MM07: Improved Crop Health

Category

Cropland and grassland management: crop management

Overview

Weeds, pests and pathogens reduce can cause crop losses before harvest and during storage (OERKE 2006) (Figure 1). Pre-harvest losses from pests and pathogens decrease the crop's ability to intercept radiation or the efficiency of processes which turn intercepted radiation to dry matter (Johnson 1987). Furthermore, the incidence of these agents is believed to increase with climate change (Olesen *et al.* 2011), with insect pests losses of wheat doubling in North West Europe. In the UK phoma stem cranker of oilseed rape is predicted to increase in severity and spread northwards (Evans *et al.* 2007), fusarium ear blight epidemics on wheat will be more severe (Madgwick *et al.* 2011), and there is a possibility of increase in the abundance and diversity of pests in the UK (Cannon 1998).

Eventually, pests and pathogens cause yield quality and/or quantity loss, leading to higher GHG emissions and land use requirements to achieve the same yield. A combination of plant breeding for disease resistance and physical, biological and chemical control is used to combat pests and diseases. However, control agents and activities have direct and indirect GHG emissions associated with them, for example the emissions embedded in pesticides and the emissions from fuel used during pesticide application.

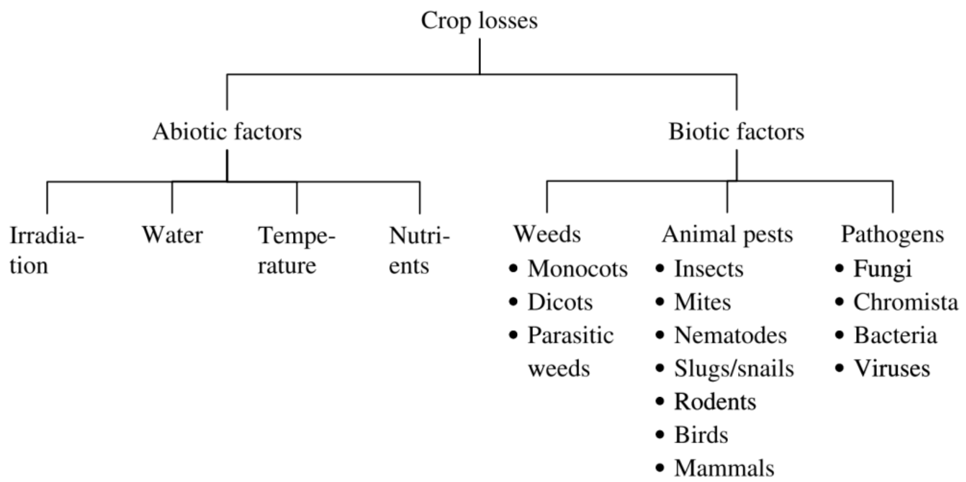

Figure 1 A classification of causes of crop losses (OERKE 2006)

Oerke estimated more than a decade ago that globally, on average 7.9%, 10.2% and 2.4% of the attainable wheat yield is lost, respectively, due to animal pests, pathogens and viruses, and 8.7%, 15.6% and 2.5% of the yield could potentially be lost due to the same agents. This suggests that the effectiveness of control is %, 35% and 4% for animal pests, pathogens and viruses, respectively (2006).

The same author estimated that in North-West Europe approximately 25% of the attainable wheat yield would be lost without controlling animal pests, pathogens and viruses, and the actual loss is 6%, i.e. 75% of the losses are prevented (2006). A more recent study based on an expert survey found similar global wheat losses (22%) but much higher losses of wheat in North West Europe (25%) (Savary *et al.* 2019).

Regarding potato Oerke estimated that 38% of the yield in Europe could be lost to the above agents and 20% yield loss is prevented (53% efficiency of loss prevention) (2006). According to Savary *et al.* the potato losses in Europe are around 10% of the yield (2019).

In this mitigation measure we attempt to give an estimate of GHG abatement potential and cost-effectiveness of improving crop health in general in the UK. A detailed approach focusing on individual agents and control mechanisms was non within the scope of this work, instead, a top-down estimate is derived from yield gap studies.

Mitigation summary

Table 1 Effects on emissions

GHG categories	Effect*	Notes
Enteric CH_4		
Manure CH_4		
Manure **N_2O**		
Soil N_2O: applied N	-	
Soil N_2O: grazing		
Energy CO_2: fieldwork		
Energy CO_2: other		
CO_2 liming and urea		
CO_2 sequestration below ground		
CO_2 sequestration above ground		
Pre-farm emissions	-	Fertiliser production
Post-farm emissions		
Substitution of higher C products		
Production increases by more than the emissions		
	Rating	
Confidence in mitigation effect	Low	
Cost-effectiveness**	Moderate	
Confidence in cost-effectiveness	Low	

* ”-“ GHG reduction, “+”: GHG increase, “ ”: no significant effect

** low: =< £0/tCO_2e, moderate: £0/tCO_2e< >SCC, high: >SCC

Related measures and potential synergies

Table 2 Likely effects on the abatement potential of other measures

Measure	Impact
	-
	-

Inclusion in other marginal abatement cost curves

Table 3 Past assessment of the measure

UK 2008	UK 2010	UK 2015	Ireland 2012	France 2013	France 2019
No	No	No	No	No	?

What does the measure entail?

The measure assumes improved pest and disease control practices, which can be a combination of management actions targeting the relevant problems on the farm. As the measure is a general one, there is no specific focus on crop types, pests or diseases, neither on crop protection actions.

Abatement rate

Berry *et al.* (2008) quantified the life cycle GHG savings arising from application of fungicides on UK wheat cultivars (fungi being the main cause of wheat yield loss in the UK). They found that across the cultivars with different disease resistance the full fungicide treatment resulted in an average yield increase of 1.51 t DM ha^{-1} (from 7.16 t DM ha^{-1}) and an emission intensity reduction of 15% (from 386 to 327 kg CO_2e (t DM)$^{-1}$). A similar study by Mahmuti *et al.* (2009) studied the GHG emission intensity gains from fungicide treatment of oilseed rape cultivars in the UK. The average yield gain due to fungicide treatment was 0.45 t DM ha^{-1} (3.53 to 3.98 t DM ha^{-1}, assuming 92% DM content), with a net average lifecycle emission decrease of 11% or 98 kg CO_2e (t DM)$^{-1}$ (the average emission intensity of treated and untreated crop was 907 kg CO_2e (t DM)$^{-1}$). However, these studies have considered the total potential yield loss rather than the actual yield loss. Oerke (2006) estimated that the actual loss (6% of the attainable yield) in wheat is ¼ of the potential loss in North-West Europe, if we assume that the actual loss is 25% of the potential loss then the emission intensity improvement in wheat and oilseed rape production in the UK can theoretically be 4% and 3%, respectively.

Based on Oerke (2006), the yield gap due to pests, pathogens and viruses between the actual and attainable yield is 6% in wheat (2% from pests, 3.5% from pathogens and 0.5% from viruses), with a control efficiency of 75%. If control practices could improve the control efficiency by another 12.5%, then the yield gap would decrease to 3%, creating a yield increase of 3.2% compared to actual yield.

Cost

Evidence on the marginal benefits of pesticides on crop productivity and farm profitability are contradictory; some suggesting that pesticides at their current level being essential for maintaining the current level of crop production and profitability (Cooper and Dobson 2007, Jess *et al.* 2014), while other authors presenting findings which suggest pesticide use can be decreased on a large proportion of farm without adverse effects on crop production (Lechenet *et al.* 2017). Integrated pest management (IPM) can provide alternatives and complements to pesticide use, increasing plant health status (Hillocks 2012), but there are costs associated with IPM too. Emerging remote sensing and variable rate application technologies also suggest that improvement in targeting crop protection can be expected over the coming decades from the increasing use of precision farming solutions. Given this mixed evidence, we cannot assume that a substantial increase in plant protection costs is needed to achieve a higher level of control. As an approximation, a 5% increase in plant protection costs is considered here.

Applicability

The measure is applicable on all crop types and farms.

Current uptake and maximum additional future uptake

Farmers do control pests and diseases; this measure is about improving those practices. Given that the technologies cover a wide range of possibilities in this measure, it is not possible to establish an uptake baseline. As for the yield improvement an UK average approach is used, and no information was found on the efficiency difference between farmers in the UK regarding pest and disease control, we assume all farms have an average level of control and therefore all of them can improve to the same extent.

Assumptions used in the MACC

Parameter	Change in value	Notes
Cereal yield	+3%	
Plant protection costs	+5%	Based on The Farm Management Handbook, variable costs 'Sprays'

Wider effects

Table 4 Wider effects of the measure

Aspect	Effect	Reference
Positive effects		
Off-farm GHG		
Production	Increased yield	
Adaptation		
Environment	Reduced reactive N pollution, reduced land use	
Negative effects		
Off-farm GHG	Increased embedded emissions in pesticides	
Production		
Adaptation		
Environment	Negative effects on biodiversity from the application of pesticides	

Identified implementation challenges and barriers

Table 5 Potential barriers of the measure

Barrier to uptake	Reference

Barrier to uptake	Reference
Other key risks/uncertainties	**Reference**

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