Perceptions differed significantly among countries, with the importance of innovation over tradition, and community integration generally greater in Morocco and Tunisia than Spain, while responsibility for soil perceived as generally greater in Tunisia than Spain and Morocco (Fig. 5). Agriculture as main form of income and having a second job were positively associated with adaptive capacity and perceived responsibility for soil. Non-ownership was negatively associated with openness to innovation, and larger farm size was positively associated to community integration. Union membership was positively associated with community integration and adaptive capacity. Practicing minimum and no-tillage was positively associated with innovation, perceived adaptive capacity, and responsibility for soil, but had no association with community integration. Overall, agreement in perception was generally high among respondents and the model coefficients were very small, except for innovation and tradition (Table 2; Fig. 5).

Agricultural traditions related to soil management

As a follow-up to the Likert-type questions on tradition, respondents were asked to name any practices that they saw to be traditional to the region. The most commonly named practices across all three countries were the use of specific crops that were cultivated more frequently in the past than in the present (Table 3). These crops included local varieties of grains (Morocco and Tunisia) and legume cultivars and viticulture (Spain). Use of animals, primarily for

Table 2 Model results for Likert scale responses related to innovation, community integration, perceived adaptive capacity and responsibility for soil. Results that are statistically significant ($p < 0.1$) are highlighted in bold

	Innovation			Community (Robust)			Adaptive capacity (Robust)			Responsibility (Robust)		
	Estimate	Std. Error	Pr	Estimate	Std. Error	Pr	Estimate	Std. Error	Pr	Estimate	Std. Error	Pr
(Intercept)	3.98	0.19	**< 0.1**	3.69	0.20	**< 0.1**	3.16	0.21	**< 0.1**	3.41	0.16	**< 0.1**
Age	-0.08	0.03	**< 0.1**	-0.02	0.03	0.58	0.02	0.04	0.58	0.03	0.03	0.31
Education	0.07	0.02	**< 0.1**	-0.05	0.02	**< 0.1**	0.07	0.03	**< 0.1**	0.07	0.02	**< 0.1**
Country_Spain	-1.19	0.09	**< 0.1**	-0.36	0.09	**< 0.1**	-0.19	0.09	**< 0.1**	-0.04	0.08	0.62
Country_Tunisia	-0.19	0.08	**< 0.1**	0.16	0.07	**< 0.1**	-0.17	0.09	**< 0.1**	0.57	0.06	**< 0.1**
Second_job	0.10	0.14	0.48	0.01	0.14	0.93	0.25	0.14	**< 0.1**	0.23	0.11	**< 0.1**
Sole_income	0.04	0.13	0.78	-0.01	0.13	0.96	0.23	0.13	**< 0.1**	0.18	0.11	0.11
Ownership_other	-0.14	0.07	**< 0.1**	-0.09	0.08	0.26	-0.07	0.08	0.36	0.00	0.06	0.99
Farm size (log)	0.02	0.02	0.34	0.04	0.02	**< 0.1**	0.03	0.02	0.13	0.03	0.02	0.15
Union	0.04	0.06	0.53	0.19	0.06	**< 0.1**	0.16	0.07	**< 0.1**	-0.05	0.05	0.32
Minimum tillage	0.31	0.06	**< 0.1**	0.02	0.06	0.66	0.12	0.07	**< 0.1**	0.16	0.05	**< 0.1**
Organic	-0.10	0.10	0.32	-0.16	0.11	0.12	-0.01	0.09	0.97	0.00	0.09	0.98
Adjusted R2	0.36			0.16			0.05			0.25		

Note: The values for the model intercept include the first levels of the following categorical variables: country, farming income and ownership, namely Morocco, hobby farming and family/sole ownership.

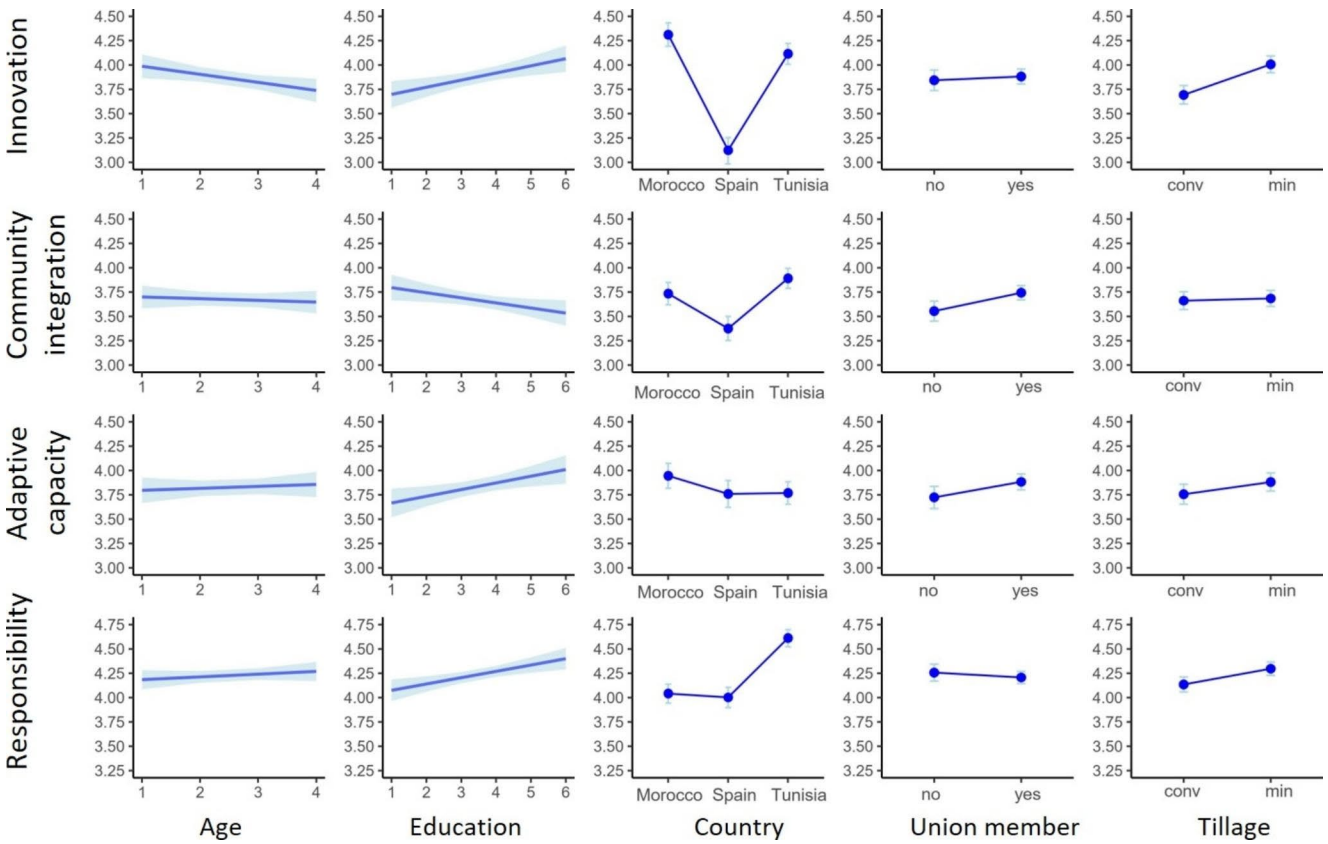

Fig. 5 Coefficients of linear regression models for mean responses to items in themes of innovation, community integration, adaptive capacity and responsibility for soil (y axes) for selected independent variables age, education, country, union membership and tillage practice (x axes). Bands and bars show 95% confidence intervals

pulling machinery, was the second most commonly mentioned practice, followed by performing tasks by hand, including sowing, weeding and harvesting. In relation to direct soil management, deep or repeated tilling was identified as a traditional practice, but one that was no longer so prevalent. Fertilizers such as slurry were also identified as being historically important. Cultural rituals related to tillage were identified in Morocco, including breaking bread or a pomegranate on the plough for good luck, demonstrating the cultural significance of disturbing the soil. Some farmers perceived use of hand tools, wooden implements and less intensive farming on smaller farms as traditional, while some farmers, primarily in Spain, viewed intensive practices, such as production of cereal monocultures, as the traditional approach in their region.

Discussion

Cognitive associations with soil

The free-association analysis revealed that farmers generally associate soil with the concept of life, and recognize it as a medium linked to life cycles and the origin of life. This suggests general awareness among the respondents of soil as a living resource. However, the second and third most salient terms were livelihood and agriculture, demonstrating the value placed on soil as a component of farming. The concept of yield was more salient among those farmers practicing conventional agriculture, suggesting a more productivist mindset connected to soil, where soil is seen as a farming asset (Lavoie and Wardropper 2021). However, the concept of biodiversity was more salient among those farmers practicing minimum and no-tillage, suggesting that these farmers identify the biological life of soil, a concept that goes more toward valuing the soil for its intrinsic value as opposed to its instrumental value (Baveye et al. 2016; Hervé et al. 2020). The salience of the terms nature and land among these farmers also indicates greater awareness of a conservation ethic.

Many of the different concepts identified were more salient among farmers in one country than the others. These differences may be due to language used to describe the concepts associated with soil, with cultural differences among regions suggesting different attachments to soil and farmland, and also with the farming approaches and identities

Table 3 Categories of traditional and cultural practices identified by farmers in Morocco, Spain and Tunisia

Traditional Practice	Morocco		Spain		Tunisia		Total
	N farmers	% Row total	N farmers	% Row total	N farmers	% Row total	
Specific crops/products (e.g. local seed varieties)	20	18.2	67	60.9	23	20.9	110
Use of animals (traction)	72	70.6	15	14.7	15	14.7	102
Performing tasks manually (e.g. planting/weeding/harvesting by hand)	26	31.3	7	8.4	50	60.2	83
Deep/repeated tilling	20	26.3	29	38.2	27	35.5	76
Use of specific tools and machinery (e.g. wooden tools)	30	60.0	20	40.0	0	0.0	50
Broadcast seeding	0	0.0	0	0.0	39	100.0	39
Specific fertilizer types (e.g. slurry, manure)	10	30.3	22	66.7	1	3.0	33
Timing of tasks (e.g. following lunar calendar)	15	48.4	14	45.2	2	6.5	31
Agriculture approach (e.g. monoculture)	0	0.0	21	95.5	1	4.5	22
Leaving fallow/pasture	5	25.0	15	75.0	0	0.0	20
Animal husbandry/breeding	5	27.8	13	72.2	0	0.0	18
Landscape features (e.g. terraces, stone walls)	0	0.0	15	100.0	0	0.0	15
Animal forage (e.g. in surrounding forest)	0	0.0	15	100.0	0	0.0	15
Use of insecticides/herbicides	0	0.0	14	93.3	1	6.7	15
Cultural rituals including food	10	100.0	0	0.0	0	0.0	10
Smaller farms	8	88.9	1	11.1	0	0.0	9
Flood irrigation	0	0.0	6	100.0	0	0.0	6
Burning fields	0	0.0	3	100.0	0	0.0	3
Gendered/family ordered tasks	0	0.0	1	100.0	0	0.0	1
Total	221		278		159		658

N refers to number of farmers that mentioned the practice from each country, while the percentage is of the row total

in each region. For example, in the region of Catalonia in Spain, many farmers practice organic or small-scale mixed farming that includes not only arable production but also arboriculture and horticulture, and place value on farming systems that incorporate biodiversity. This ecological mindset may also be related to the location of many of these farms in the Gallecs region, which is partially managed as a nature protection area. Corresponding farming identities can shape farmers' perceptions of their natural resources (McGuire et al. 2015).

The different concepts identified demonstrate how soil can be perceived at multiple cognitive levels. Soil was perceived as a foundation for life and linked with life cycles, not only from a farming perspective, but from a broader human perspective. Multiple respondents linked soil with family and belonging, while several noted the role of soil in death and burial, a human ritual that involves physical processes but is also imbued with social meaning. Thus we can see that respondents' perceptions of soil can be grounded in fundamental understanding of the role of soils in provisioning for basic human needs, but also to more advanced social constructs of agricultural management and technology, and to higher 'self-actualization' needs, including belonging and social ritual (Dominati et al. 2010).

Perceptions related to tillage

Respondents performing conventional tillage perceived tillage to have benefits related to yield, weed management and farm aesthetics more than those performing minimum tillage. A main challenge for farmers that do not use herbicides is to integrate reduced tillage with weed management (Casagrande et al. 2016). Another important aspect to address is the perception of how tillage affects soil water availability. Our findings suggest that many farmers practicing conventional tillage do not perceive tillage to have a negative impact on water availability, although in dry years CA systems have been shown to reduce evaporation to the benefit of the crop and yield stability (Vastola et al. 2017). These results demonstrate diverging beliefs on the effects of tillage for soil health among farmers, whose practices may not always achieve optimum soil condition for their region and farm. Proponents of CA must address these beliefs in order to increase its uptake, including demonstrating how sufficient yields may still be achieved with CA (Devkota et al. 2022).

Sociocultural aspects of soil management

We found that education and tillage practices were consistently associated with four sociocultural aspects of soil management, similar to many studies elsewhere (e.g. de Graaff

et al. 2008). These associations were observable when differences among countries were also considered. In terms of innovation, farmers with a higher level of education may have more exposure to innovative technologies and the knowledge as to how to implement them. Along with education, age also plays a role in the shift towards adoption of new practices, as younger farmers may take over from the previous generation, or be more open-minded toward trying new approaches, such as reduced tillage and no-till (Ahnström et al. 2009; Koutsou et al. 2014; Dhehibi et al. 2019; Mrabet et al. 2022). While respondents in Morocco and Tunisia were similar in terms of preference for innovation, respondents in Spain expressed less preference for innovation over tradition. This may be due to the ecological mindset among this particular farming community. Traditional practices can be viewed as low-intensity and thus more ecologically sound than modern intensive farming, which requires heavy inputs in terms of fertilizers and pesticides. In Morocco and Tunisia, emphasis on increasing productivity by government over the past half-century has encouraged a shift away from traditional low-intensity practices (Mrabet et al. 2022). The low number of women in the sample may also impact the results, as a gender gap has been observed for technological adoption and attitudes toward agrobiodiversity. While women may be more receptive to adoption of certain practices and nature conservation on farms, they can be hindered by lack of access to and knowledge of technologies (Druschke and Secchi 2014; Theis et al. 2018). The limited number of women interviewed may be explained by rural demographics, such as the aging and masculinization of depopulated areas (Camarero and Oliva 2019).

Interestingly, level of education was negatively associated with perceived community integration, suggesting that farmers with a higher level of education may consider themselves as apart to the wider farming community. Within this theme, we found that the strongest difference among farmers practicing minimum and conventional tillage was for the perceived similarity of farming decisions to those of their neighbors. This perception may be representative of "pioneer" farmers, that implement a new method or approach before it becomes widespread. Such methods may include conservation agriculture approaches, or organic methods, which have been found to stigmatize farmers when this approach is viewed negatively by the wider farming community (Lähdesmäki et al. 2019). These farmers are the crucial innovators that are the first to adopt new technologies in the DOI theory. Ensuring that the network of innovators is open to newcomers is another key aspect for promoting CA (Padel 2001).

Lower scores for perceived community integration were found for respondents from Spain, where many farmers are practicing organic farming, in comparison to those from Morocco and Tunisia. However, we did not find an association among perceived community integration and tillage practice or organic practice, suggesting that farmers' perceptions of their community integration may be related to other sociocultural aspects, social structures or practices. One such aspect is union membership, that enables networking among farmers on shared issues of interest, such as environmental regulations (Mills et al. 2017). Association membership has been shown to be an important factor for farmers' adoption of innovative technologies in Tunisia (Dhraief et al. 2019a).

Climate change, drought, fluctuating global market conditions and rising costs challenge the concept that Mediterranean farmers may operate in predictable change conditions (Darnhofer et al. 2009; Mrabet et al. 2022). Perceived capacity to adapt and change is therefore an important component of uptake of soil conservation measures. If farmers feel that they do not have the opportunity or the means to improve their soils, this may suggest a lack of available information or assistance for soil improvement, as well as perceived environmental limitations. Adaptive capacity may also link to the variety of options that farmers believe they have, including off-farm income (Dhraief et al. 2019b). Again, we found that farmers with a higher level of education perceived themselves to have greater adaptive capacity to manage soil, as well as those in unions, echoing Rust et al. (2020) who posit that adaptiveness in the context of soil management can be linked to connectedness and social norms.

In addition to adaptive capacity, perceived responsibility for soil is a cognitive variable that has been found to have a positive effect on the adoption of soil conservation practices (Lynne et al. 1988; Vignola et al. 2010). Indeed, we found that farmers implementing minimum and no-tillage perceived greater responsibility for soil, although we found general agreement with the notion of farmers' responsibility for soil, both on the land they manage and beyond. Responsibility was related to farmers with a higher level of education, as found by García-Martín et al. (2018), who revealed strong links among placement attachment, environmental awareness and responsibility across multiple European sites. This sense of responsibility is a core component of relational values, a concept that emphasizes bidirectional relations between humans and nature (Chan et al. 2016; Deplazes-Zemp and Chapman 2021). It is important to note that these are only simple answers but attitudes and perceptions towards conservation in agriculture are complex and multifaceted (Reimer et al. 2012). Deeper engagement in the form of extended interviews with farmers could shed more light on these themes.

Traditional practices and relation to soil management

Mediterranean countries have long arable farming histories and traditions compared to other areas of the world that have a large uptake of CA, such as Australia, South Africa and the USA. By asking farmers what practices they consider traditional to their region, we could identify links among agricultural tradition and soil management. The majority of practices identified were on-farm activities for production. Many of these are directly related to soil management, such as animal traction, deep and repeated tilling and use of animal manure as fertilizer. These practices are generally less common following intensification and mechanization across Mediterranean agriculture, but are still used in some areas, with implications for soil health. For example, in Catalonia, Spain, the application of pig slurry can result in soil, water and air pollution and requires high levels of monitoring by farmers, which may be a problem when farmers need to simultaneously increase production and observe environmental regulations (Barbeta-Viñas and Requena-i-Mora 2022).

Manual farming activities including planting, weeding and harvesting by hand were identified more frequently among respondents in Morocco and Tunisia than in Spain. This is likely a consequence of the socioeconomic differences in farming among these countries, with availability of human labor and pressure for resources being higher in the southern Mediterranean (Kassam et al. 2020; Mrabet et al. 2022). A more balanced gender representation may provide more detail on gendered tasks, which were mentioned by few participants. This is important since the number of women in farming has been slowly increasing in recent years (Eurostat 2022). In addition to on-farm activities, respondents in Morocco identified the cultural activity of breaking bread or eating pomegranate on the first day of tilling, demonstrating how tillage is historically a celebrated part of agricultural routine. The plough has long been a symbol of "good" farming from which farmers derive meaning and cultural capital (Burton et al. 2008). Respondents in all three countries identified deep tillage as a traditional practice, indicating how this type of soil preparation has been historically embedded in agricultural tradition.

Study limitations

We recognize that our study has some limitations inherent in the methods employed and the data generated. The analysis of keywords in the free association exercise is limited, particularly for the subject of soil, where many terms have multiple meanings, making interpretation challenging. For example, 'working' the soil can relate to tilling the soil or ploughing, but some respondents mentioned 'hard work', referring to the effort they must make for farming and taking care of their land. Where words may be interpreted to have more than one meaning, they were assigned to all relevant codes. In addition, we recognize that the Likert scales can be arbitrary, and the positions related to each Likert statement may not be mutually exclusive, although the correlation analysis (Supplementary Material 2) suggests correlation among the Likert item responses put together for the mean scores. While we aimed to target a range of farmers including those who had not been involved in previous extension or research activities, some bias towards these farmers may be a result of the sampling.

Conclusion

Our study linked tillage practices to perceptions of soil and sociocultural aspects of soil management among Mediterranean farmers. We could only partially confirm our first hypothesis that CA farmers have different conceptions of soil as a resource compared to conventional farmers, as this was true for environmental themes such as biodiversity, but not for the association of soil to themes such as life, agriculture and fertility. We found that farmers recognize social and cultural values of soil as well as livelihood value. Emphasizing these multiple values in outreach and extension programs could help foster farmers' perceived responsibility for soil, a characteristic we found to be related to reducing tillage.

We were also able to partially confirm our second hypothesis, as we found that CA adoption is related to some sociocultural aspects of management, such as openness to innovation. Many farmers in our study held beliefs that tillage is beneficial for yield and water availability. As drought pressures increase, yield stability through soil health becomes more important across the region. Thus, the benefits of reduced tillage for water retention must continue to be promoted, whether that be through training, providing examples of successful local soil improvement, free trial days or other forms of support. This support may also help to develop farmers' own adaptive capacity for soil management, another sociocultural aspect that we identified to play a role for soil conservation. Importantly, effort should be made to reach farmers that are not in existing extension or scientific networks. For farmers without higher levels of education or scientific backgrounds, both theory and implementation of CA should be presented in straightforward and accessible terms. It is also important to accept that late-adopters require time and tailored advice to adopt, according to DOI theory (Padel 2001).

Our study also found differences in perceptions among countries, suggesting that CA promotion should be tailored

to the local context. In Morocco and Tunisia, special attention should be paid to a more participatory approach for integrating environmental issues into the farmers' need to generate profit. In Spain, where environmental aspects such as biodiversity are more widely recognized, particularly among the organic farming community, technical support to integrate organic farming with reduced tillage should be priority. Recognizing the cultural and traditional practices that relate to soil in local regions could be useful when advocating for specific practices to be locally acceptable.

To date, investigation of the psychological and cultural factors that underpin adoption of CA have taken place largely in Europe, North America or sub-Saharan Africa, and often as single-country studies. Our study advances this understanding in the Mediterranean context, with a cross-country perspective that provides insights for the wider region. We shed light on the salient concepts underpinning farmers' relationship to soil, an under-researched human-nature relationship that has crucial implications for future agricultural resilience. Further research could focus in greater depth on farmers' understanding of tillage and soil health, their preferences for agricultural traditions, as well as their roles for soil and landscape stewardship across the Mediterranean.

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Authors' contributions HC, CQS, TP, ET conceived the study; OEG, LR, MEA, AS, JP, HCM, MZD, MZ collected data; MEA, AS, LR, MZD, MZ translated and collated data; ET and MEA analyzed the data; HC, OEG, TP, CQS acquired funding; ET wrote the manuscript with input from all authors.

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Data Availability The data are available from the corresponding author on reasonable request.

Statements and Declarations

Competing Interests The authors confirm that they have no competing interests that are relevant to the content of this article.

Ethics approval Prior to beginning the study, we conducted an ethics self-assessment from the University of Kassel and were recommended to take an ethically sensitive approach with adherence to scientific standards, but not required to obtain clearance from the university's ethics committee.

Consent to participate All respondents gave their consent to participating in the study by completing a consent form that informed the respondent of their right to withdraw from the study at any time, that their data would be treated confidentially and they would be pseudonymised, their right to request their data, the potential uses of the data and data privacy regulations.

Consent for publication The authors confirm that the respondents provided informed consent for publication of data acquired from their participation.

References

Aguilera, E., L. Lassaletta, A. Sanz-Cobena, J. Garnier, and A. Vallejo. 2013. The potential of organic fertilizers and water management to reduce N2O emissions in Mediterranean climate cropping systems. A review. *Agriculture Ecosystems and Environment* 164: 32–52. https://doi.org/10.1016/j.agee.2012.09.006.

Ahnström, J., J. Höckert, H. L. Bergeå, C. A. Francis, P. Skelton, and L. Hallgren. 2009. Farmers and nature conservation: what is known about attitudes, context factors and actions affecting conservation? *Renewable Agriculture and Food Systems* 24: 38–47. https://doi.org/10.1017/S1742170508002391.

Ajzen, I. 1991. The theory of Planned Behaviour. *Organizational Behavior and Human Decision Processes* 50: 179–211. https://doi.org/10.47985/dcidj.475.

Barbeta-Viñas, M., and M. Requena-i-Mora. 2022. The paradoxes of dairy farmers in Catalonia (Spain): Crisis and 'double bind'. *Sociologia Ruralis* 62: 91–111. https://doi.org/10.1111/soru.12357.

Bartling, M., A. C. Robinson, H. Achicanoy Estrella, and A. Eitzinger. 2022. The impact of user characteristics of smallholder farmers on user experiences with collaborative map applications. *Plos One* 17: 1–30. https://doi.org/10.1371/journal.pone.0264426.

Baveye, P. C., J. Baveye, and J. Gowdy. 2016. Soil "ecosystem" services and natural capital: critical appraisal of research on uncertain ground. *Frontiers in Environmental Science* 4: 1–49. https://doi.org/10.3389/fenvs.2016.00041.

Becker, W., M. Saisana, P. Paruolo, and I. Vandecasteele. 2017. Weights and importance in composite indicators: closing the gap. *Ecological Indicators* 80: 12–22. https://doi.org/10.1016/j.ecolind.2017.03.056.

Bijttebier, J., G. Ruysschaert, R. Hijbeek, M. Werner, A. A. Pronk, L. Zavattaro, and L. Bechini et al. 2018. Adoption of non-inversion tillage across Europe: Use of a behavioural approach in understanding decision making of farmers. *Land Use Policy* 78: 460–471. https://doi.org/10.1016/j.landusepol.2018.05.044.

Billiet, J. B., and M. J. McClendon. 2000. Modeling acquiescence in measurement models for two balanced sets of items. *Structural Equation Modeling* 7: 608–628. https://doi.org/10.1207/S15328007SEM0704_5.

Booysen, F. 2002. An overview and evaluation of composite indices of development. *Social Indicators Research* 59: 115–151. https://doi.org/10.1023/A:1016275505152.

Borges, J., A. Rossi, A.G.J.M. Oude Lansink, C. Marques Ribeiro, and V. Lutke. 2014. Understanding farmers' intention to adopt improved natural grassland using the theory of planned behavior. *Livestock Science* 169: 163–174. https://doi.org/10.1016/j.livsci.2014.09.014.

Burton, R. J. F., C. Kuczera, and G. Schwarz. 2008. Exploring farmers' cultural resistance to voluntary agri-environmental schemes. *Sociologia Ruralis* 48: 16–37. https://doi.org/10.1111/j.1467-9523.2008.00452.x.

Camarero, L., and J. Oliva. 2019. Thinking in rural gap: mobility and social inequalities. *Palgrave Communications* 5: 1–7. https://doi.org/10.1057/s41599-019-0306-x.

Casagrande, M., J. Peigné, V. Payet, P. Mäder, F. Xavier Sans, J. M. Blanco-Moreno, and D. Antichi et al. 2016. Organic farmers' motivations and challenges for adopting conservation agriculture in Europe. *Organic Agriculture* 6: 281–295. https://doi.org/10.1007/s13165-015-0136-0.

Cerdà, A., J. Rodrigo-Comino, A. Giménez-Morera, and S. D. Keesstra. 2017. An economic, perception and biophysical approach to the use of oat straw as mulch in Mediterranean rainfed agriculture land. *Ecological Engineering* 108: 162–171. https://doi.org/10.1016/j.ecoleng.2017.08.028.

Chan, K. M. A., P. Balvanera, K. Benessaiah, M. Chapman, and S. Díaz. 2016. Why protect nature? Rethinking values and the environment. *Pnas* 113: 1462–1465. https://doi.org/10.1073/pnas.1525002113.

Cramer, W., J. Guiot, M. Fader, J. Garrabou, J. P. Gattuso, A. Iglesias, and M. A. Lange et al. 2018. Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change* 8: 972–980. https://doi.org/10.1038/s41558-018-0299-2.

Darnhofer, I., S. Bellon, B. Dedieu, and R. Milestad. 2009. Adaptiveness to enhance the sustainability of farming systems. *Sustainable Agriculture* 2: 45–58. https://doi.org/10.1007/978-94-007-0394-0_4.

Bicalho, De Souza Mello, A. M., and R. Trippia Dos Guimarães Peixoto. 2016. Farmer and scientific knowledge of soil quality: a social ecological soil systems approach. *Belgeo* 2016: 0–21. https://doi.org/10.4000/belgeo.20069.

de Graaff, J., A. Amsalu, F. Bodnár, A. Kessler, H. Posthumus, and A. Tenge. 2008. Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. *Applied Geography* 28: 271–280. https://doi.org/10.1016/j.apgeog.2008.05.001.

Deplazes-Zemp, A., and M. Chapman. 2021. The ABCs of relational values: environmental values that include aspects of both intrinsic and instrumental valuing. *Environmental Values* 30: 669–693. https://doi.org/10.3197/096327120X15973379803726.

Devkota, M., K. P. Devkota, and S. Kumar. 2022. Conservation agriculture improves agronomic, economic, and soil fertility indicators for a clay soil in a rainfed Mediterranean climate in Morocco. *Agricultural Systems* 201: 103470. https://doi.org/10.1016/j.agsy.2022.103470.

Dhehibi, B., U. Ruediger, and M. Z. Dhraief. 2019. *Factors Influencing Farmers' Decisions to Adopt Improved Technologies in Semi-Arid Farming Systems: A case study of the barley variety Kounouz and feed blocks technology in Tunisia*. Working paper, International Center for Agricultural Research in the Dry Areas (ICARDA), Cairo, Egypt.

Dhraief, M. Z., S. Bedhiaf, B. Dhehibi, M. Oueslati-Zlaoui, O. Jebali, and S. Ben-Youssef. 2019a. Factors affecting innovative technologies adoption by livestock holders in arid area of Tunisia. *New Medit* 18: 3–18. https://doi.org/10.30682/nm1904a.

Dhraief, M. Z., B. Dhehibi, H. Daly Hassen, M. Zlaoui, C. Khatoui, S. Jemni, and O. Jebali, M.Rekik. 2019b. Livelihoods strategies and household resilience to food insecurity: a case study from rural Tunisia. *Sustainability (Switzerland)* 11: 1–17. https://doi.org/10.3390/su11030907.

Dominati, E., M. Patterson, and A. Mackay. 2010. A framework for classifying and quantifying the natural capital and ecosystem services of soils. *Ecological Economics* 69: 1858–1868. https://doi.org/10.1016/j.ecolecon.2010.05.002.

Druschke, C. G., and S. Secchi. 2014. The impact of gender on agricultural conservation knowledge and attitudes in an Iowa watershed. *Journal of Soil and Water Conservation* 69: 95–106. https://doi.org/10.2489/jswc.69.2.95.

Eurostat. 2022. Labor force Survey 2022. Available at: https://ec.europa.eu/eurostat/databrowser/explore/all/popul?lang=en&subtheme=labour.employ&display=list&sort=category (accessed 16/05/2023).

Fagerholm, N., M. Torralba, G. Moreno, M. Girardello, F. Herzog, S. Aviron, and P. Burgess et al. 2019. Cross-site analysis of perceived ecosystem service benefits in multifunctional landscapes. *Global Environmental Change* 56: 134–147. https://doi.org/10.1016/j.gloenvcha.2019.04.002.

FAO. 2017. *Conservation Agriculture* Factsheet. Available at: https://www.fao.org/conservation-agriculture/en/. Accessed 15.05.2023.

FAO, ITPS GSBI, and CBD EC. 2020. *State of knowledge of Soil Biodiversity: Status, challenges and potentialities, Report 2020*. Rome. https://doi.org/10.1016/b978-0-12-348536-6.50017-4.

Ferreira, C. S. S., S. Seifollahi-Aghmiuni, G. Destouni, N. Ghajarnia, and Z. Kalantari. 2022. Soil degradation in the european Mediterranean region: processes, status and consequences. *Science of the Total Environment* 805: 150106. https://doi.org/10.1016/j.scitotenv.2021.150106.

Fogarty, B. J. 2019. *Quantitative Social Science Data with R: An Introduction*. Edited by J. Seaman. First. London: SAGE.

Fremout, T., C. E. Gutiérrez-Miranda, S. Briers, J. L. Marcelo-Peña, E. Cueva-Ortiz, and R. Linares-Palomino et al. 2021. The value of local ecological knowledge to guide tree species selection in tropical dry forest restoration. *Restoration Ecology* 29. https://doi.org/10.1111/rec.13347. M. de los Ángeles La Torre-Cuadros.

García-Martín, M., T. Plieninger, and C. Bieling. 2018. Dimensions of landscape stewardship across Europe: Landscape values, place attachment, awareness, and personal responsibility. *Sustainability (Switzerland)* 10: 1–27. https://doi.org/10.3390/su10010263.

García-Martín, M., M. Torralba, C. Quintas-Soriano, J. Kahl, and T. Plieninger. 2021. Linking food systems and landscape sustainability in the Mediterranean region. *Landscape Ecology* 36: 2259–2275. https://doi.org/10.1007/s10980-020-01168-5.

Gottwald, S., C. Albert, and N. Fagerholm. 2021. Combining sense of place theory with the ecosystem services concept: empirical insights and reflections from a participatory mapping study. *Landscape Ecology* 37: 633–655. https://doi.org/10.1007/s10980-021-01362-z.

Greco, S., A. Ishizaka, M. Tasiou, and G. Torrisi. 2019. On the Methodological Framework of Composite Indices: a review of the issues of weighting, aggregation, and Robustness. *Social Indicators Research* 141: 61–94. https://doi.org/10.1007/s11205-017-1832-9.

Hervé, M. E. T., M. Renault, E. Plaas, R. Schuette, M. Potthoff, D. Cluzeau, and A. Nicolai. 2020. From Practices to values: Farmers' relationship with Soil Biodiversity in Europe. *Sociologia Ruralis* 60: 596–620. https://doi.org/10.1111/soru.12303.

Hyland, J. J., D. L. Jones, K. A. Parkhill, A. P. Barnes, and A. P. Williams. 2016. Farmers' perceptions of climate change: identifying types. *Agriculture and Human Values* 33: 323–339. https://doi.org/10.1007/s10460-015-9608-9.

Ingram, J., P. Fry, and A. Mathieu. 2010. Revealing different understandings of soil held by scientists and farmers in the context of soil protection and management. *Land Use Policy* 27: 51–60. https://doi.org/10.1016/j.landusepol.2008.07.005.

Jendoubi, D., M. S. Hossain, M. Giger, J. Tomićević-Dubljević, M. Ouessar, H. Liniger, and C. I. Speranza. 2020. Local livelihoods and land users' perceptions of land degradation in northwest Tunisia. *Environmental Development* 33: 100507. https://doi.org/10.1016/j.envdev.2020.100507.

Kassam, A., T. Friedrich, F. Shaxson, and J. Pretty. 2009. The spread of conservation agriculture: justification, sustainability and uptake. *International Journal of Agricultural Sustainability* 7: 292–320. https://doi.org/10.3763/ijas.2009.0477.

Kassam, A., R. Derpsch, and T. Friedrich. 2020. Development of Conservation Agriculture systems globally. In *Advances in Conservation Agriculture*, 1st Edition, 30–46. Burleigh Dodds Science Publishing. https://doi.org/10.1515/9783112318577-003.

Keddem, S., F. K. Barg, and R. Frasso. 2021. Practical Guidance for Studies using freelisting interviews. *Preventing Chronic Disease* 18: 1–8. https://doi.org/10.5888/pcd18.200355.

Kessler, C. A. 2006. Decisive key-factors influencing farm households' soil and water conservation investments. *Applied Geography* 26: 40–60. https://doi.org/10.1016/j.apgeog.2005.07.005.

Knowler, D. 2015. Conservation agriculture. In *Conservation Agriculture*, eds. M. Farooq and K. H. M. Siddique, First Edition, 1–665. Springer International Publishing. https://doi.org/10.1007/978-3-319-11620-4.

Knowler, D., and B. Bradshaw. 2007. Farmers' adoption of conservation agriculture: a review and synthesis of recent research. *Food Policy* 32: 25–48. https://doi.org/10.1016/j.foodpol.2006.01.003.

Koutsou, S., M. Partalidou, and A. Ragkos. 2014. Young farmers' social capital in Greece: Trust levels and collective actions. *Journal of Rural Studies* 34: 204–211. https://doi.org/10.1016/j.jrurstud.2014.02.002.

Laghrour, M., R. Moussadek, R. Mrabet, R. Dahan, M. El-Mourid, A. Zouahri, and M. Mekkaoui. 2016. Long and Midterm Effect of Conservation Agriculture on Soil Properties in Dry Areas of Morocco. *Applied and Environmental Soil Science* 2016: 1–9. https://doi.org/10.1155/2016/6345765.

Lähdesmäki, M., M. Siltaoja, H. Luomala, P. Puska, and S. Kurki. 2019. Empowered by stigma? Pioneer organic farmers' stigma management strategies. *Journal of Rural Studies* 65: 152–160. https://doi.org/10.1016/j.jrurstud.2018.10.008.

Lahmar, R. 2010. Adoption of conservation agriculture in Europe. Lessons of the KASSA project. *Land Use Policy* 27: 4–10. https://doi.org/10.1016/j.landusepol.2008.02.001.

Lang, Z., and S. Rabotyagov. 2022. Socio-psychological factors influencing intent to adopt conservation practices in the Minnesota River Basin. *Journal of Environmental Management* 307: 0–2. https://doi.org/10.1016/j.jenvman.2022.114466.

Lavoie, A., and C. B. Wardropper. 2021. Engagement with conservation tillage shaped by "good farmer" identity. *Agriculture and Human Values* 38: 975–985. https://doi.org/10.1007/s10460-021-10205-1.

Lee, H., S. Lautenbach, A. P. García Nieto, A. Bondeau, W. Cramer, and I. R. Geijzendorffer. 2019. The impact of conservation farming practices on Mediterranean agro-ecosystem services provisioning—a meta-analysis. *Regional Environmental Change* 19: 2187–2202. https://doi.org/10.1007/s10113-018-1447-y.

Lynne, G. D., J. S. Shonkwiler, and L. R. Rola. 1988. Attitudes and Farmer Conservation Behaviour. *American Journal of Agricultural Economics* 70(1): 12–19. https://doi.org/10.2307/1241971.

McGuire, J. M., L. W. Morton, J. G. Arbuckle, and A. D. Cast. 2015. Farmer identities and responses to the social-biophysical environment. *Journal of Rural Studies* 39: 145–155. https://doi.org/10.1016/j.jrurstud.2015.03.011.

Mills, J., P. Gaskell, J. Ingram, J. Dwyer, M. Reed, and C. Short. 2017. Engaging farmers in environmental management through a better understanding of behaviour. *Agriculture and Human Values* 34: 283–299. https://doi.org/10.1007/s10460-016-9705-4.

Montsant, A., O. Baena, L. Bernárdez, and J. Puig. 2021. Modelling the impacts of climate change on potential cultivation area and water deficit in five Mediterranean crops. *Spanish Journal of Agricultural Research* 19: e0301. https://doi.org/10.5424/sjar/2021192-17112.

Mrabet, R., H. Bahri, O. Zaghouane, H. Cheikh, M. Hamed, S. R. M. El-Areed, and M. M. Abou El-Enin. 2022. Adoption and spread of Conservation Agriculture in North Africa. In *Advances in Conservation Agriculture volume 3: adoption and spread*, ed. A. Kassam. vol. 3 1–61. Cambridge, UK: Burleigh Dodds Science Publishing. https://doi.org/10.1080/00207233.2020.1805879.

Padel, S. 2001. Conversion to organic farming: a typical example of the diffusion of an innovation? *Sociologia Ruralis* 41: 40–61. https://doi.org/10.1111/1467-9523.00169.

Panagos, P., C. Ballabio, J. Poesen, E. Lugato, S. Scarpa, L. Montanarella, and P. Borrelli. 2020. A soil erosion indicator for supporting agricultural, environmental and climate policies in the european union. *Remote Sensing* 12. https://doi.org/10.3390/RS12091365.

Petrescu-Mag, R. M., D. C. Petrescu, and H. Azadi. 2020. A social perspective on soil functions and quality improvement: romanian farmers' perceptions. *Geoderma* 380: 1–8. https://doi.org/10.1016/j.geoderma.2020.114573.

Purzycki, B. G., and A. Jamieson-Lane. 2017. AnthroTools: an R Package for Cross-Cultural Ethnographic Data Analysis. *Cross-Cultural Research* 51: 51–74. https://doi.org/10.1177/1069397116680352.

Quartuch, M. R., and T. M. Beckley. 2013. Landowners perceptions of their Moral and ethical stewardship responsibilities in New Brunswick, Canada, and Maine. *USA Small-scale Forestry* 12: 437–460. https://doi.org/10.1007/s11842-012-9222-2.

Quintas-Soriano, C., M. García-Llorente, A. Norström, M. Meacham, G. Peterson, and A. J. Castro. 2019. Integrating supply and demand in ecosystem service bundles characterization across Mediterranean transformed landscapes. *Landscape Ecology* 34: 1619–1633. https://doi.org/10.1007/s10980-019-00826-7.

Reimer, A. P., A. W. Thompson, and L. S. Prokopy. 2012. The multi-dimensional nature of environmental attitudes among farmers in Indiana: implications for conservation adoption. *Agriculture and Human Values* 29: 29–40. https://doi.org/10.1007/s10460-011-9308-z.

Rust, N. A., E. N. Ptak, M. Graversgaard, S. Iversen, M. S. Reed, J. R. de Vries, and J. Ingram et al. 2020. Social capital factors affecting uptake of sustainable soil management practices: a literature review. *Emerald Open Research* 2: 8. https://doi.org/10.35241/emeraldopenres.13412.2.

Schmitzberger, I., T. Wrbka, B. Steurer, G. Aschenbrenner, J. Peterseil, and H. G. Zechmeister. 2005. How farming styles influence biodiversity maintenance in austrian agricultural landscapes. *Agriculture Ecosystems and Environment* 108: 274–290. https://doi.org/10.1016/j.agee.2005.02.009.

Schneider, F., T. Ledermann, P. Fry, and S. Rist. 2010. Soil conservation in swiss agriculture-approaching abstract and symbolic

meanings in farmers' life-worlds. *Land Use Policy* 27: 332–339. https://doi.org/10.1016/j.landusepol.2009.04.007.

Sutherland, L. A., and K. L. Holstead. 2014. Future-proofing the farm: On-farm wind turbine development in farm business decision-making. *Land Use Policy* 36: 102–112. https://doi.org/10.1016/j.landusepol.2013.07.004.

Sutrop, U. 2001. List Task and a cognitive salience index. *Field Methods* 13: 263–276. https://doi.org/10.1177/1525822X0101300303.

Taber, K. S. 2018. The Use of Cronbach's alpha when developing and reporting Research Instruments in Science Education. *Research in Science Education* 48: 1273–1296. https://doi.org/10.1007/s11165-016-9602-2.

Talanow, K., E. N. Topp, J. Loos, and B. Martín-López. 2021. Farmers' perceptions of climate change and adaptation strategies in South Africa's Western Cape. *Journal of Rural Studies* 81: 203–219. https://doi.org/10.1016/j.jrurstud.2020.10.026.

Tama, R. A. Z., L. Ying, M. Yu, M. M. Hoque, K. M. Mehedi Adnan, and S. A. Sarker. 2021. Assessing farmers' intention towards conservation agriculture by using the Extended Theory of Planned Behavior. *Journal of Environmental Management* 280: 1–10. https://doi.org/10.1016/j.jenvman.2020.111654.

Theis, S., N. Lefore, R. Meinzen-Dick, and E. Bryan. 2018. What happens after technology adoption? Gendered aspects of small-scale irrigation technologies in Ethiopia, Ghana, and Tanzania. *Agriculture and Human Values* 35: 671–684. https://doi.org/10.1007/s10460-018-9862-8.

Vastola, A., P. Zdruli, M. D'Amico, G. Pappalardo, M. Viccaro, F. Di Napoli, M. Cozzi, and S. Romano. 2017. A comparative multidimensional evaluation of conservation agriculture systems: a case study from a Mediterranean area of Southern Italy. *Land Use Policy* 68: 326–333. https://doi.org/10.1016/j.landusepol.2017.07.034.

Vignola, R., T. Koellner, R. W. Scholz, and T. L. McDaniels. 2010. Decision-making by farmers regarding ecosystem services: factors affecting soil conservation efforts in Costa Rica. *Land Use Policy* 27: 1132–1142. https://doi.org/10.1016/j.landusepol.2010.03.003.

Vuillot, C., N. Coron, F. Calatayud, C. Sirami, R. Mathevet, and A. Gibon. 2016. Ways of farming and ways of thinking: do farmers' mental models of the landscape relate to their land management practices? *Ecology and Society* 21(1): 35. https://doi.org/10.5751/ES-08281-210135.

Wartenberg, A. C., W. J. Blaser, K. N. Janudiannto, J. M. Roshetko, M. van Noordwijk, and J. Six. 2018. Farmer perceptions of plant-soil interactions can affect adoption of sustainable management practices in cocoa agroforests: a case study from Southeast Sulawesi. *Ecology and Society* 23: 12–19. https://doi.org/10.3929/ethz-a-010782581.

Wartmann, F. M., and R. S. Purves. 2018. Investigating sense of place as a cultural ecosystem service in different landscapes through the lens of language. *Landscape and Urban Planning* 175: 169–183. https://doi.org/10.1016/j.landurbplan.2018.03.021.

West, S., L. J. Haider, V. Masterson, J. P. Enqvist, U. Svedin, and M. Tengö. 2018. Stewardship, care and relational values. *Current Opinion in Environmental Sustainability* 35: 30–38. https://doi.org/10.1016/j.cosust.2018.10.008.

Willy, D. K., and K. Holm-Müller. 2013. Social influence and collective action effects on farm level soil conservation effort in rural Kenya. *Ecological Economics* 90: 94–103. https://doi.org/10.1016/j.ecolecon.2013.03.008.

Wittwer, R. A., S. F. Bender, K. Hartman, S. Hydbom, R. A. A. Lima, V. Loaiza, and T. Nemecek et al. 2021. Organic and conservation agriculture promote ecosystem multifunctionality. *Science Advances* 7: 1–13. https://doi.org/10.1126/sciadv.abg6995.

Wuepper, D. 2019. Does culture affect soil erosion? Empirical evidence from Europe. *European Review of Agricultural Economics* 47(2): 619–653. https://doi.org/10.1093/erae/jbz029.

Yazdanpanah, M., D. Hayati, S. Hochrainer-Stigler, and G. H. Zamani. 2014. Understanding farmers' intention and behavior regarding water conservation in the Middle-East and North Africa: a case study in Iran. *Journal of Environmental Management* 135: 63–72. https://doi.org/10.1016/j.jenvman.2014.01.016.

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