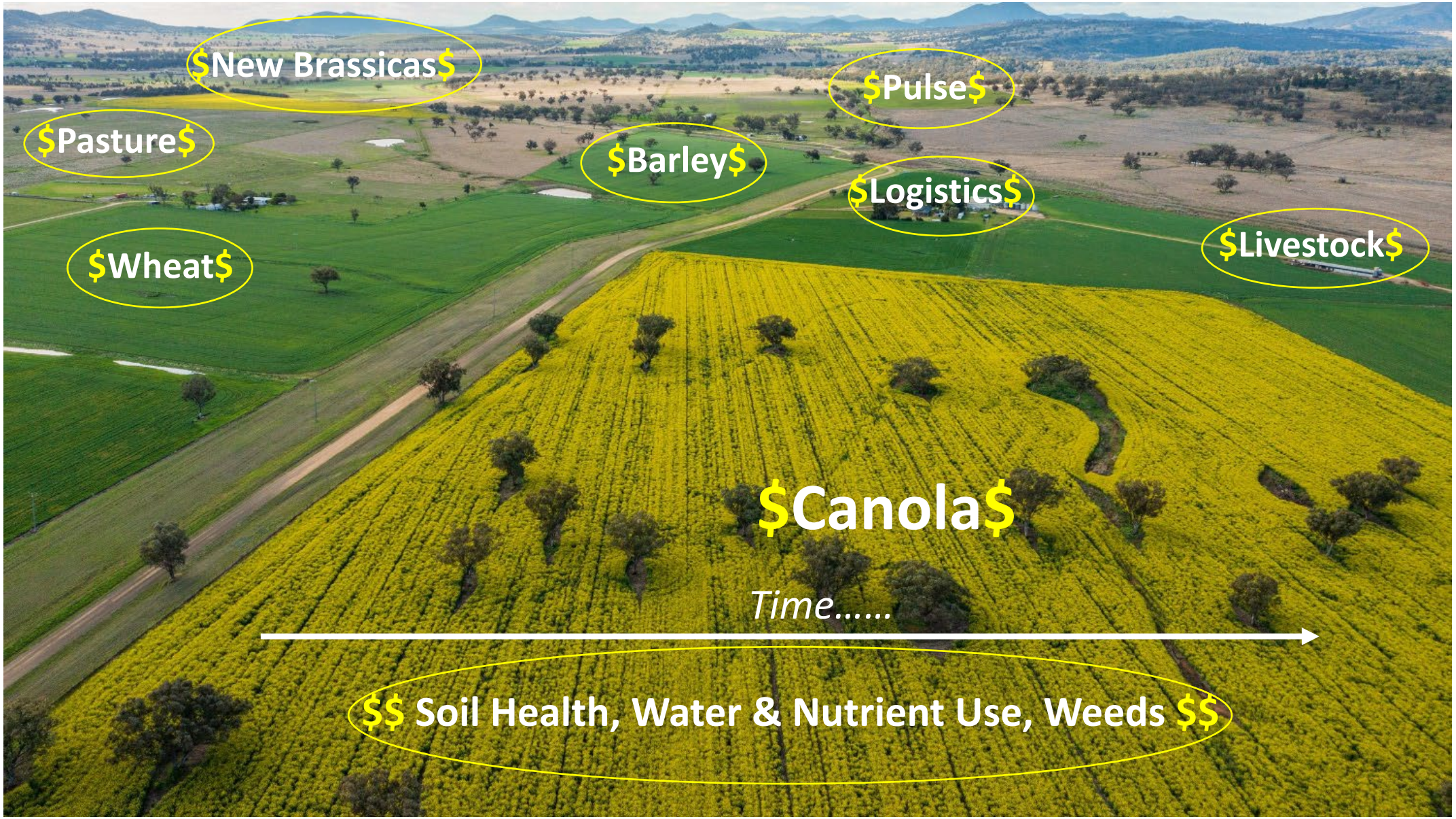
Brassica oilseeds

– underpinning diversity and productivity in global cropping systems




John Kirkegaard, CSIRO Australia

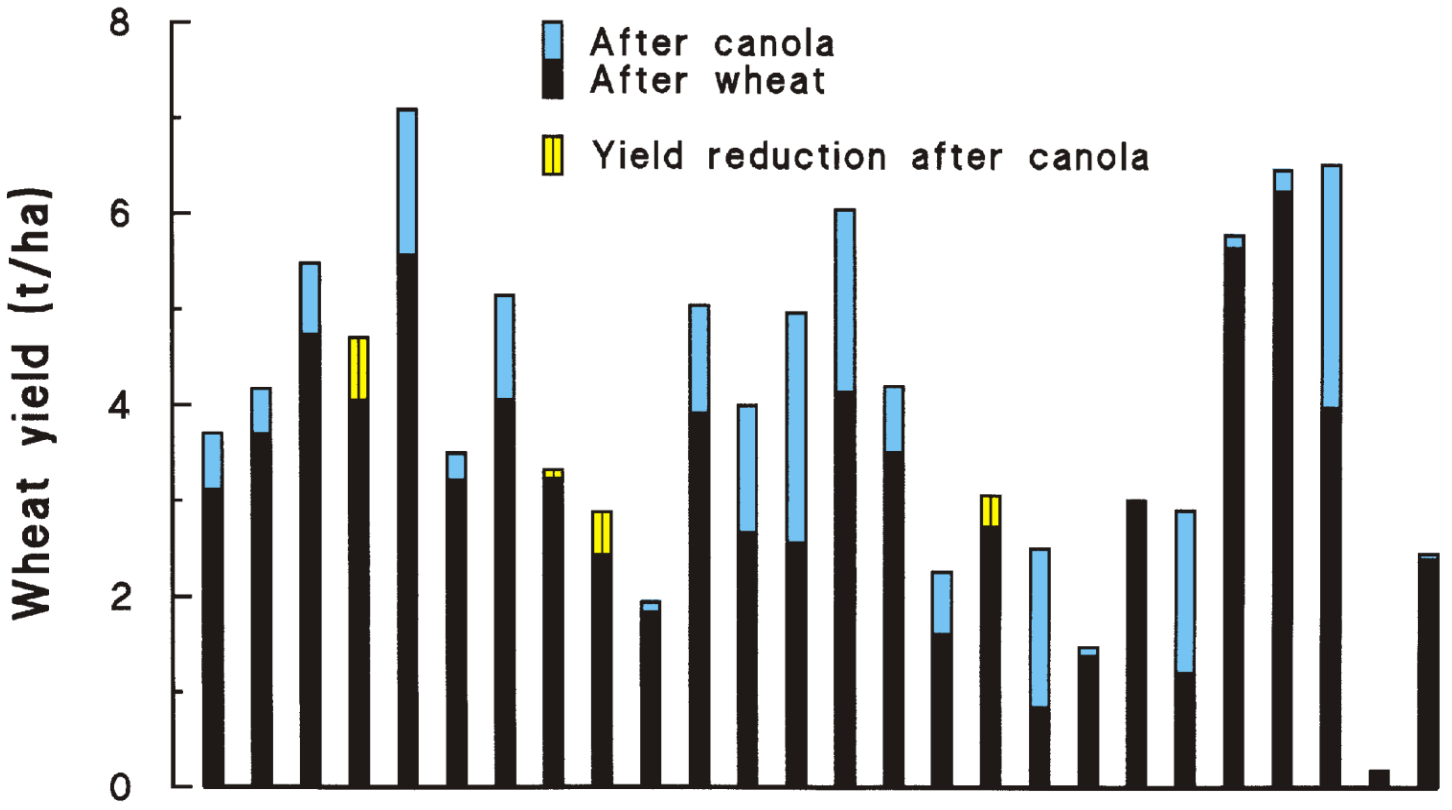
Farming Systems Benefits



Exceptional rotation crop for cereals

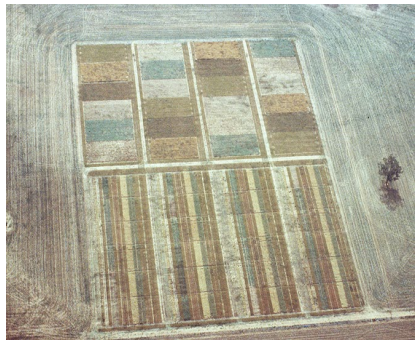
- Yield increase 20%
- 2-yr profit increase of 27%
- 70% due to higher wheat yield

26 on-farm experiments from 1989 - 1998



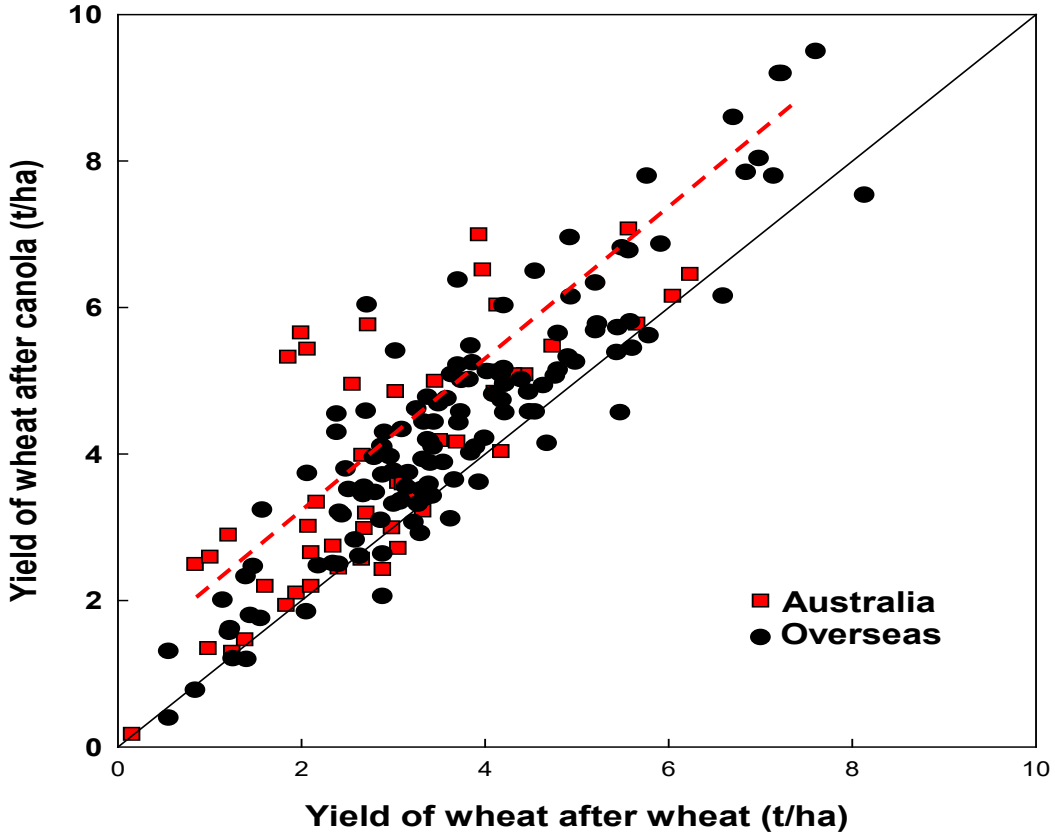
Rotation benefits consistent globally……





Region	Yield Response (range)	Yield Response (mean)	Studies (no.)
Nth Europe	-7% to 57%	~ 20%	15
Nth America	-10% to 62%	~ 20%	15
SE Australia	-16% to 197%	~ 20%	15

Kirkegaard et al., (2008) Field Crops Research



- **0.70 t/ha** yield advantage after canola
- **0.12 t/ha** yield advantage in 2nd wheat

Angus et al. (2015) Crop Pasture Science

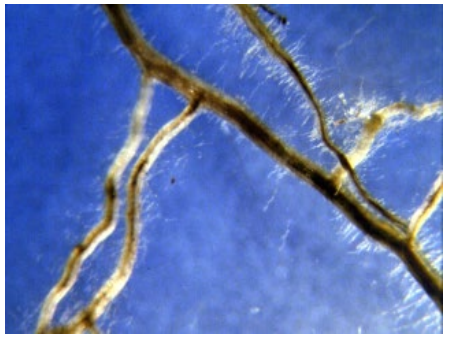
Mechanisms – reduced disease (non-host)

Root disease

Take-all

Crown rot

Pratylenchus



Wheat after Wheat Wheat after Canola

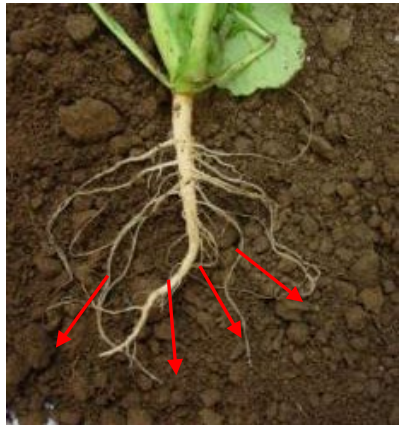
Shoot disease

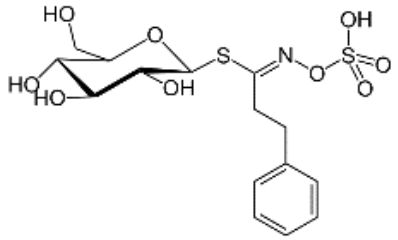
Yellow leaf spot

Eyespot

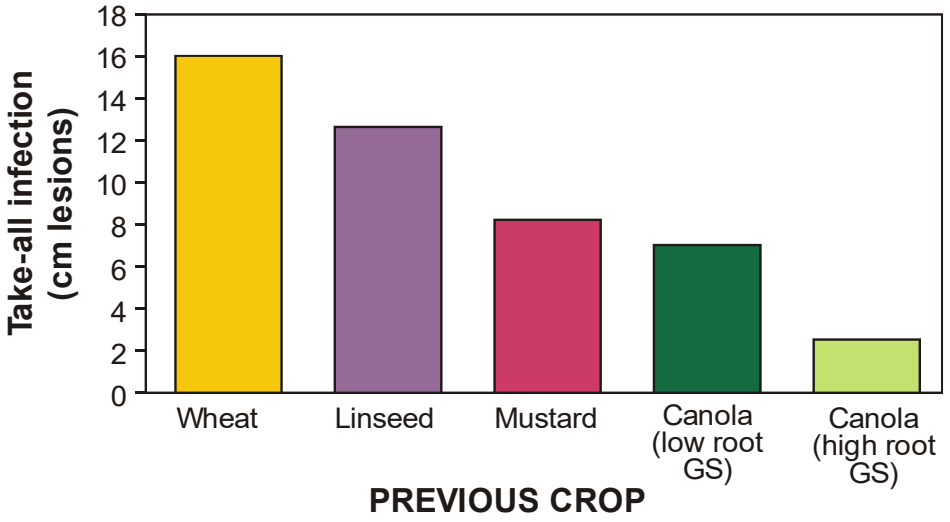
Septoria

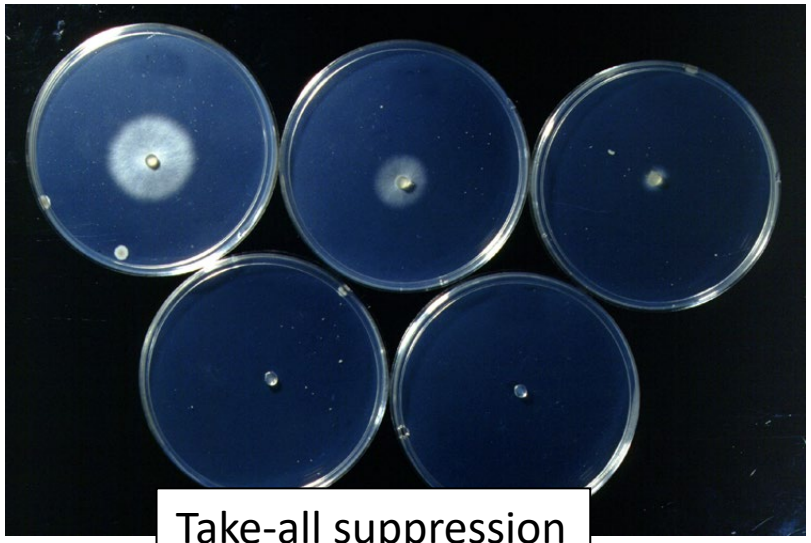
Disease suppression - biofumigation



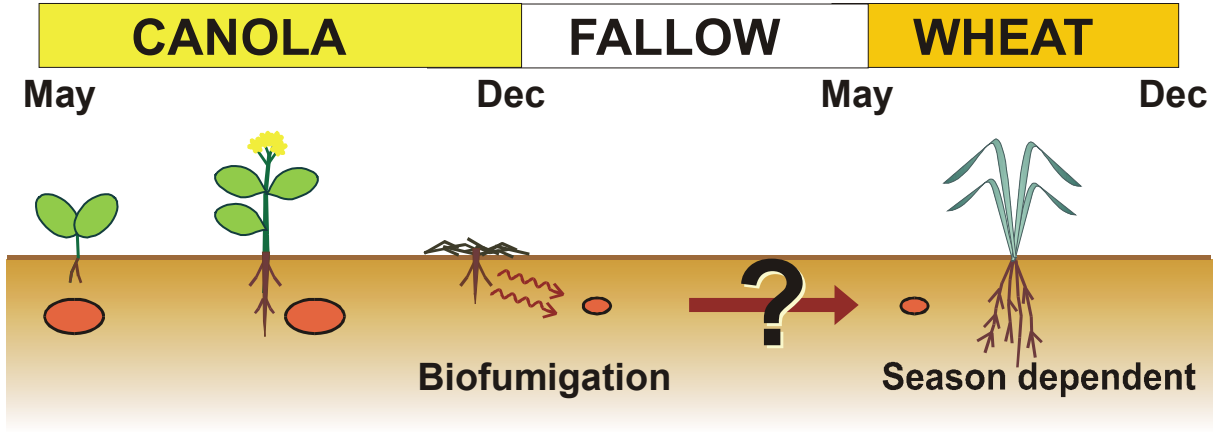


2-phenylethyl GSL





Take-all suppression



Kirkegaard et al., (2000) AJAR

Water and N interactions

Yield responsive
Doesn't "hay-off"

Low N removal

High N requirement
& uptake

High N return

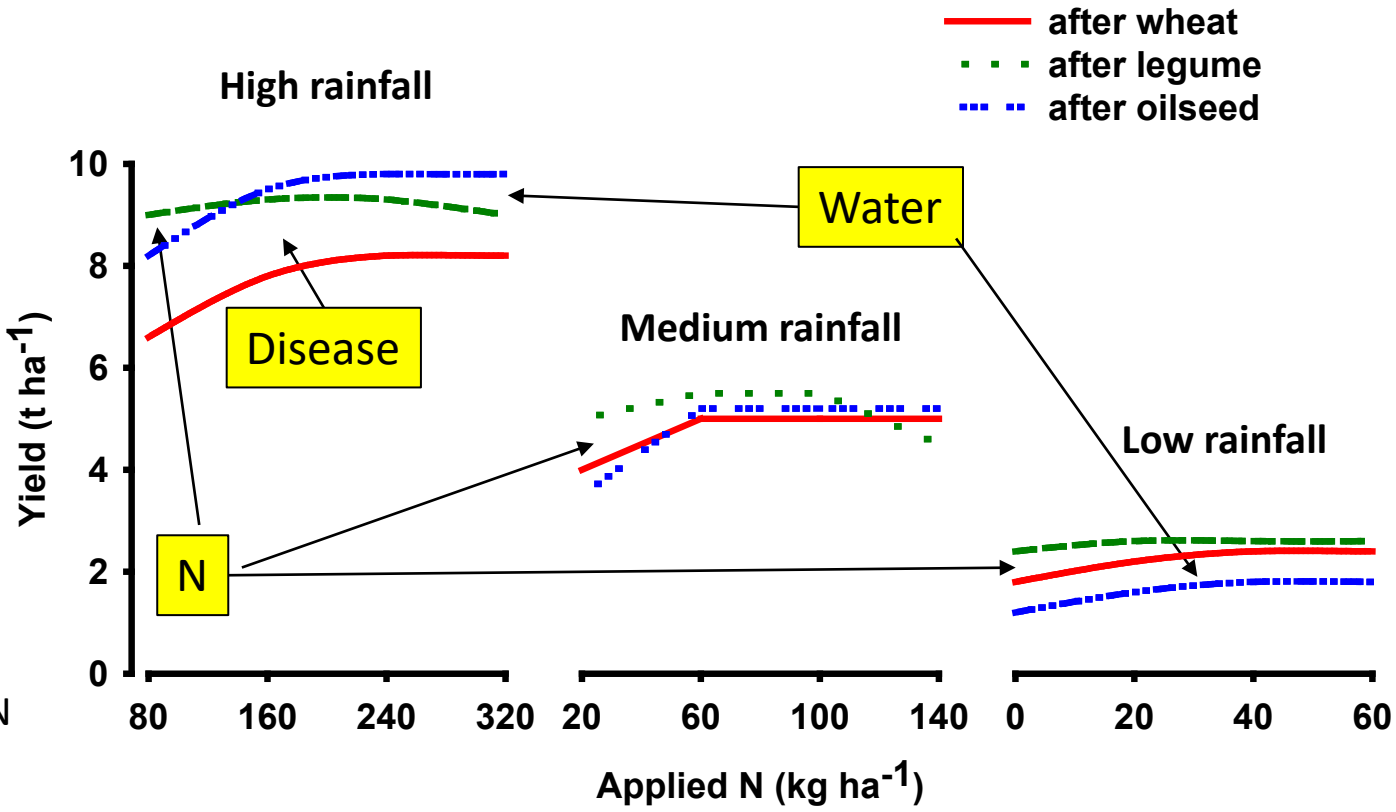
High soil Min-N

+ Residual N

X Leaching

Deep taproot, extensive fine roots

Effective water and N capture



Kirkegaard et al., (2008) Field Crops Research

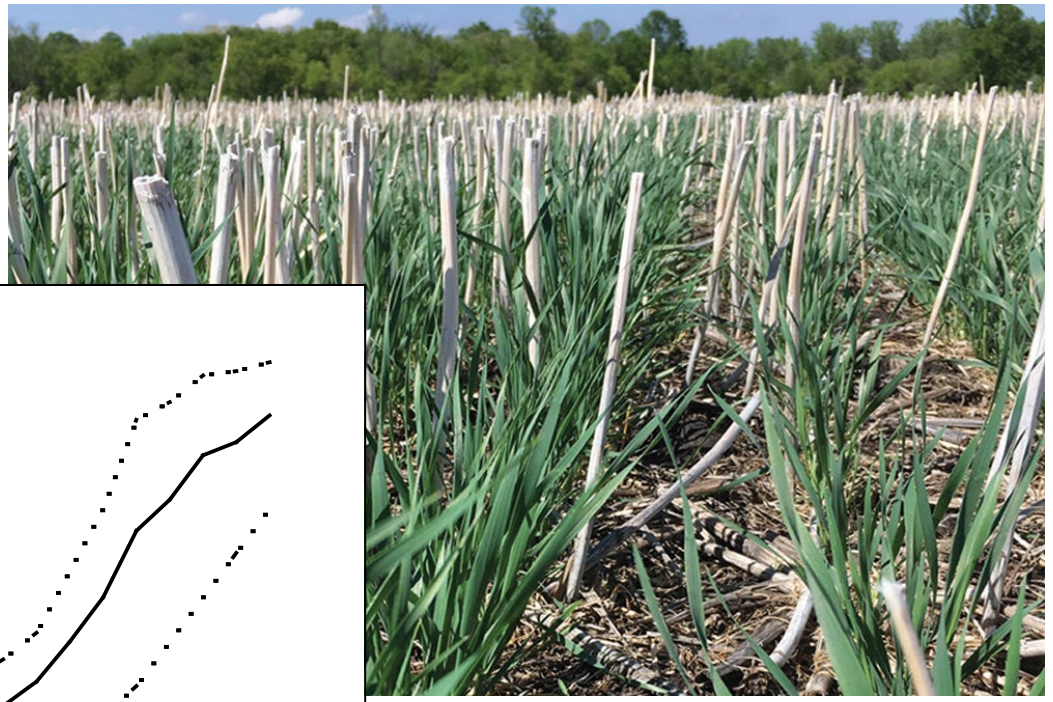
Canola is lime reponive on acid soils

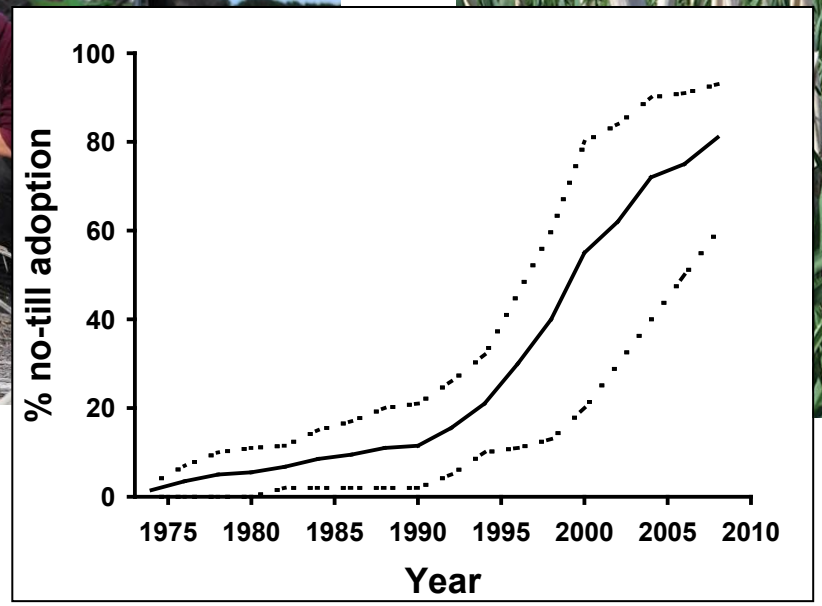
- Responsiveness of canola paid for lime
- Lime improved pH and soil fertility
- Flow-on benefits to other crops and pastures

Canola facilitated conservation agriculture

- Easier to sow through retained stubble

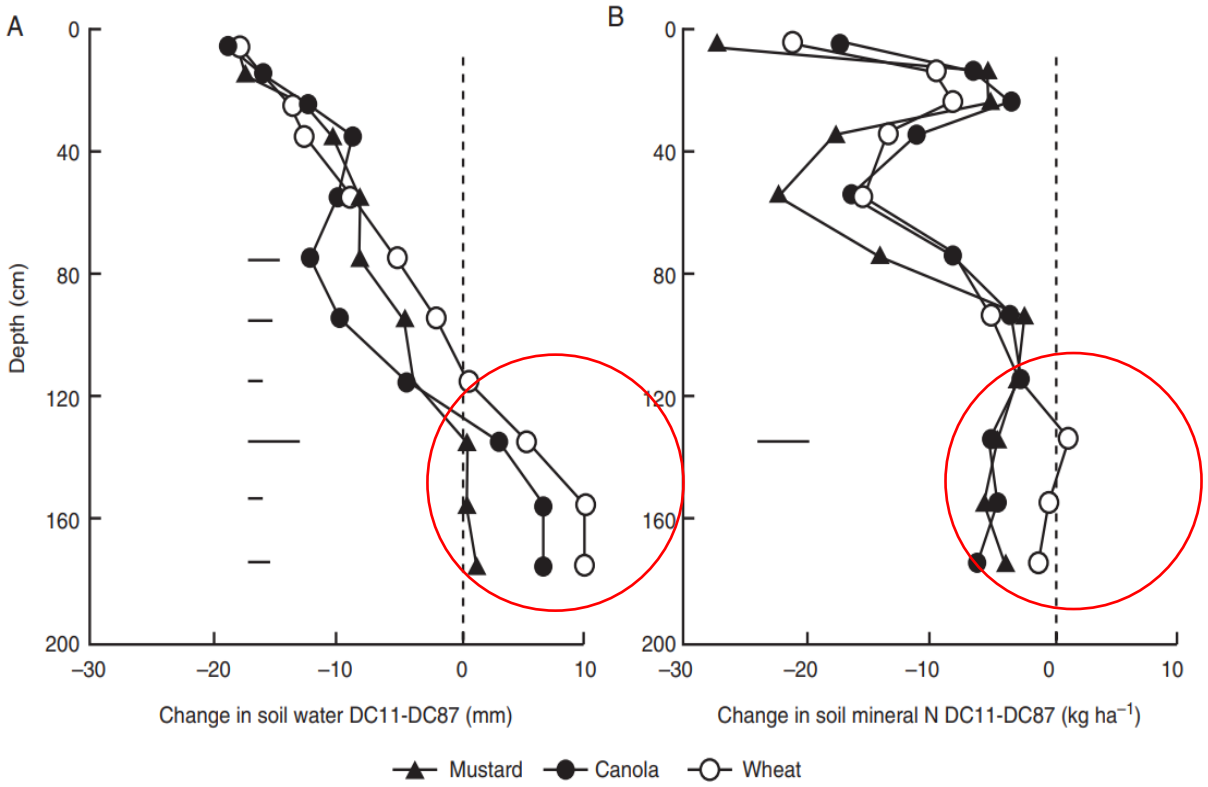
- Less stubble-borne disease carry-over





Improved water and N uptake in wheat

- More responsive to applied N fertiliser (*Angus, 2020)*
- Improved subsoil water and N uptake
  (Kirkegaard and Thorup-Kristensen, 2015)

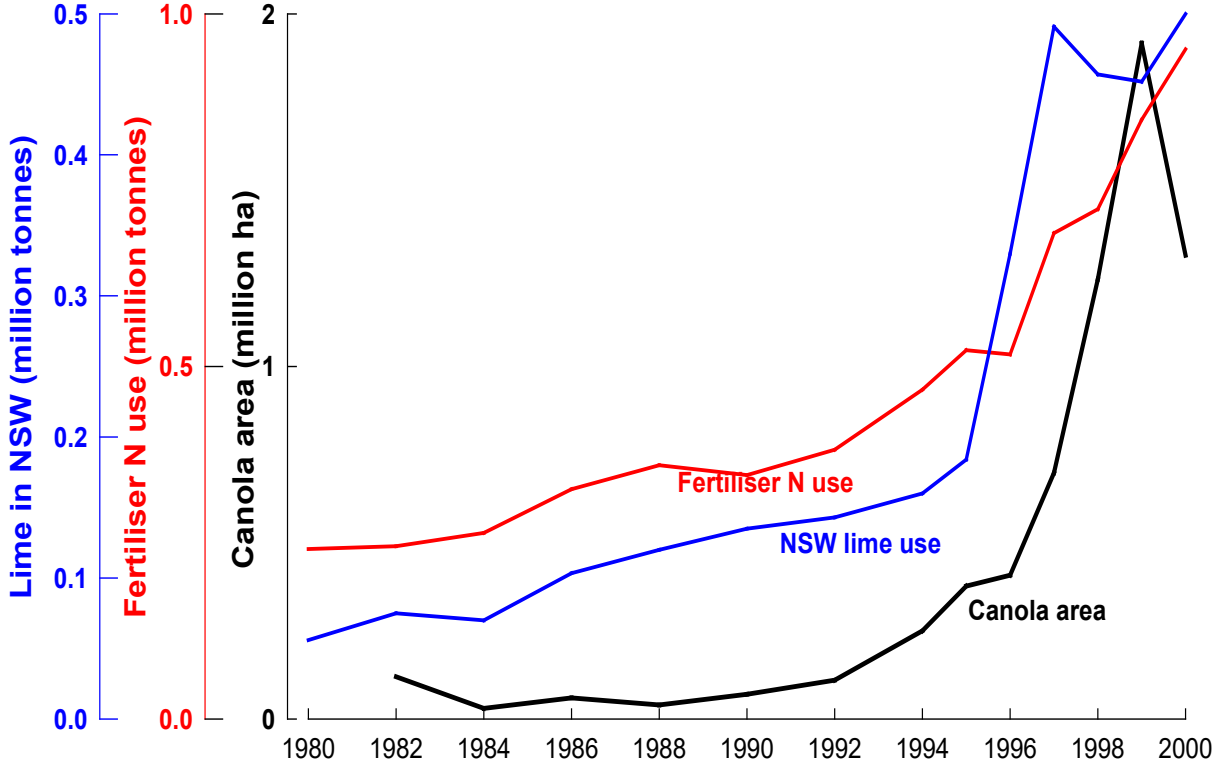


- 8 comparisons 1991-98

  Mean increase 31 mm

  Angus, van Heerwarden (2001)

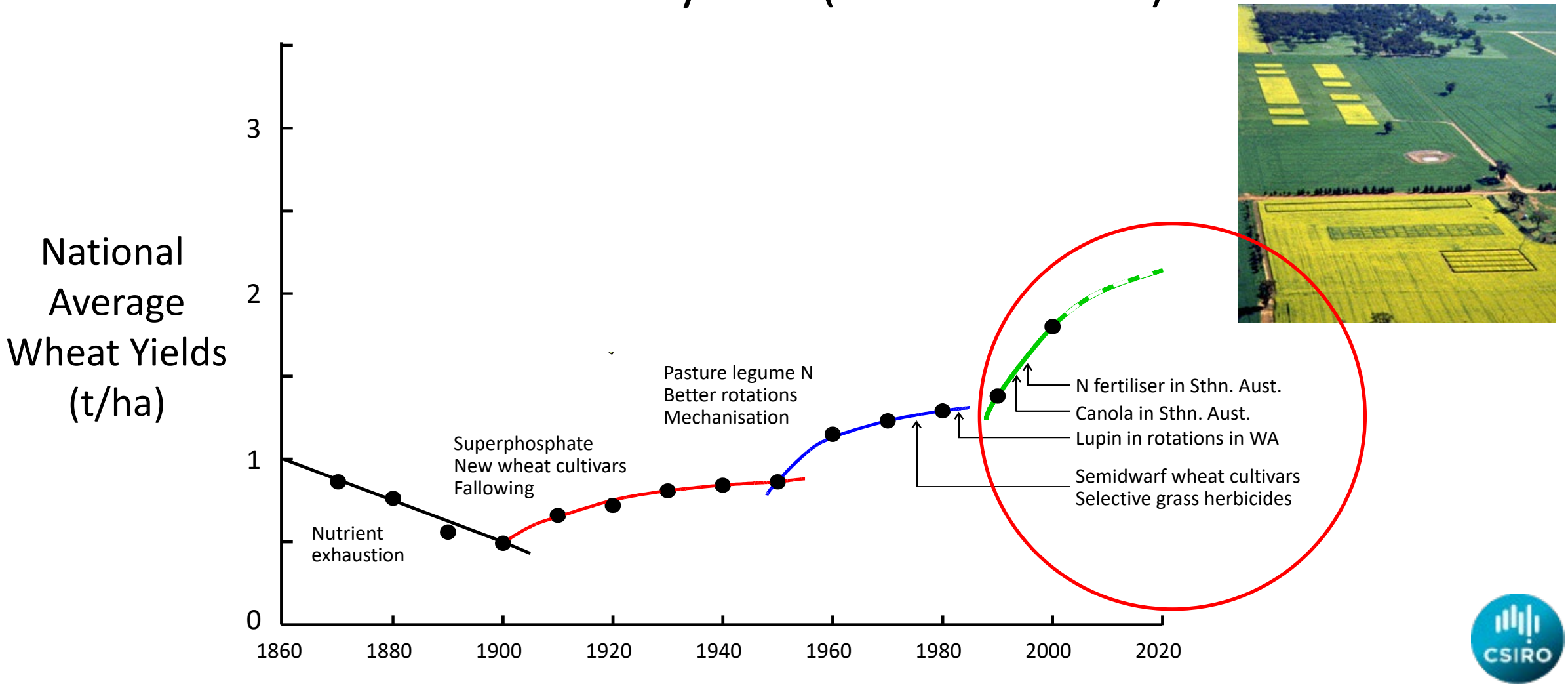
Canola underpins a synergy of improvement



Angus (2001)

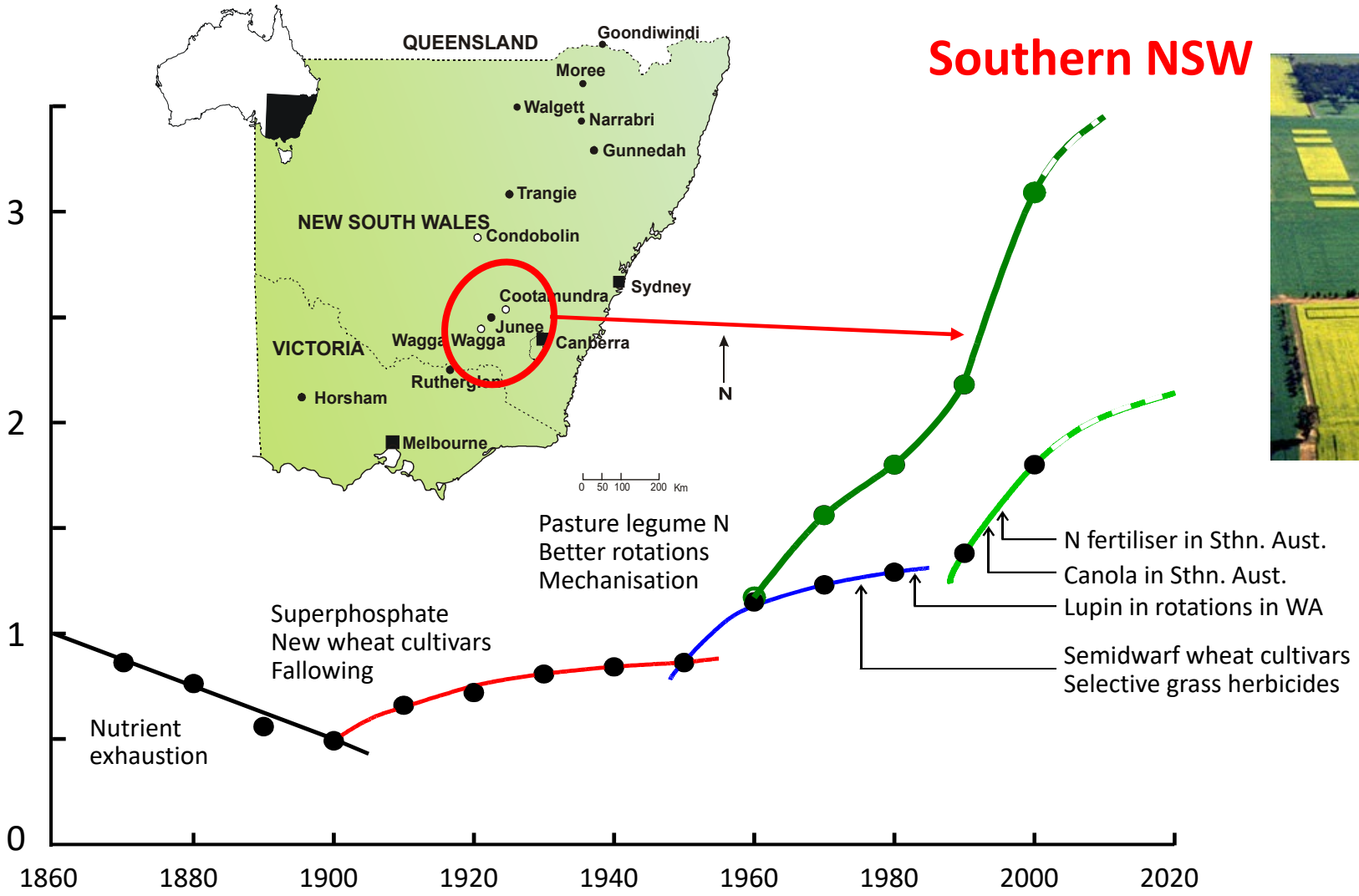
Canola underpins a synergy of improvement

National wheat yields (decadal trend)



Canola underpins a synergy of improvement

National Average Wheat Yields (t/ha)

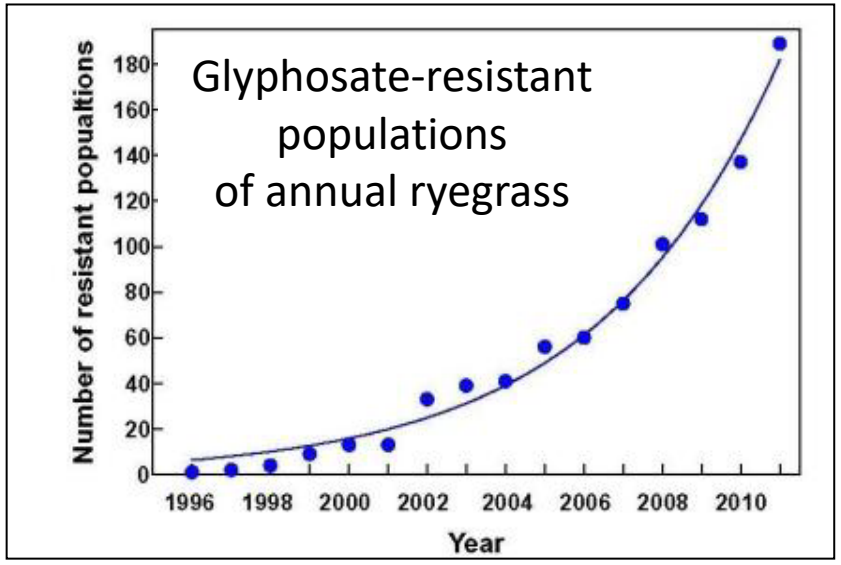


Weed control

- Selective grass weed control

- Over-reliance in no-till systems

- Herbicide resistance



- 85% resistant to one or more herbicides

Cost-effective HR weed management

- Sequence and input treatments (Junee, NSW) (initial ARG 1815 pl/m^2)

CROP SEQUENCE (Management intensity)	3 Yr System Financials				2017* ARG (/m^2)
	Herb. cost ($/ha/yr)	Total cost ($/ha/yr)	Profit ($/ha/yr)	Profit/Cost ratio	
Wheat-Wheat-Wheat (conservative)	59	317	388	1.20	**3146**
Wheat-Wheat-Wheat (aggressive)	128	560	585	1.04	366
Canola-Wheat-Wheat (aggressive)	96	609	883	1.45	219

Swan et al., (2023) Crop and Pasture Science

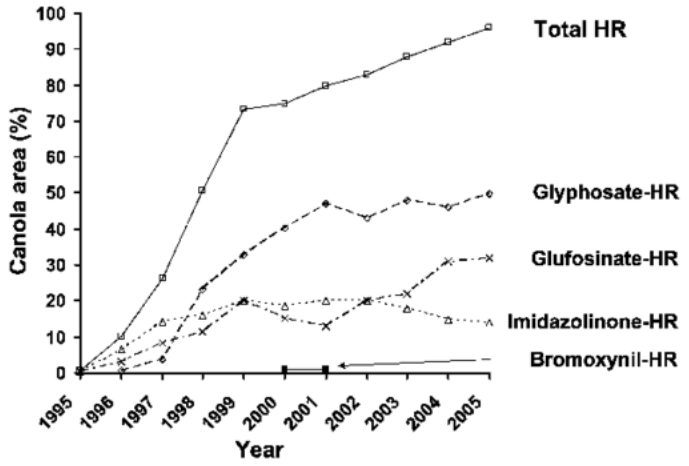
Underpins integrated weed management

- Hybrids for competition

Outcompetes wild oats (Canada, 2006)

- Herbicide-tolerant options

Herbicide tolerance systems	Abbreviations	Herbicide group
Conventional	CC (Conv.)	-
Triazine tolerant	TT	C
Clearfield® (Imidazolinone-tolerant)	CL or IMI	B
Triazine tolerant + Clearfield®	TT + CL	C + B
Glyphosate tolerant	GT	M
• Roundup Ready®	RR	M
• TruFlex®	-	M
• Optimum GLY®	-	M
• Glyphosate tolerant +Triazine tolerant	GT + TT	M + C
• Glyphosate tolerant + Clearfield®	GT + CL	M + B



Beckie et al., (2006)

- Cultural control

Crop-topping
Spray-swathing

Benefits of canola in other systems

- China – rice-wheat system

wheat - rice
rapeseed - rice

Yield increase 0.56 t/ha
(Weiser et al., 2018)

Hubei Province Central China *(Fang et al., 2021)*

Pre-crop	Zero	Optimum	High
Wheat	3.61	7.31	7.91
Fallow	3.80	7.60	7.89
Rapeseed	4.35	7.79	8.84

- Related to higher indigenous soil N supply

- Argentina – double cropping

wheat/barley - soybean/maize
canola - soybean/maize

Mazzilla and Ernst (2019)

Yield increase 11% in soybean

Yield increase 17% in maize

- 40-80% increase in 2-yr gross margin

Timeliness and farm logistics

- Modern farmers are time poor

- Timeliness in agronomy marks high performing farms
- Machinery and labour efficiency are key features of business success
- Canola has different and complementary timing to cereals and pulses

Seeding

Herbicides

Spreading

Fungicides

Harvesting

Dual-purpose (graze-grain) canola

Sheep: southern Australia

Grazing high quality forage

Recovery

Oilseed yield

“Canolage”

Cattle: Great Plains, PNW (USA)

System-wide benefits on mixed farms

- Paddock-scale profit increases $300 to $1000/ha
- Earlier sowing and break crop benefit
- Increased winter stocking rates
- Turning animals off earlier, or at higher weights
- Pasture spelling while stock on crops
- Finance for pasture improvement
- Spread the workload (sow, graze, harvest)
- Risk management (different exit strategies – graze, hay, silage, grain)

- Farm profit benefits of ~$100-200 per farm ha

Diversity, flexibility, profit…..

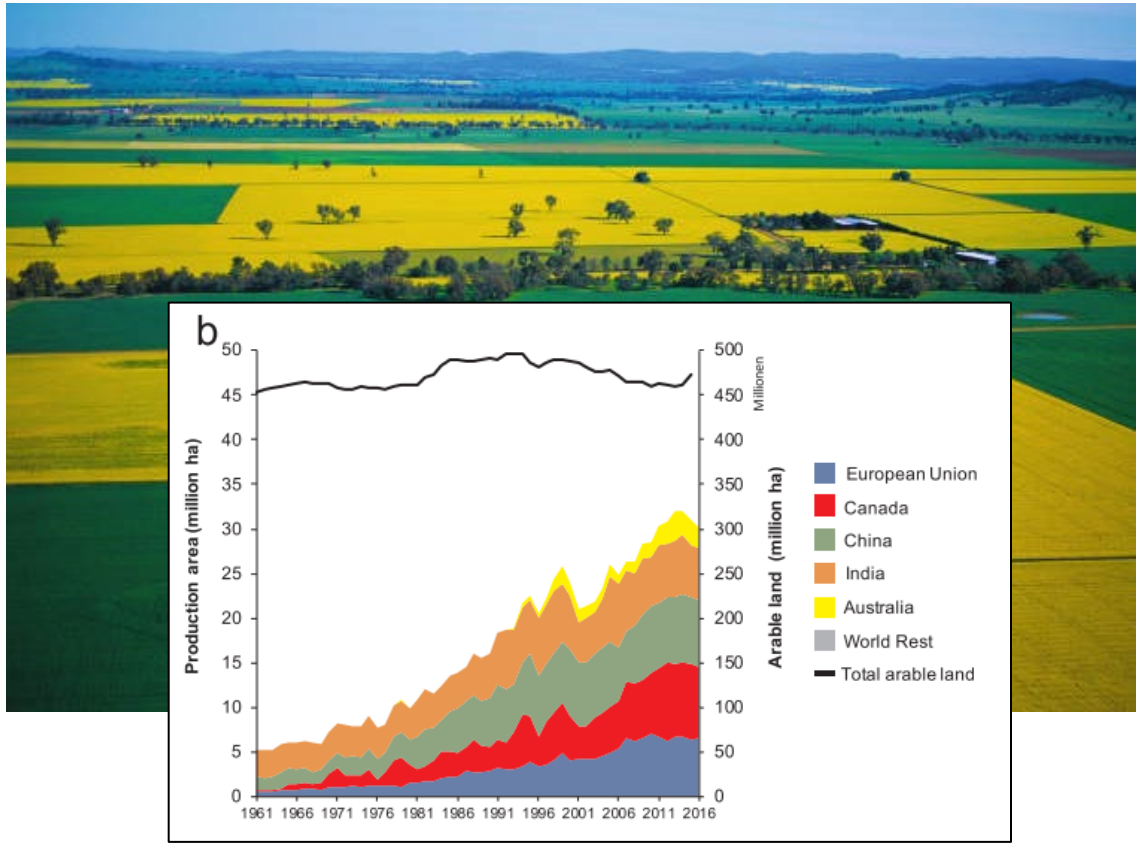
"We increased crop area by 10% and winter stocking rate from 12 to 18 animals/ha (worth $1 Mill pa to business)"

"A decade ago, we only grew fine wool …now we grow crops for forage, silage, hay, grain as well as sheep and cattle"

"Crop grazing is allowing the same farm stocking rate on 80% of the farm while producing and selling grain."

Now ~200,000 ha pa, worth $2 Bill since 2007

Risk of Intensification



Rotation lengths

Recommended 1 in 4 years

Commonly 1 in 2

Value of breaks

1-year break + 0.26 t/ha

2-year break + 0.52 t/ha

3-year break + 0.50 t/ha

Diseases

Clubroot
Blackleg
Sclerotinia
Verticillium

Weeds

23 HR weed species

Pests

Root maggots (Delia)
Pollen beetles

- markets, technological advances, incentives,

Hegewald et al., (2018) Eur. J. Agron.

Role of legumes – “double-breaks”

- Review of 10 European studies

cereal - rapeseed
legume - rapeseed

Yield increase **18%** (0.65 t/ha)

Preissel et al., (2015) Field Crops Research

- 7 sites across Canada

cereal - rapeseed - barley
legume - rapeseed - barley

Yield increase **10%** in canola
&
Yield increase **7%** in barley

O’Donavan et al., (2014) Agronomy Journal

- SE Australia – 4 experiments over 12 years

- higher profit
- lower risk
- declining weed/disease
- reduced N
- reduced GHG emission

System	Average $GM ($/ha/yr)	Profit:Cost ratio
Wht-Can-Wht (Low N)	778	1.6
Wht-Can-Wht (High N)	826	1.4
Chickpea-Can-Wht (Low N)	854	1.7
Fababean-Can-Wht (Low N)	977	1.9

Swan et al., (2023) ILS4, Grenada, Spain

Intercropping – diversity in space

Resource efficiency and yield

- "Overyielding" (complementary, facultative)
- Higher Land Equivalent Ratios (LERs)

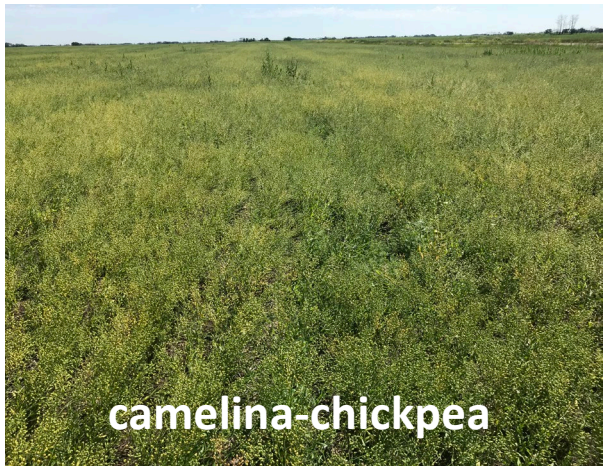
Cereal-legume

Fletcher et al., 2016

Systems Benefits

- Reduced input cost (N, pesticides, herbicides)
- Improved soil health
- Reduced risk (landscape, price)
- Lodging and harvestability
- Stabilise yield and profitability

Canola-legume intercrops



- 35 of 41 economic, yield, NUE benefits
- less agronomic/technical issues
- break-crop, pest repellence

- Canadian prairies ~100 producers, 20,000 ha

Dowling et al., (2021) Field Crop Research

Fletcher et al., (2021) Annals Applied Biology

Covercrops – non-harvested

- Grown between cash crops and terminated for multiple environmental benefits

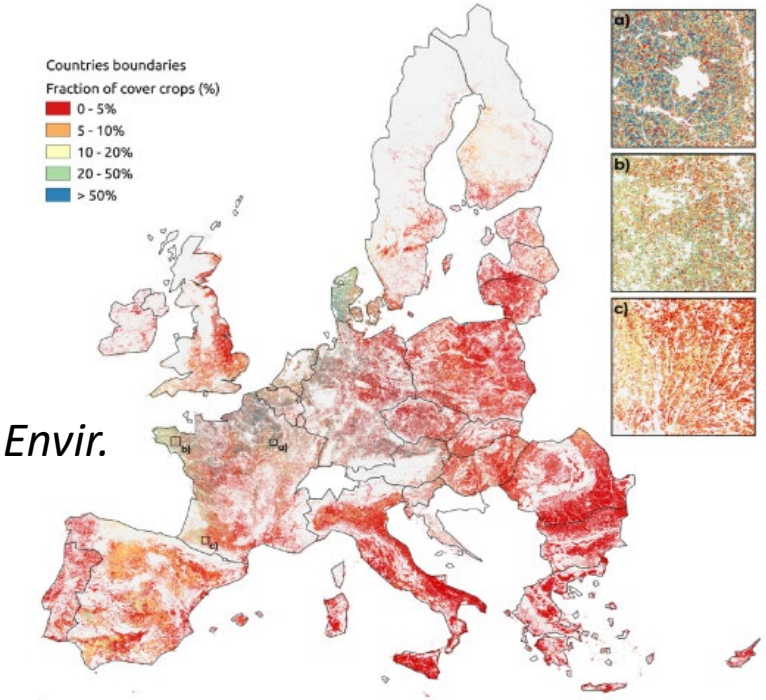
- Grasses, legumes, brassicas
  (radish, mustard, rape, turnip)

Brassica-legume mixes

Couedel et al., (2019) Advances in agronomy

Europe:
Areas uncertain but increasing
(surveys suggest **8.9%** in 2016)

Fendrich et al., (2023) Sci. of Total Envir.

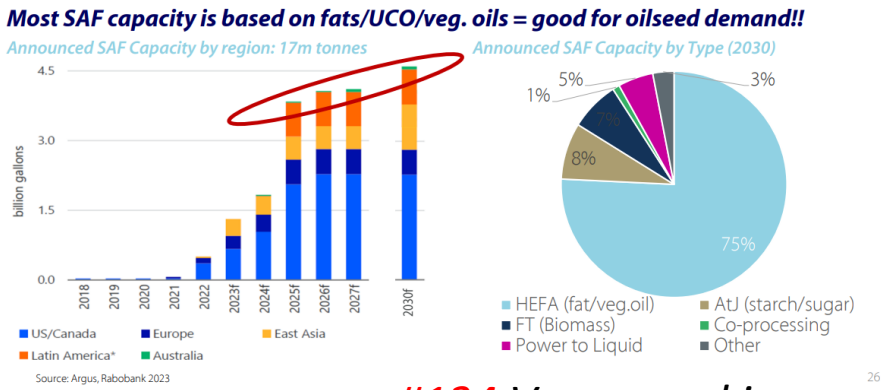


USA

Midwest increased 4-fold since 2011 to **7.2%** (EQIP)

Zhou et al., (2022) Geophysical Research Letters

Oilseed “covercrops” - harvested



#134 Voznesenski

#100 Zanetti et al.

#82 Guillen-Portal et al

- Sustainable Aviation Fuels (SAFs)
  - non-food, low emission production systems – caution re **ILUC**
  - replace fallows, marginal sites, intercrops, relay crops
  - **+** bioherbicides, biopesticides, animal feed, human supplements
- Potential area
  - **170 Mill ha** across Europe and North America (Nuseed)
  - **29.3 Mill ha** in United States by 2035 (*Taheripour et al., 2022*)
- Impacts
  - expand the influence of oilseed brassicas beyond canola
  - diverse options for economic and environmental benefit
  - economics at farm scale *(Karami et al. 2022; Panoutsou et al. 2022)*

Farming Systems Benefits