ResidueGas DELIVERABLE NO. 6.3

Report on potential, barriers and incentives for mitigating GHG emissions from crop residues

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1. Summary

The overall aim of ResidueGas WP6 was to identify and quantify mitigation measures that can reduce nitrous oxide emissions from crop residues in North European cropping systems while also contributing to storing soil carbon. This report focuses on the feasibility of alternative strategies for the management of crop residues, as assessed through a structured questionnaire that was addressed to farmers in Northern European countries. In Denmark, the survey was distributed via email to 5154 representative farmers, of which 592 completed it. In Norway, the survey was mainly distributed via social media and 45 completed responses were collected.

The questions included background information on farming system and values (e.g., perceptions about sustainability), current management of crop residues and acceptability of alternative management options (including obstacles and incentives).

The importance of sustainable farming was acknowledged by the large majority of respondents. Aspects related to soil fertility had a high level of agreement, while emissions of greenhouse gases was one of the aspects with the lowest priority, especially in connection with management decisions. Similarly, greater interest was expressed on the status of soil organic matter (SOM) compared to emissions of greenhouse gases. In Denmark, organic and conventional farmers had different perceptions of the status of SOM in their farms, varying with age group. Specifically, a larger proportion of organic farmers thought that SOM in their farms was increasing compared to conventional farmers, with the difference being inversely correlated with age and with the use of soil tests. Overall, the majority of respondents in both countries employ management strategies to maintain or improve SOM; retention of plant residues was the most widely used option (74%). Consequently, removal of plant residues was considered negatively in connection with ecosystem services as well as crop production. On the other hand, retention of residues on the field surface or incorporation (shallow and deep) were perceived as management options with positive effects. The main barrier to the adoption of alternative methods of residue management for the mitigation of nitrous oxide emission was “Lack of knowledge about which option is most effective”, including the use of nitrification inhibitors. The main solutions were “Indicators and tools for farmers to measure progress in reducing farm emissions” and the strengthening of farm advisory services (knowledge and advice) and financial support.

2. Introduction

The fraction of plant biomass that is not harvested (plant residues from crops and cover crops) can be returned to the soil to increase soil organic matter (SOM) and soil fertility. When incorporated into the soil, crop residues that are rich in nitrogen affect nitrogen availability and cycling, with positive and negative effects on crop production and the environment, including emission of greenhouse gases. In particular, emissions of nitrous oxide (N_2O) from crop residues are affected by several factors in an interactive way, which complicates the identification of mitigation measures in a general setting. Therefore, the management of crop residues should be context-specific and account for soil characteristics, climatic conditions and type of residues.

A successful implementation of measures to mitigate N_2O emissions from crop residues requires taking into account the acceptability of such measures from different stakeholders, in connection with other aspects such as soil carbon storage. Thus, it is crucial to understand farmers´ current management strategies and perceptions, as well as barriers and incentives related to the adoption of mitigation measures.

The overall aim of ResidueGas WP6 was to identify and quantify mitigation measures that can reduce N_2O emissions from crop residues in North European cropping systems while also contributing to storing soil carbon. The identification of mitigation measures was conducted through a literature review, meta-analysis and expert knowledge, as reported by Abalos et al. (2021). Here we focus on the feasibility of alternative strategies for the management of crop residues, as assessed through a structured questionnaire that was addressed to farmers in Northern European countries.

3. Materials and methods

The survey was targeted at farmers and aimed at being representative of the conditions in the countries of interest. The text of the survey was originally written in English, and then translated by each partner organization of the ResidueGas consortium. The survey was distributed in Denmark, Norway, the UK and France. However, adequate responses were only acquired from Denmark and Norway.

3.1 Design of the survey

The survey mainly consisted of close-ended questions, addressing:

- Background on farm type, farmer age and concerns for the environment
- Current management of crop residues
- Acceptability of alternative management options
- Barriers to the adoption of alternatives
- Incentives to the adoption of alternatives
- Other effects of alternative management options

The full list of questions is shown in Appendix A.

3.2 Data collection and analysis

The survey was distributed online using SurveyXact and all answers were anonymized automatically upon completion. Each country used their available tools to reach a wide audience of farmers. In Denmark, a representative sample of 5154 farmers was extracted randomly from the Research Related Agricultural Register (FRJOR), which in 2018 included approximately 30 000 farmers. The selected farmers were contacted via email on 15 July 2020, and a reminder was sent on 21 August 2020. By the end of 2020, 592 farmers completed the questionnaire, corresponding to a response rate of approximately 11%.

In Norway, advisors at the Norwegian Agricultural Advisory Services (NLR) were requested to share the survey via newsletters, web sites and social media. The number of farmers reached by this method is not known but the responses were few. In total, 45 farmers completed the questionnaire.
In France and in the UK the questionnaire was distributed through social media and announcements in farmers´ magazines, but the responses collected were too few to be analysed.

Data are reported as percentage of respondents (completed questionnaires) separately for each country and, when relevant, grouped based on farming strategy (organic and conventional).

4. Results and discussions

4.1 Background on farms and farmers

4.1.1 Background

In Denmark, respondents were draft from a representative sample of the Danish farming sector, as the distribution between different groups was close to national statistics for 2019 (Statistics Denmark). The question “Which soil types(s) are there in your farm?” was answered as: 32% sand, 57% loam, 37% clay and 11% organic soil, which indicates that the farms well represented Danish soil types. In addition, 60% of farmers were 51-70 years old, 14% farmed according to organic regulations, 51% had cereal-based systems and 28% livestock and crop production. A larger percentage of organic farmers (18%) reported permanent grassland as primary cropping system compared to conventional (4%), while the opposite occurred for cereal-based systems (Fig. 1). This difference well reflects the differences between organic and conventional farming practices (Olesen et al., 2020).

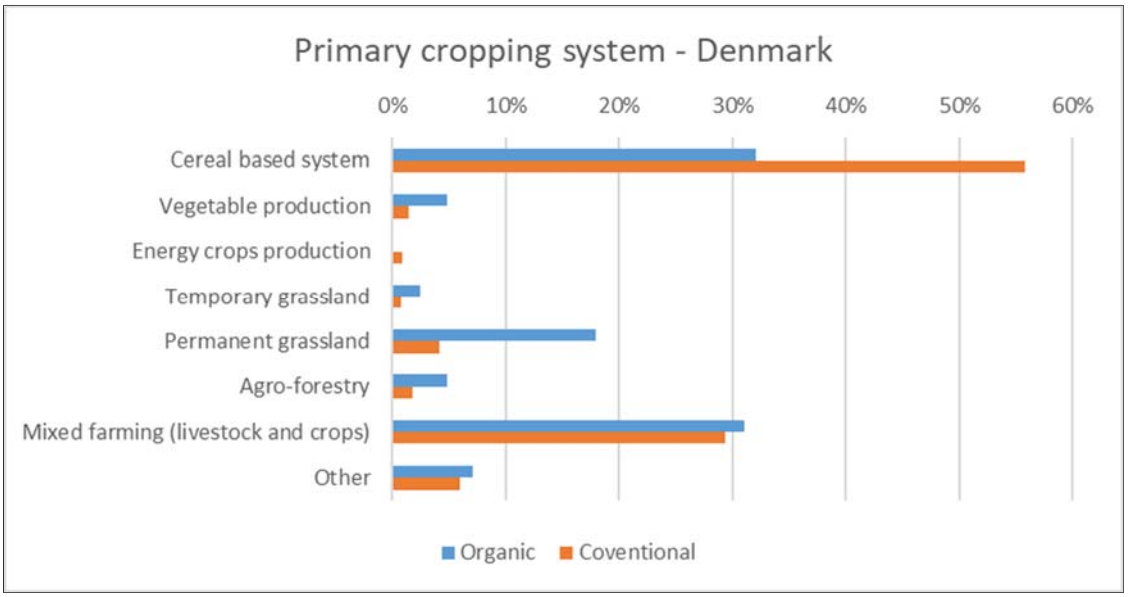

Figure 1: Percentage of responses from Danish farmers to “Specify primary cropping system”, divided by organic and conventional farmers.

In Denmark, cover crops were grown by 54% of organic and 74% of conventional farmers, reflecting the greater percentage of organic farmers having grassland and agro-forestry systems, compared to conventional ones (Fig. 1). Among all farmers, around 50% used grasses and cereals as cover crops. Legumes were used in cover crop mixtures by 47% of organic and 21% of conventional farmers. When asked about the main function of cover crops, “retention of nutrients” and “green manure” were chosen by 49% and 29% of organic and 67% and 12% of conventional farmers, respectively. Danish organic farmers preferred to undersow cover crops in spring (67%), while conventional farmers preferred to sow cover crops after harvest of the main crop (73%). The majority of both organic and conventional farmers

terminated cover crops in the following spring (82% and 60%), but 45% of conventional farmers indicated autumn termination as an option (against 11% for organic). These differences in type and management of cover crops may very well affect nitrous oxide emissions after termination.

In Norway, soil types were 47% sand, 62% loam, 67% clay and 20% organic soils. In addition, 53% of farmers were 51-70 years old, 64% had cereal-based systems whereof 40% practised no-till. The majority of the rest had either temporary grassland or a mixed cropping system. The organic farmers (7%) had livestock. 24% of respondents (11 out of 45 farmers) grew cover crops, with the main function being “retention of nutrients” (64%). Sowing time varied, with no clear preference, while termination was in spring (91%) and primarily by winterkill. The termination time practice is reflecting that no management are required for receiving financial support for using cover crops.

4.1.2 Concerns for sustainability

89% of Danish and 100% of the Norwegian farmers were concerned about sustainable farming. When asked about the importance of different aspects in connection to sustainable farming, 88% of Danish farmers agreed or strongly agreed on the importance of soil fertility, while greenhouse gas emissions had a lower priority (62%). Differences among organic and conventional farmers could be observed in relation to the importance of environmental and productivity aspects (Fig. 2).

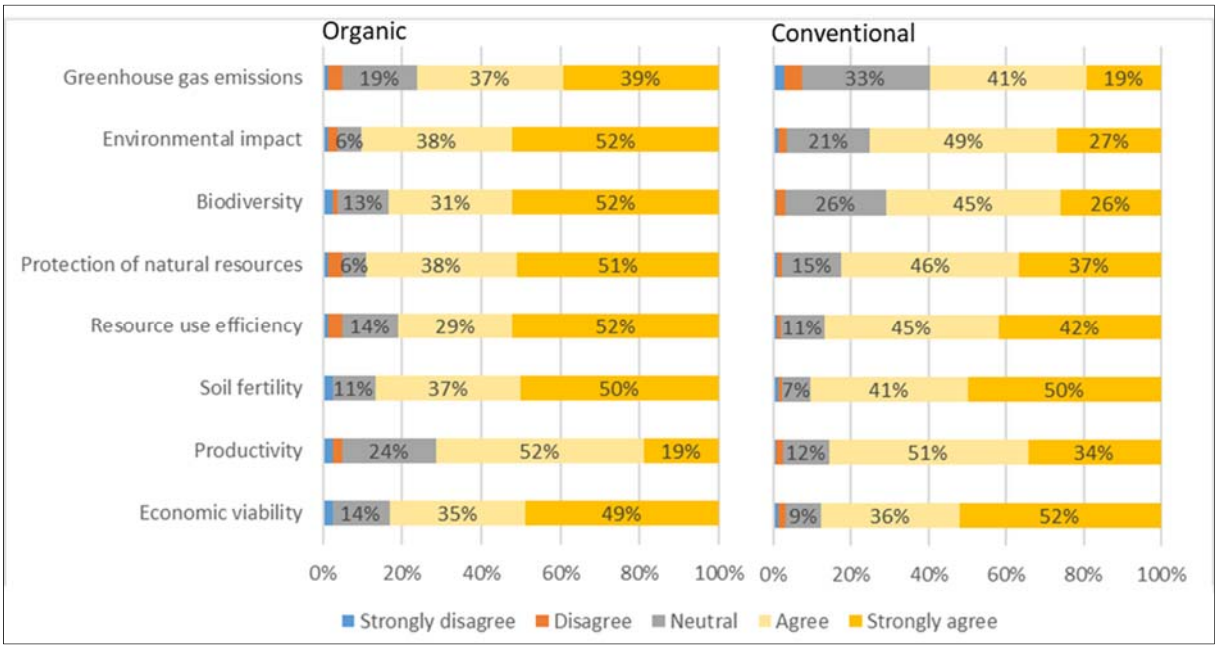

Figure 2: Percentage of responses from Danish farmers to “Indicate your level of agreement with the following statement: this aspect is important in connection to sustainable farming”, divided by organic and conventional farmers.

When Danish farmers were asked about the importance of the same aspects in connection to management decisions, greenhouse gas emissions had the lowest percentage of “agree” and “strongly agree”, with less than 50% for conventional farmers. Overall, organic farmers

gave the greatest importance to environmental impact, while conventional farmers to economic viability (Fig. 3).

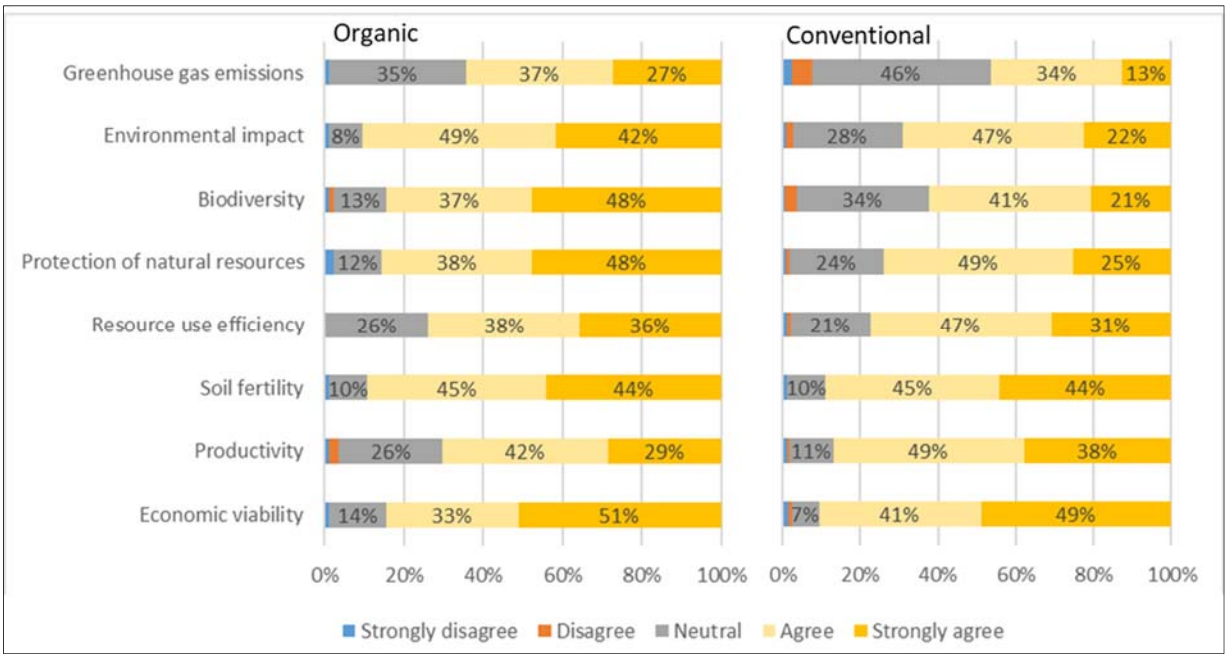

Figure 3: Percentage of responses from Danish farmers to “Indicate your level of agreement with the following statement: this aspect is important when taking management decisions”, divided by organic and conventional farmers.

In Norway, 98% of the respondents agreed or strongly agreed on the importance of soil fertility and economic viability for sustainable farming, while the lowest level of agreement was on the importance of greenhouse gas emissions (71%). In connection to management decisions, 100% of respondents agreed or strongly agreed on the importance of economic viability, and more than 90% on productivity, soil fertility and resource use efficiency, while 73% on greenhouse gas emissions and 60% on biodiversity.

4.1.3 Soil status

In Denmark, 88% of respondents expressed interest in the status of SOM in their farm, while only 57% were concerned about emissions of greenhouse gases (74% of organic and 53% of conventional). Interestingly, the perception of SOM status varied according to age and farming strategy, with the majority of organic farmers > 70 years perceiving the SOM in their farm to be increasing, while a larger proportion of the conventional farmers in the same age group thought that SOM was stable (Fig. 4). In both cases, only a small percentage had information on the SOM status from soil sampling and analysis.

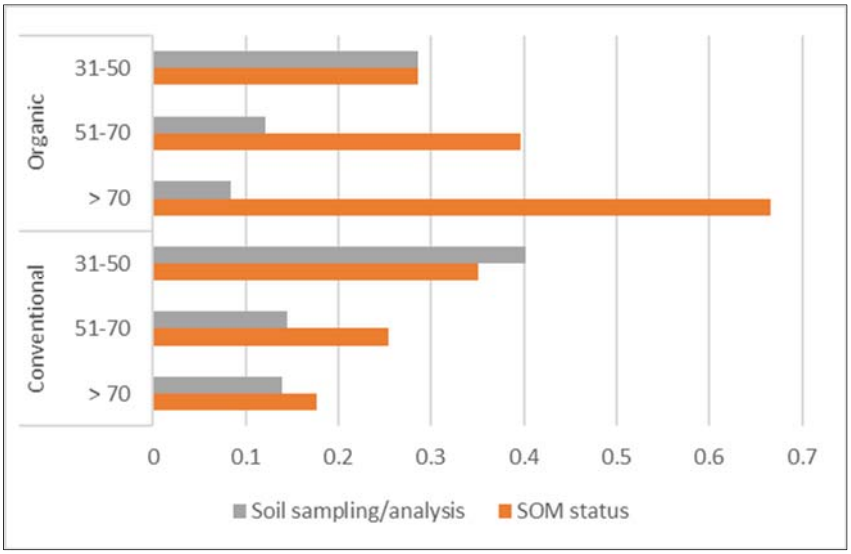

Figure 4: Average of the responses to the questions, “Do you think that soil organic matter in your farm is: stable (0), increasing (1), decreasing (-1)” and “Do you know the soil carbon status from soil sampling/analysis? Yes (1), no (0)”. Results are from Danish farmers and are grouped by organic vs conventional, and age group.

In Norway, 98% of respondents expressed interest in the status of SOM in their farm, the same percentage knew the SOM status from soil sampling and analysis and 56% indicated that SOM was stable. A smaller percentage of farmers (84%) was concerned about emissions of greenhouse gases compared to SOM status.

The majority of both Danish and Norwegian farmers indicated that they retain plant residues in the field to maintain or increase SOM (74%), with use of manure or compost, cover crops and grass in rotation being other widely used options.

4.2 Current management of crop residues

Crop residues were divided into four groups: straw after grain or seed crop, vegetable residues, cover crops, grassland renewal or termination. For each group, farmers were asked about their current management. Percentages of total respondents (excluding “not applicable”) in Denmark and Norway are reported in Table 1.

Table 1: Percentages of total respondents (excluding “not applicable”) to the question, “What is your main management strategy for crop residues in your farm? Select the appropriate choice for each residue type”, in Denmark and Norway.

	Denmark				Norway			
	Straw	Vege-table	Cover crop	Grassland	Straw	Vege-table	Cover crop	Grassland
Removed	33%	5%	2%	-	18%	25%	0%	-
Left on surface	43%	68%	48%	12%	38%	25%	25%	0%
Shallow inc.	15%	20%	20%	19%	10%	0%	42%	17%
Deep inc.	9%	7%	30%	69%	33%	50%	33%	83%

4.3 Acceptability of alternative management options, barriers and incentives

When asked about alternative options of residue management, Danish farmers expressed a positive attitude towards even surface spreading, while removal of vegetable and cover crop residues was perceived negatively (Table 2). In particular, removal of residues from the field was perceived as having negative effects on crop production and ecosystem services related to soil quality by the majority of respondents (53-72%), while retention of residues on the surface and incorporation were considered as having positive effects.

Most respondents would consider deep incorporation of residues, while 42% said they would not be willing to adopt nitrification inhibitors. However, this was the option with the largest uncertainty. The same large unwillingness to adopt measures also applied to removal of vegetable and cover crop residues. Across types of residues, the main barrier to the adoption of alternative methods for residue management was “Lack of knowledge about which option is most effective” (36%), and 37% of the respondents indicated “Indicators and tools for farmers to measure progress in reducing farm emissions” as an incentive. Strengthening of farm advisory services (knowledge and advice) and financial support followed, with 35% and 33% of respondents. Similar results were obtained in Norway but here the barriers for using nitrification inhibitors were even higher, especially due to lack of knowledge about the effect of this option.

Table 2: Percentages of total Danish respondents (excluding “not relevant”) to the question, “If not already implemented, would you be willing to adopt the following options of residues management?”

Method	Type of residue	Yes	No	Already implemented	Maybe
Even surface spreading	Straw	42%	9%	44%	5%
	Vegetable	48%	16%	30%	6%
	Cover crop	43%	6%	48%	3%
Direct seeding	Grassland renewal	39%	42%	9%	10%
Removal	Straw	42%	37%	17%	4%
	Vegetable	16%	70%	7%	7%
	Cover crop	18%	68%	8%	6%
Deep incorporation	Straw	43%	29%	23%	5%
	Vegetable	37%	38%	15%	10%
	Cover crop	46%	25%	25%	5%
	Grassland termination/renewal	51%	17%	27%	5%
Nitrification inhibitors		35%	42%	2%	21%
Other		14%	42%	7%	37%

5. Conclusions

The responses collected through the present online survey allowed the identification of current management of crop residues and perceptions towards alternative solutions by Danish and Norwegian farmers. The large majority of respondents agreed on the importance of sustainable farming, with emphasis on soil fertility and productivity. Emissions of greenhouse gases was one of the aspects with the lowest priority, especially in connection with management decisions. In Denmark, organic and conventional farmers had different perceptions of the status of SOM in their farms; more organic farmers thought that SOM in their farms was increasing compared to conventional farmers, especially when the SOM status was not based on soil tests. Overall, the majority of respondents in both countries retain crop residues to maintain or improve SOM (74%). Consequently, removal of crop residues was considered negatively in connection with ecosystem services as well as crop production. The main barrier to the adoption of alternative methods of residue management for the mitigation of nitrous oxide emission was “Lack of knowledge about which option is most effective”, including the use of nitrification inhibitors. The main solutions were “Indicators and tools for farmers to measure progress in reducing farm emissions” and the strengthening of farm advisory services (knowledge and advice) and financial support.

6. References

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Olesen, J.E., Kristensen, T., Kristensen, I.S., Børgesen, C.D., Eriksen, J., Pedersen, B.F. & Kongsted, A.G. (2020). Opdatering af kvælstofudvaskning fra økologiske bedrifter. DCA rapport nr. 176.

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7. Appendix A

Introduction to the questionnaire

This survey is being conducted as part of the ResidueGas project, aiming at improving the estimation and mitigation of greenhouse gases emissions and soil carbon storage from crop residues. The project is funded in the framework of FACCE ERA-GAS under the European Union's Horizon2020 Research & Innovation Programme.

The aim of this questionnaire is to identify current management of crop residues in North European cropping systems, and the possible barriers and incentives to the adoption of management strategies that could mitigate the emission of greenhouse gases.

In a nutshell, the portion of plant biomass that is not harvested (plant residues from crops and cover crops) can be returned to the soil to increase SOM and soil fertility. When incorporated into the soil, crop residues that are rich in nitrogen affect nitrogen availability and cycling, with positive and negative effects on crop production and the environment, including emission of greenhouse gases.

There are no "right" or "wrong" answers, and no prior knowledge of the subject is required to participate in the survey, which takes approximately 15-25 minutes to complete.

The survey is anonymous, and the data collected will be used in the context of the European project ResidueGas solely for scientific purposes. Data will be handled by the Department of Agroecology at Aarhus University, Denmark, and the results will be disseminated in such a way that it is not possible to identify individual respondents.
We really appreciate your contribution!

In order to proceed with the questionnaire, please tick the box below:

(1) ❑ I consent to having my information collected and stored.

Select your country of residence

(8) ❑ Denmark
(14) ❑ France
(15) ❑ Germany
(16) ❑ Norway
(17) ❑ Sweden
(18) ❑ United Kingdom

What is your age?

(1) ❑ 18-30

(2) ❑ 31-50

(3) ❑ 51-70

(4) ❑ > 70

Which soil type(s) are there in your farm?

(1) ❑ Sand

(2) ❑ Loam

(3) ❑ Clay

(4) ❑ Peat

Are you concerned about sustainable farming?

(1) ❑ Yes

(2) ❑ No

Indicate your level of agreement with the following statement.
This aspect is important in connection to sustainable farming:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Economic viability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Productivity	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil fertility	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Resource use efficiency	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Protection of natural resources	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Biodiversity	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Environmental impact	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Greenhouse gas emissions	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Do you farm according to any specific concept?

(1) ❑ Organic farming

(2) ❑ Biodynamic

(3) ❑ Conservation agriculture

(4) ❑ No-till

(5) ❑ Conventional

(6) ❑ Other (specify) _____

Specify primary cropping system

(1) ❑ Cereal based system
(2) ❑ Vegetable production
(4) ❑ Energy crops production
(5) ❑ Temporary grassland
(6) ❑ Permanent grassland
(7) ❑ Agro-forestry
(10) ❑ Mixed farming (livestock and crop production)
(9) ❑ Other _____

Do you grow your crops mainly in:

	Cereals	Cereals and other annuals	An-nual crops	Annu-als and ley	Perenni-als	Other	Specify crop(s)
Monoculture	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	_____
Crop rotation	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	_____

Do you grow cover crops?

(1) ❑ Yes
(2) ❑ No

Which cover crop species do you use?

(1) ❑ Legumes
(2) ❑ Grasses and cereals
(3) ❑ Other annuals
(4) ❑ Mixtures including legumes
(5) ❑ Mixtures without legumes
(6) ❑ Other _____

What is the main function of the cover crops?

(1) ❑ Catch crop (retention of nutrients)

(2) ❑ Green manure

(3) ❑ Soil cover

(4) ❑ Other _____

Do you have specific cover crops for specific cash crops?

(1) ❑ Yes (please specify) _____

(2) ❑ No

When do you sow the cover crop?
(If you have more than one type of cover crop with different management, please specify it in "Other")

(1) ❑ Undersown in spring

(4) ❑ Undersown before harvest

(2) ❑ After harvest

(3) ❑ Other _____

When is the cover crop terminated?
(If you have more than one type of cover crop with different management, please specify it in "Other")

(1) ❑ Autumn

(2) ❑ Spring

(3) ❑ Other _____

How is the cover crop terminated?
(If you have more than one type of cover crop with different management, please specify it in "Other")

(1) ❑ Spraying with herbicides

(2) ❑ Rolling and crimping

(3) ❑ Ploughing

(4) ❑ Winterkill (frost)

(5) ❑ Other _____

Are you concerned about the status of soil organic matter in your farm?

(1) ❑ Yes

(2) ❑ No

Do you think that soil organic matter in your farm is:

(1) ❑ Stable

(2) ❑ Increasing

(3) ❑ Decreasing

Do you know the soil carbon status from soil sampling/analysis?

(1) ❑ Yes

(2) ❑ No

Do you apply any of the following options to maintain or increase soil organic matter?

(1) ❑ Plant residues left in the field

(2) ❑ Reduced/minimum tillage

(5) ❑ Zero tillage

(6) ❑ Use of manure and/or compost

(7) ❑ Perennial grass crops in rotation

(8) ❑ Annual grass crops in rotation

(9) ❑ Use of cover crops

(10) ❑ Use of legumes

(11) ❑ Use of biochar

(3) ❑ Use of solid sewage waste

(12) ❑ Use of biogas digestates

(13) ❑ None

(14) ❑ Other _____

Are you concerned about emissions of greenhouse gas from agriculture?

(1) ❑ Yes

(2) ❑ No

Are you concerned about emissions of the greenhouse gas nitrous oxide from agriculture?

(1) ❑ Yes

(2) ❑ No

Indicate your level of agreement with the following statement.
This aspect is important when taking management decisions:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Economic viability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Productivity	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil fertility	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Resource use efficiency	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Protection of natural resources	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Biodiversity	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Environmental impact	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Greenhouse gas emissions	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

What is your main management strategy for crop residues in your farm? Select the appropriate choice for each residue type.

Straw after grain or seed crop

(1) ❑ Removed from the field

(0) ❑ Left on the soil surface

(2) ❑ Shallow incorporation (<10 cm depth)

(3) ❑ Deep incorporation (>10 cm depth)

(4) ❑ Not applicable

Straw residues are used for

(1) ❑ Bed/feed on farm

(2) ❑ Compost

(3) ❑ Export out of farm

(4) ❑ Export for biogas

(5) ❑ Other _____

Straw residues are

(1) ❑ Evenly spread

(2) ❑ Chopped

(3) ❑ Transferred to other field

(4) ❑ Other _____

Type of shallow incorporation of straw residues

(1) ❑ Rotary tillage

(2) ❑ Shallow harrowing (stubble cultivation)

(3) ❑ Hoeing

(4) ❑ Other _____

Type of deep incorporation of straw residues

(1) ❑ Deep harrowing

(2) ❑ Ploughing

(4) ❑ Other _____

Vegetable residues

(1) ❑ Removed from the field

(0) ❑ Left on the soil surface

(2) ❑ Shallow incorporation (<10 cm depth)

(3) ❑ Deep incorporation (>10 cm depth)

(4) ❑ Not applicable

Vegetable residues are used for

(1) ❑ Compost

(2) ❑ Other _____

Vegetable residues are

(1) ❑ Evenly spread

(2) ❑ Chopped

(3) ❑ Transferred to other field

(4) ❑ Other _____

Type of shallow incorporation of vegetable residues

(1) ❑ Rotary tillage

(2) ❑ Shallow harrowing (stubble cultivation)

(3) ❑ Hoeing

(4) ❑ Other _____

Type of deep incorporation of vegetable residues

(1) ❑ Deep harrowing

(2) ❑ Ploughing

(4) ❑ Other _____

Cover crop residues

(1) ❑ Removed from the field

(0) ❑ Left on the soil surface

(2) ❑ Shallow incorporation (<10 cm depth)

(3) ❑ Deep incorporation (>10 cm depth)

(4) ❑ Not applicable

Cover crop residues are used for

(1) ❑ Compost

(3) ❑ Export for biogas

(2) ❑ Other _____

Cover crop residues are

(1) ❑ Evenly spread

(2) ❑ Chopped

(3) ❑ Transferred to other field

(4) ❑ Other _____

Type of shallow incorporation of cover crop residues

(1) ❑ Rotary tillage

(2) ❑ Shallow harrowing (stubble cultivation)

(3) ❑ Hoeing

(4) ❑ Other _____

Type of deep incorporation of cover crop residues

(1) ❑ Deep harrowing

(2) ❑ Ploughing

(4) ❑ Other _____

Grassland renewal or termination

(1) ❑ Left on the field surface and direct seeding

(2) ❑ Shallow incorporation (<10 cm depth)

(3) ❑ Deep incorporation (>10 cm depth)

(4) ❑ Not applicable

Type of shallow incorporation

(1) ❑ Rotary tillage

(2) ❑ Shallow harrowing (stubble cultivation)

(3) ❑ Hoeing

(4) ❑ Other _____

Type of deep incorporation

(1) ❑ Deep harrowing

(2) ❑ Ploughing

(4) ❑ Other _____

If not already implemented, would you be willing to adopt the following options of residues management?

	Yes	No	Already implemented	Not relevant	Maybe (please specify)	
Even surface spreading of straw (grain or seed crop)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Even surface spreading of vegetable residues	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____

	Yes	No	Already implemented	Not relevant	Maybe (please specify)	
Even surface spreading of cover crop residues	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Direct seeding for grassland renewal	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Removal of straw (grain or seed crop)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Removal of vegetable residues	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Removal of cover crop residues	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Deep incorporation of straw (grain or seed crop)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Deep incorporation of vegetable residues	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Deep incorporation of cover crop residues	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Deep incorporation for grassland termination/renewal	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Use of nitrification inhibitors	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____
Other	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	_____

Which would be the barriers to the adoption of the listed options of residues management?

	Even surface spreading of crop residues	Removal of crop residues	Deep incorporation of crop residues	Use of nitrification inhibitors
Lack of funds to access technology or machinery	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Initial investment costs are too high	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Additional costs are too high	(1) ❑	(2) ❑	(3) ❑	(4) ❑
The right machinery is not available	(1) ❑	(2) ❑	(3) ❑	(4) ❑

	Even surface spreading of crop residues	Removal of crop residues	Deep incorporation of crop residues	Use of nitrification inhibitors
Lack of incentive for medium/long-term investment due to lack of successor	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Concerns about productivity and economic benefits	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Lack of subsidies	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Unsuitable climate or soil	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Lack of knowledge about which option is most effective	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Concern about soil organic matter	(1) ❑	(2) ❑	(3) ❑	(4) ❑
None	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Other (specify)	(1) ❑	(2) ❑	(3) ❑	(4) ❑

Please specify other barriers, if any.

_____

Which solutions would be most important for increasing the adoption of the listed options of residue management?

	Even surface spreading of crop residues	Removal of crop residues	Deep incorporation of crop residues	Use of nitrification inhibitors
Tailored guidance and advice for farmers	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Strengthen farm advisory services and knowledge exchange (e.g. workshops, demonstrations)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Financial support (e.g. loans or grants for investments)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Compulsory standards set by food companies	(1) ❑	(2) ❑	(3) ❑	(4) ❑

	Even surface spreading of crop residues	Removal of crop residues	Deep incorporation of crop residues	Use of nitrification inhibitors
Set mandatory targets and regulatory requirements for residues management	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Indicators and tools for farmers to measure progress in reducing farm emissions	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Improved awareness among the public	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Incentives (specify which kind)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
None	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Other (specify)	(1) ❑	(2) ❑	(3) ❑	(4) ❑

Please specify other solutions, if any.

_____

How do you consider the effect of the following management practices on crop production?

	Negative	Partly negative	Neutral	Partly positive	Positive
Residues removed from the field	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Residues left on the field surface	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Shallow incorporation of residues (<10 cm depth)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Deep incorporation of residues (>10 cm depth)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

How do you consider the effect of the following management practices on ecosystem services?

Residues removed from the field

	Negative	Partly negative	Neutral	Partly positive	Positive
Soil fertility	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Negative	Partly negative	Neutral	Partly positive	Positive
Soil nitrogen availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil organic carbon	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil water availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Control of pests and diseases	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Mitigation of soil erosion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Residues left on the field surface

	Negative	Partly negative	Neutral	Partly positive	Positive
Soil fertility	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil nitrogen availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil organic carbon	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil water availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Control of pests and diseases	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Mitigation of soil erosion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Shallow incorporation (<10 cm depth)

	Negative	Partly negative	Neutral	Partly positive	Positive
Soil fertility	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil nitrogen availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil organic carbon	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil water availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Control of pests and diseases	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Mitigation of soil erosion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Deep incorporation (>10 cm depth)

	Negative	Partly negative	Neutral	Partly positive	Positive
Soil fertility	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil nitrogen availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil organic carbon	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Soil water availability	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Negative	Partly negative	Neutral	Partly positive	Positive
Control of pests and diseases	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Mitigation of soil erosion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Please specify any additional effect that you think crop residue management may have

_____

What additional information (knowledge) do you think farmers need regarding residue management?

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