Boosting grain yield by including leguminous bioenergy crops in the rotation – a life cycle approach

Pernilla Tidåker and Göran Bergkvist

Swedish Institute of Agricultural and Environmental Engineering, and
Swedish University of Agricultural Sciences

Background

- Current bioenergy production in the EU largely based on crops that may conserve monoculture cropping practices
- Urgent need for bioenergy crops that:
  - reduce the competition between food, feed and fuel, and
  - improve long-term agricultural productivity

Grass/clover in the rotation –

a means for improving short- and long-term productivity

- Low/no N requirement due to symbiotic N fixation
- Reduces the need for N mineral fertilizer for subsequent crops
- Increases the yield potential for subsequent crops (up to 20%)
- Potential to sequester carbon

Goal and scope

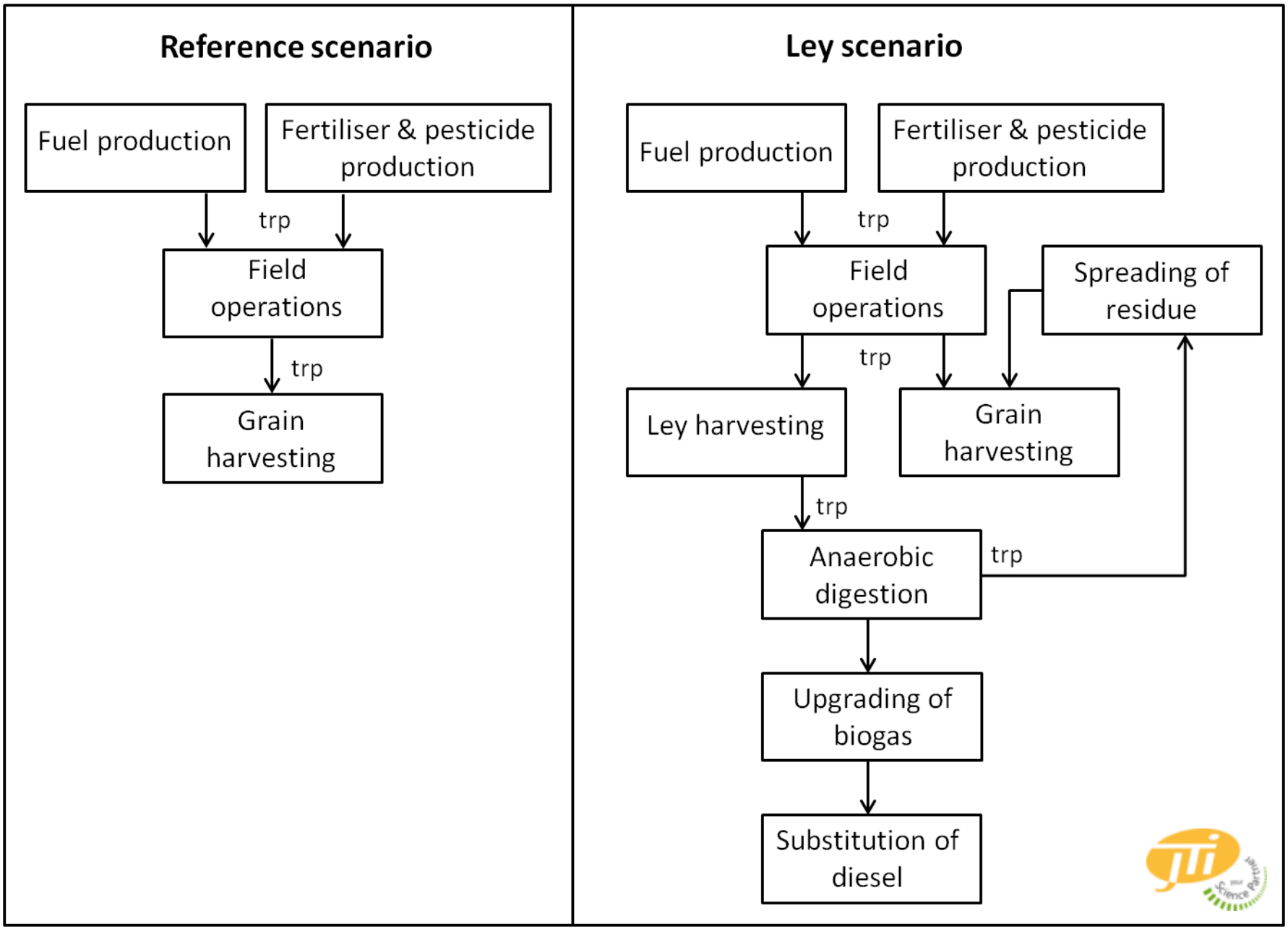
- Evaluate energy use, GWP and land use for grain production when grass/clover for anaerobic digestion is included in a cereal cropping system
- Highlight rotational effects influencing yield potential, C sequestration and N requirements

Functional unit: 1 tonne of grain harvested

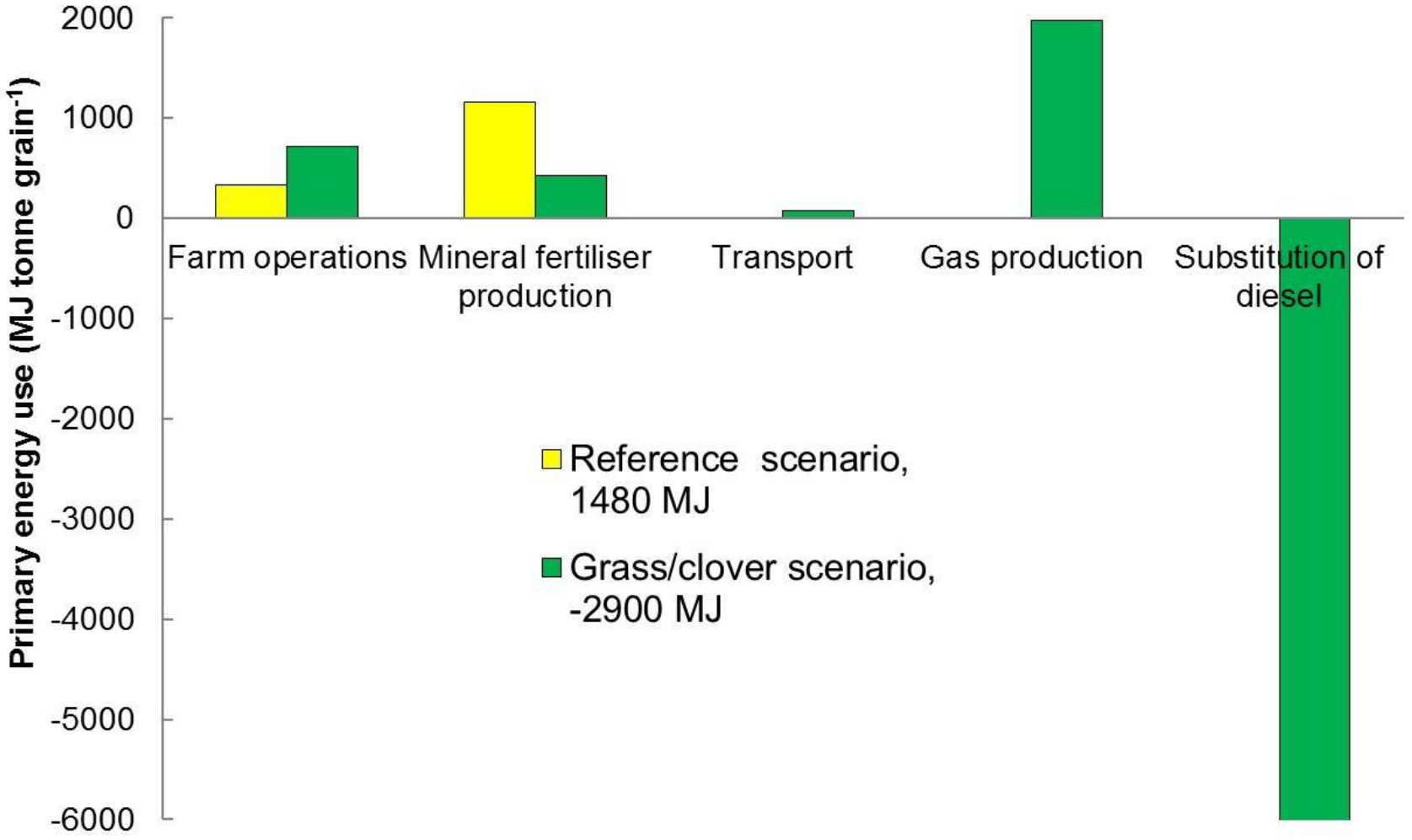
System description

- Assumed location: eastern part of Sweden
- Grass/clover: digested and biogas upgraded to vehicle fuel
- Digestate used in cereal production replacing N mineral fertilizer

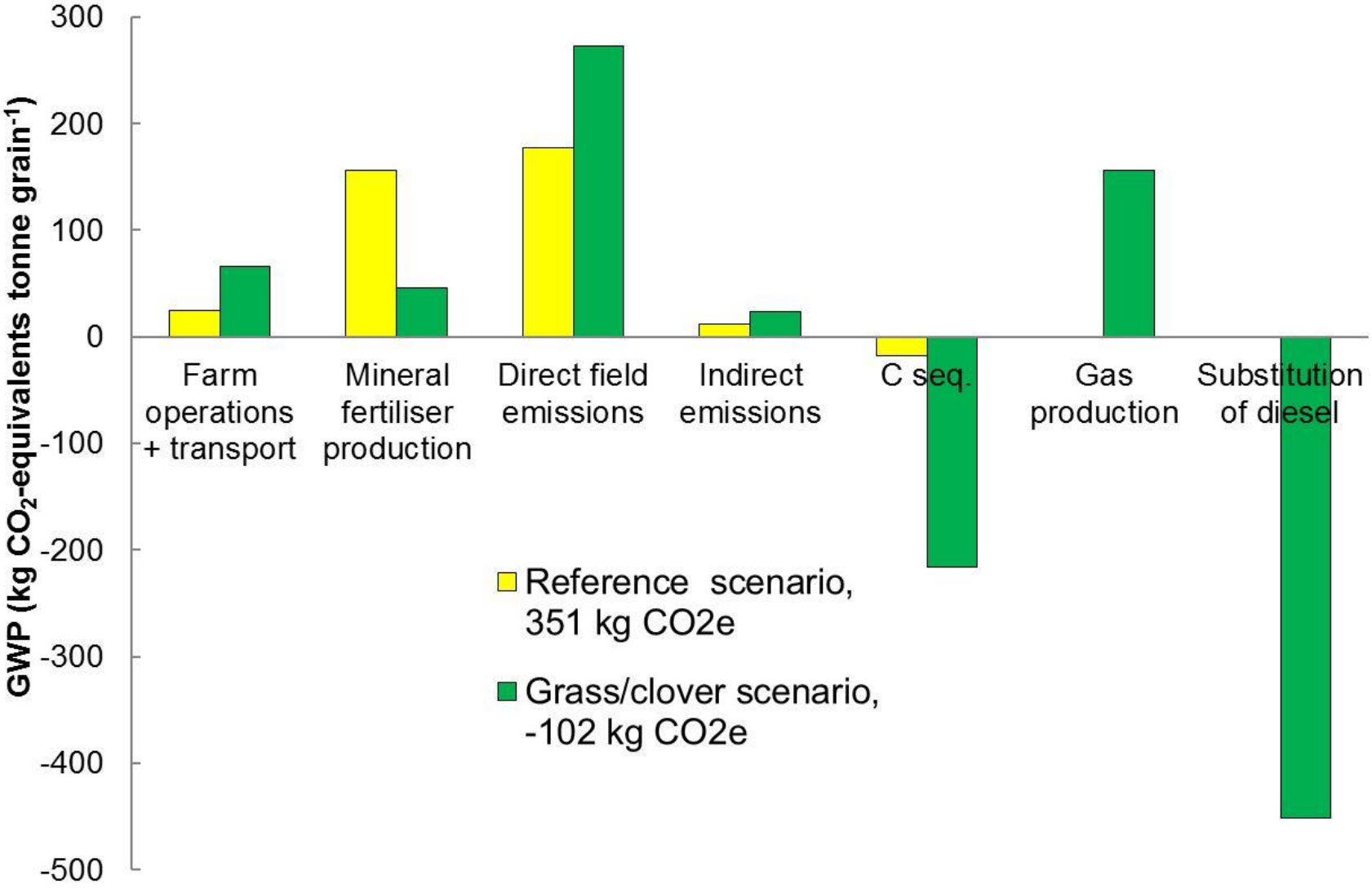
	Yield (kg, ha^{-1})	Plant-avail. N applied ha^{-1}
REFERENCE		
Spring barley	4300	80 kg N (min fert)
Winter wheat x 2	5600	135 kg N (min fert)
GRASS/CLOVER SCENARIO		
Spring barley	4300	80 kg N (digestate)
Grass/clover (2 years)	7000	
Winter wheat I	6600	110 kg N (mainly min fert)
Winter wheat II	6000	140 kg N (digestate)


Reference scenario
Fuel production
Fertiliser & pesticide production
trp
Field operations
trp
Grain harvesting
Ley scenario
Fuel production
Fertiliser & pesticide production
trp
Field operations
Spreading of residue
trp
Ley harvesting
Grain harvesting
trp
Anaerobic digestion
trp
Upgrading of biogas
Substitution of diesel

Results (Energy)



Results (GWP)


GWP (kg CO_2-equivalents tonne grain^{-1})
300
200
100
0
-100
-200
-300
-400
-500
Farm operations + transport
Mineral fertiliser production
Direct field emissions
Indirect emissions
C seq.
Gas production
Substitution of diesel
Reference scenario, 351 kg CO2e
Grass/clover scenario, -102 kg CO2e

Results (Land use)

- Grain production in the grass/clover scenario was 66% compared to the reference scenario, but occupied 60% of the area
- Higher cereal yields after grass/clover and C sequestration important aspects to counterbalance iLUC
- With an iLUC factor <4300 kg CO2e per ha and year, the grass/clover scenario would score better for GWP

Discussion and conclusions

- Digested grass/clover replacing N mineral fertilizer in cereal production decrease the energy use and GWP, but require careful N management
- Grass/clover as bioenergy crop can (partly) offset some negative effects from iLUC through higher yield potential and C sequestration
- Crucial to evaluate crop sequences when N-fixating break crops is included to consider increased yield potential and N delivered to other crops
- Important soil fertility aspects can be included directly in the assessment without considering a separate indicator for soil fertility
- Different N-fixating energy crops should be further evaluated as part of future mitigation strategies

Thank you for your attention!
Questions?

Additional reading:

Tidåker et al. (2014). Rotational grass/clover for biogas integrated with grain production – a life cycle perspective. Agricultural systems 129: 133-141.