Australian grains baseline and mitigation assessment

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Key words

emission intensity, crop rotation, nitrogen, emissions reductions

Take home messages

- Potential to increase production without significantly increasing overall on-farm emissions, improving emissions intensity by 20%, is possible by optimising N applications based on seasonal conditions and rotations
- Improved N management is a clear option to reduce GHG intensity but by increasing production by 30-40% would result in an industry wide emissions increase
- Monitoring and improving the greenhouse-gas (GHG) intensity of our grain production systems is critical to remain competitive in global markets and provide evidence of Australia's low-emissions credentials
- On-farm emissions (Scope 1) comprise 61% of total emissions, most of which comes from application of lime and fertiliser (26%), denitrification losses (20%) and fuel use (11%)
- Fertiliser is the largest contributor (38%) to GHG emissions both from the production and the use of fertiliser
- The GHG emissions intensity of Australian grains crops is relatively low, producing around 315 kg CO2 equivalent per tonne of grain with regional differences evident
- To achieve reduction in overall absolute emissions, with increasing production, significant reductions of emissions associated with the production of fertilisers and other inputs will be needed.

Introduction

Australian agriculture has defined ambitious climate change objectives, such as in the 2030 Roadmap of the National Farmers' Federation, which aim to contribute to Australia's emissions reductions. Emissions reductions also keep our commodities competitive in export markets that increasingly require evidence of low-GHG emissions credentials. GHG credentials are established using GHG accounting to estimate the GHG's emitted directly or indirectly by a farming enterprise, or emitted in a chain of processes resulting in a particular product. At sector level, establishing GHG baselines provides a reference to estimate GHG emissions reductions associated with climate change mitigation strategies.

Climate change mitigation strategies also need to be assessed for GHG emissions reduction potential to guide the Australian grains industry towards a low GHG emissions future. This is important because it will allow the grains industry to contribute to state/national emissions reduction targets and ensure access to key international markets is maintained.

What we did

GRDC commissioned this study to establish a detailed and robust GHG emissions baseline for the Australian grains sector and explore mitigation pathways that maintain or increase production. An estimate of the GHG emissions associated with grain production in 2005 was developed based on management practices and production statistics for that year (a static baseline) based on 25 leviable crops; wheat, barley, oats, maize, triticale, millets, cereal rye, canary seed, lupins, fieldpeas, chickpeas, faba beans, vetch, peanuts, mungbeans, navy beans, pigeon peas, soybeans, cowpeas, lentils, canola, sunflowers, safflower and linseed. The same approach was used to develop an estimate of current emissions for industry and used data for 2016 because that was the most recent year with the required data available. The study also developed a dynamic baseline that estimated the business-as-usual scenario over the period 1991-2019 using APSIM simulations of common rotations used in grain production systems on a regional basis. The emissions reduction potential of a number of strategies (Table 1) was assessed by either running APSIM models with modified management or by undertaking a static assessment using different emissions factors.

Table 1. Description of GHG mitigation strategies/combinations of strategies that offer the greatest reductions in emissions intensity and whether they were modelled using APSIM or used modified factors

Strategy/combination	Description	APSIM/modified
Best N	N was applied in split-applications, at sowing and GS6. N was only applied at GS6 if adequate moisture for a growth response was present. N rates were pre-determined and not adjusted for available soil moisture. This meant surplus N could remain in the soil after harvest.	APSIM
Max N	N was applied throughout the crop to maintain sufficient N in the soil to ensure that N was not limiting for growth.	APSIM
Rotations	The most optimal crop rotation in terms of the generated economic return per unit of GHG emissions was chosen from amongst 7-10 diverse rotations simulated at each location. This scenario is combined with either “Best N” or “Max N” application.	APSIM
GreenFert	Assumed production of fertiliser occurred using renewable energy and low GHG feedstocks	Modified
Controlled Traffic	Fuel efficiency and yields increased while N_2O emissions associated with fertiliser use declined.	Modified

The study included relevant Scope 1 (i.e. on-farm emissions), Scope 2 (i.e. off-farm emissions from electricity production) and Scope 3 (i.e. emissions associated with the production and transport of inputs other than electricity) emissions associated with crop production. The majority of grain farmers have no control over the end use of crops, so downstream (e.g. post-storage) Scope 3 emissions were excluded from the analysis.

Total emissions and emissions sources

The historic static baseline of the emissions associated with Australian crop production in 2005, so for one year of emissions, showed that GHG emission associated with crop production for that year was 13.75 Mt CO2-e. A breakdown of emissions sources (Figure 1) showed that fertilizer production and use contributed nearly 40% of the total emissions for that year. Emissions derived from N loss from crop residue decomposition were also a key source of emissions, as were emissions from the use of lime, on-farm operations and the production of farm chemicals. When aggregated, on-farm emissions (Scope 1) made the greatest contribution to total emissions (61%) and pre-farm emissions (Scope 2 &3) the remainder.

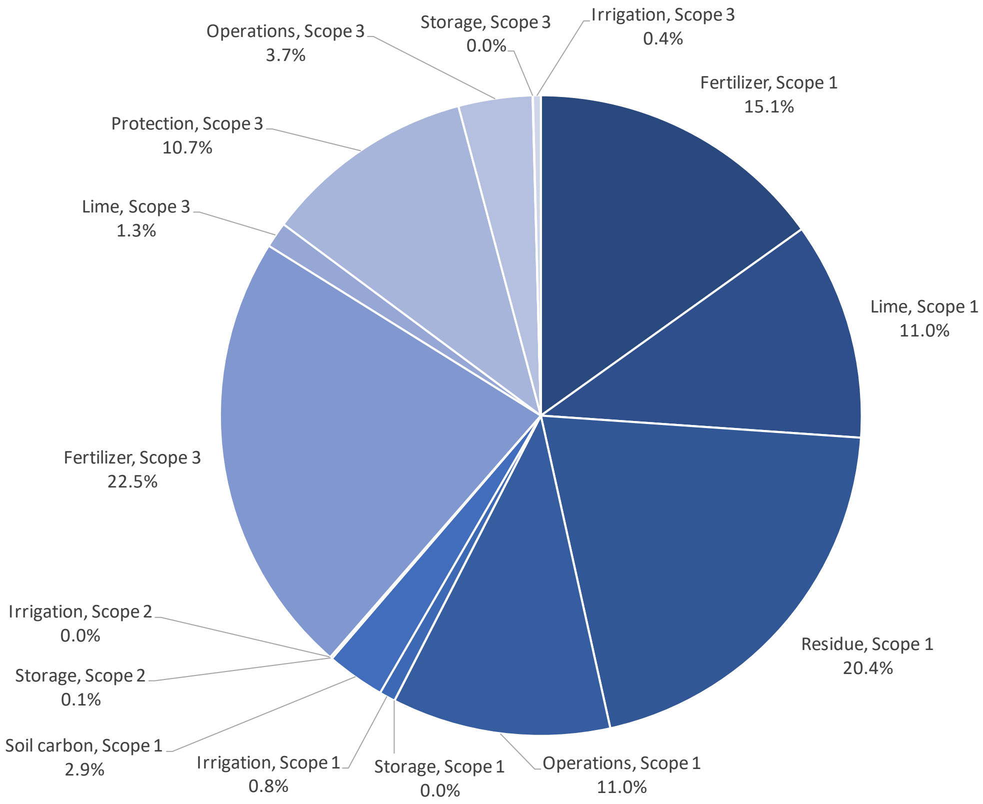

Figure 1. Contributions of emission source categories to the total GHG emissions baseline using 2005 data. Residue emissions are those from the burning and decomposition of crop residue.

Emissions intensity and regional differences

It is also important to assess the GHG emissions intensity of crop production (i.e. the GHG's emitted to produce 1 tonne of crop) because this is the metric on which many decisions are based. Our assessment for the 2005 static baseline showed that 315 kg CO2-e were emitted for each tonne of crop produced. The GHG emissions intensity of crop production is spatially variable as demonstrated by the difference between the GRDC regions (Figure 2) with the emissions intensity greatest for the Western region, lowest in the Southern region and intermediate in the Northern region. The higher emissions intensity for the Western region was primarily due to the use of lime and to lower yields relative to system inputs, which means that per unit of production the emissions were found to be higher.

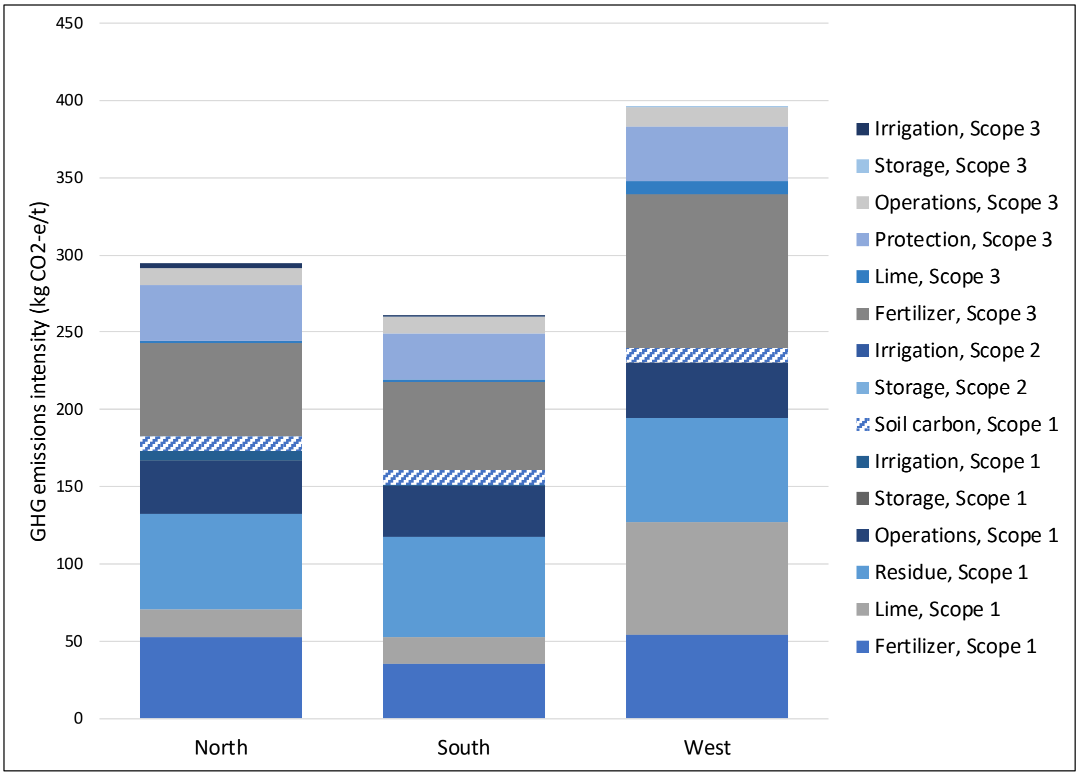

Figure 2. GHG emissions intensity and the contributing sources of emission in 2005 for each GRDC region.

Total emissions for the grain industry also varied significantly on an annual basis, ranging from 6 to 30 Mt CO2-equivalent in any one year (Figure 3). This variability was the result of changes in climate, causing variation in emissions (nitrogen losses) as well as production. The lowest emissions occur in the drought years of 2007 and 2019.

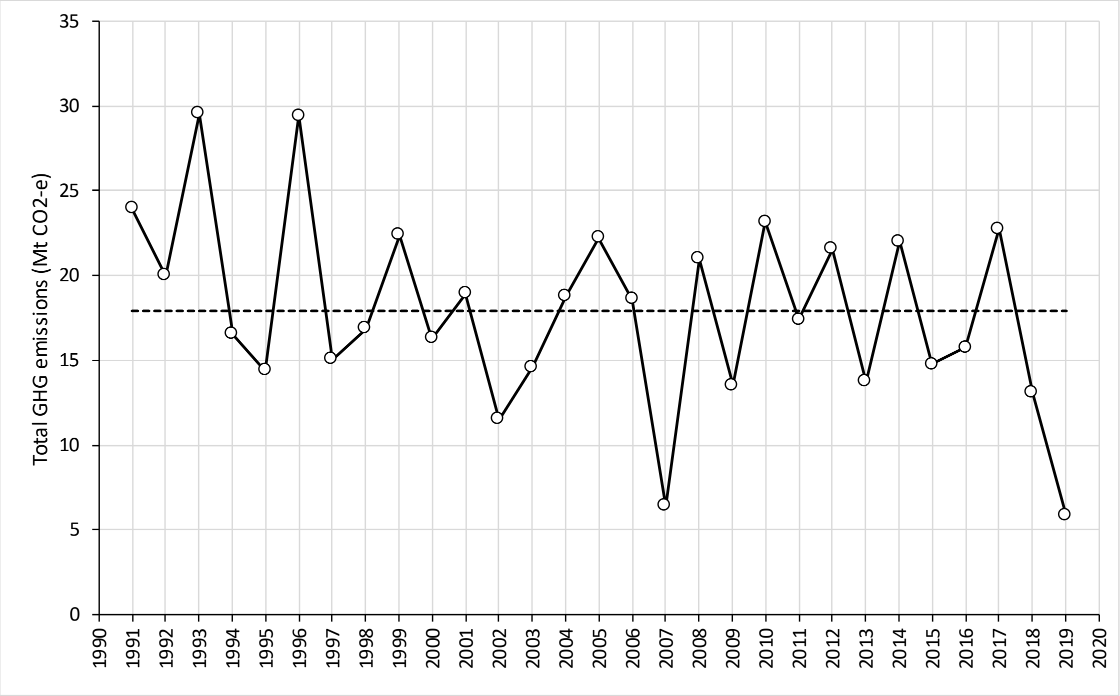

Figure 3. National year-by-year variability in simulated GHG emissions using APSIM (dotted line indicates the 29-year average).

How does Australia compare with other grain producing countries?

Results suggest that the GHG emissions intensity of Australian produced cereals, the majority of which is wheat production, is considerably lower than that estimated by a prominent international database of wheat and barley (Figure 4). With our estimates the emissions intensity of Australian cereal production would be relatively low compared to production in other countries. While the results in Figure 4 for other countries may also be contain inaccuracies, several of the relevant emissions factors deviate from the default values for the Australian environment.

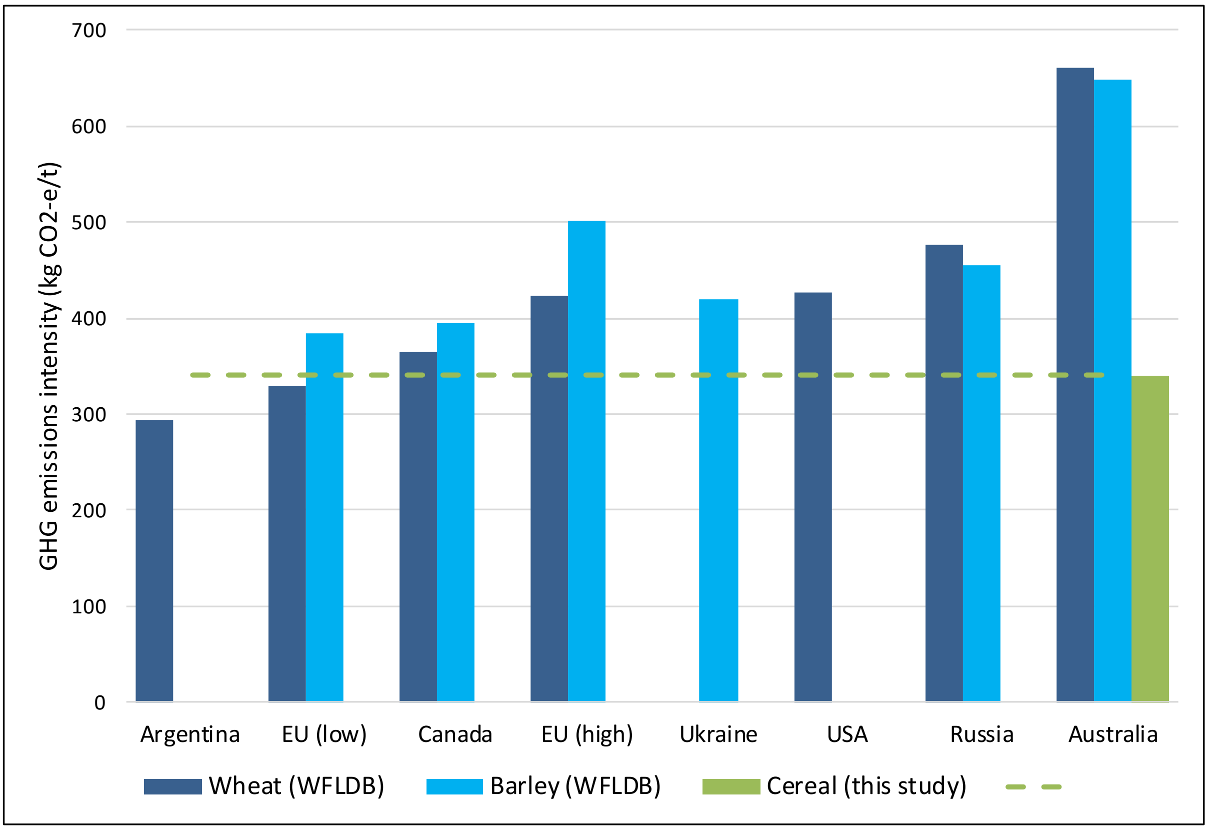

Figure 4. Comparison of GHG intensity results for wheat and barley, by country as available in the World Food Life Cycle Assessment Database (WFLDB), with the result from this baseline assessment for cereals. All data exclude emissions from soil carbon change and land use change.

Options for mitigation – how much can GHG emission intensity be improved?

Our analysis examined several prospective mitigation strategies/combinations on an emissions intensity basis as described in Table 1. The 'MaxN' scenario is not included in this discussion because the 'BestN' scenario is more likely to be achieved. The impact the other scenarios are predicted to have on the emissions intensity of national grain production are presented in Figure 5, along with the emissions for 2015 (Current), relative to the 2005 static baseline (Baseline). Our estimates suggest that the GHG intensity of current systems are 5% higher than those in 2005, due to significant increases in N fertiliser usage and a change in the crop sequences used across the country.

The greatest GHG emissions intensity reductions occurred when the most optimal rotation in each subregion was selected in combination with improved fertiliser N management being implemented. Just implementing improved N management did not reduce GHG emissions intensity to the same extent, but the difference was minimal, suggesting that modifying rotations made a small additional contribution to reducing emissions intensity. Replacing fertiliser produced using conventional manufacturing processes with fertiliser manufactured using low GHG inputs also reduced GHG emissions intensity as did implementing controlled traffic, however these reductions were not as large as those achieved from implementing best N practices.

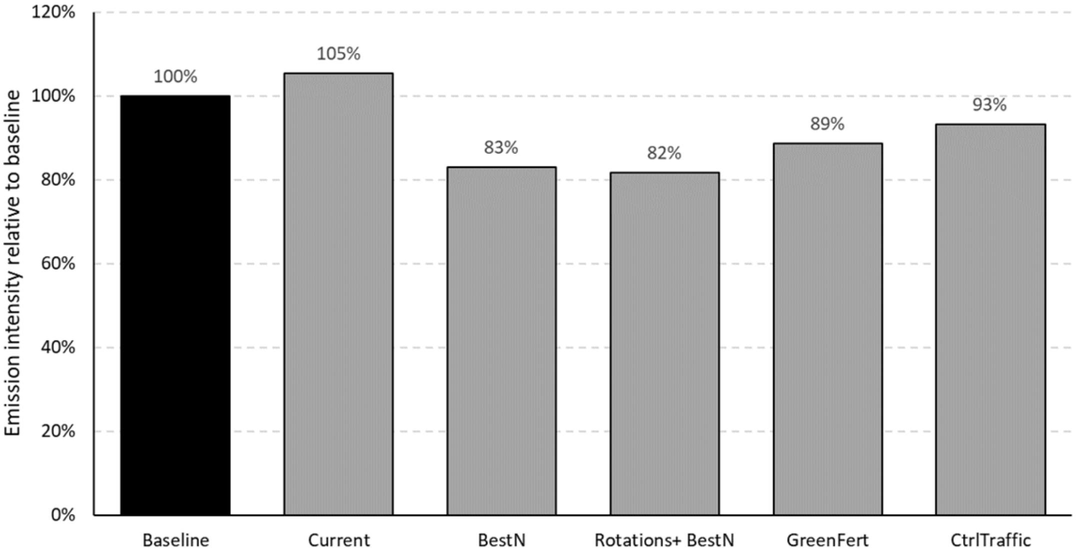

Figure 5. Relative total emission intensity in kg CO_2-equivalent per tonne grain nationally by mitigation scenario modelled compared to the static baseline (2005). The Current (2015) scenario reflects the effects that changes in rotation and nitrogen application rates since 2005 have had. Values for four left-hand columns are the mean over the time series (1991-2019).

Emissions intensity versus total emissions

Results suggest that significant reductions in the GHG emissions intensity of crop production may be possible. However, implementing the Best N and Rotation + Best N strategies that had the greatest reductions (Figure 5) would increase total emissions at a national scale (Figure 6). The increase in total emissions occurs because those strategies involve more use and therefore production of nitrogen. However, because they are also associated with an increase in production (Figure 6) the GHG intensity decreases as shown in Figure 5. The GreenFert and Controlled Traffic strategies had some effect on emissions but only very small to no effect on production so the reduction in total emissions is similar percentage to the reduction in GHG intensity.

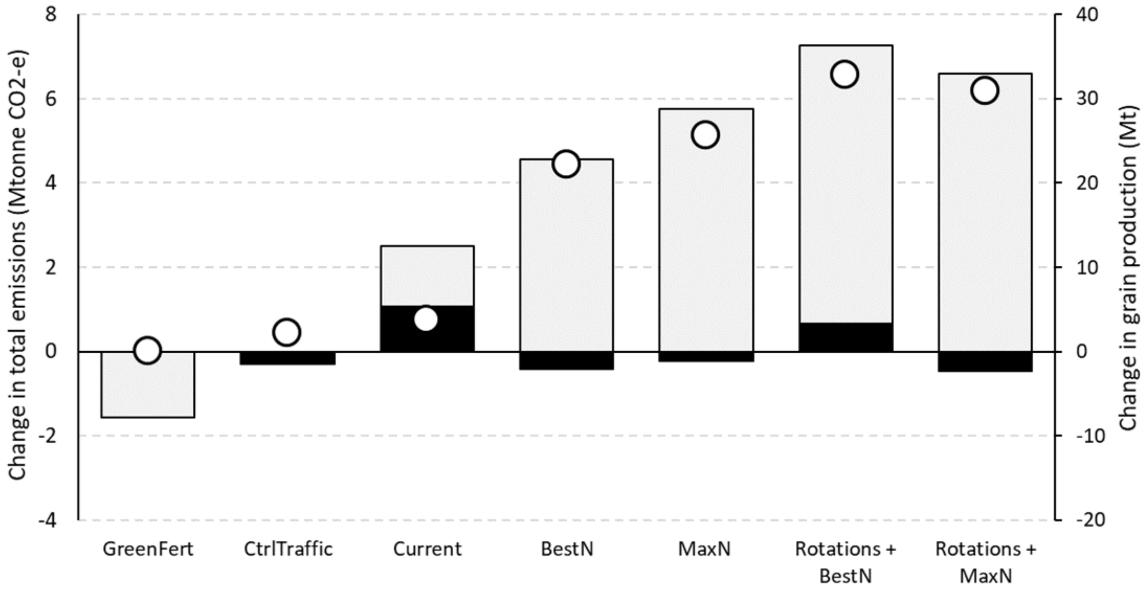

Figure 6. Estimated change in total national GHG emissions (on-farm in black, pre-farm in grey) and total grain production (in Mtonne) relative to the 2005 baseline for mitigation scenarios (see Table 1).

Conclusions

The baseline assessment successfully pulls together data from a wide range of sources with varying levels of spatial resolution into a very detailed GHG inventory for grains with a high level of completeness. This estimates Australia's total GHG emissions associated with grains production in 2005 to be 13.75 Mt CO_2-equivalent or 315 kg CO_2-equivalent/tonne grain. This is much lower than previously calculated for Australia.

On-farm emissions contribute about 60% of this, while about 40% come from emissions associated with agricultural inputs.

Fertilisers were a critical source of GHG emissions both from their production and use on farm. Hence, a clear opportunity is to improve fertiliser application practices that increase production and overall GHG intensity. Further, significant reduction of those emissions can be expected in the longer term via the production of green fertilisers and (other) decarbonisation of energy supply. Offsetting of emissions via reforestation seems the most likely option to reduce absolute emissions and this could be compensated for by increasing production on remaining land.

Absolute GHG mitigation potential in the Australian grains sector is limited due to an intrinsic trade-off between total emissions and production. Given widely supported goals to increase production, it is unrealistic to expect significantly reduced absolute total emissions, given the essential role that carbon and nitrogen play in plant growth, but Scope 1 emissions are shown to reduce in the high-nitrogen scenarios in some regions. Setting targets in terms of GHG intensity, combined with minimum conditions around Scope 1 emissions and production, is the most realistic and in line with recommendations made by the National Farmers' Federation.

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