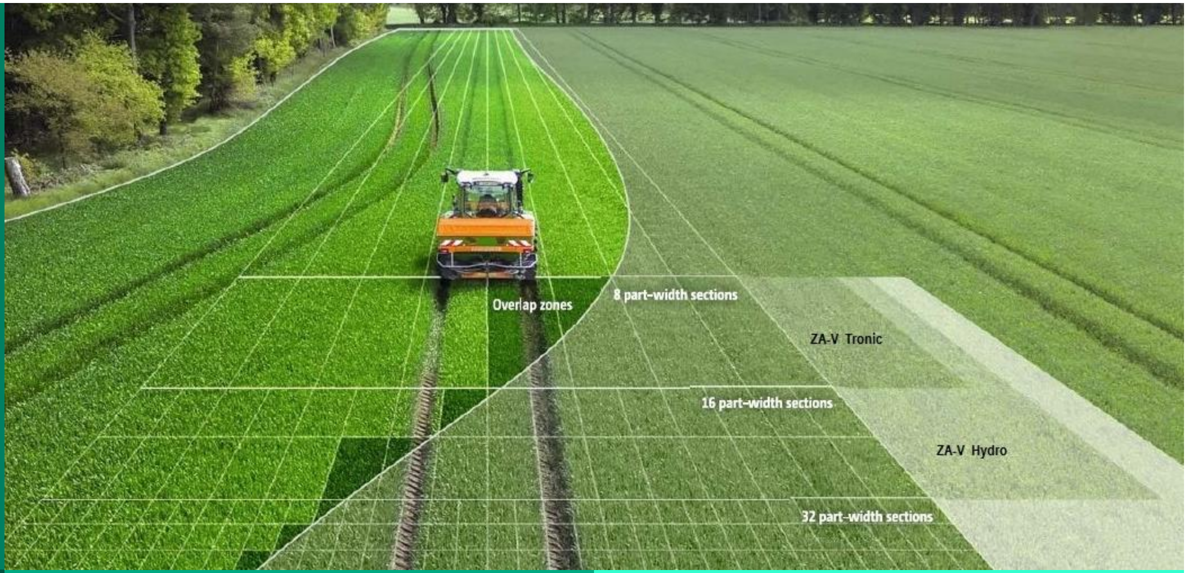
Economic Benefits of Variable Rate Application Depending on In-field Heterogeneity

Christoph Rotter, Yelto Zimmer
agri benchmark Cash Crop Team



Agenda

1. Introduction Potentials of Precision Farming
2. Methodology
3. Results: Economic Benefits based on Typical Farms*
4. Summary and Discussion
5. Conclusions

* Economic results are in €; 1 € equals roughly 1,11 USD, 1,47 CAD, 9,46 SK and 1,49 AUD

1. Potentials of Precision Farming

Economic Potentials:

- Revenue/Yield increase
- Input savings: fertilizer, seed, crop protection

Possible to quantify!

Research question:

- What is the economic benefit from site-specific seeding, fertilization and crop protection application?
- Do not consider additional cost for equipment, training and time to establish routines (because largely unknown and subject to a steep cost reduction as market size increases)

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2. Methodology

“We digitize, quantify and monitor every single agricultural field on the planet.”

-> Land cover classification + statistics (crop type information)
-> <u>Yield zoning</u> and real-time growing conditions

https://www.greenspin.de/

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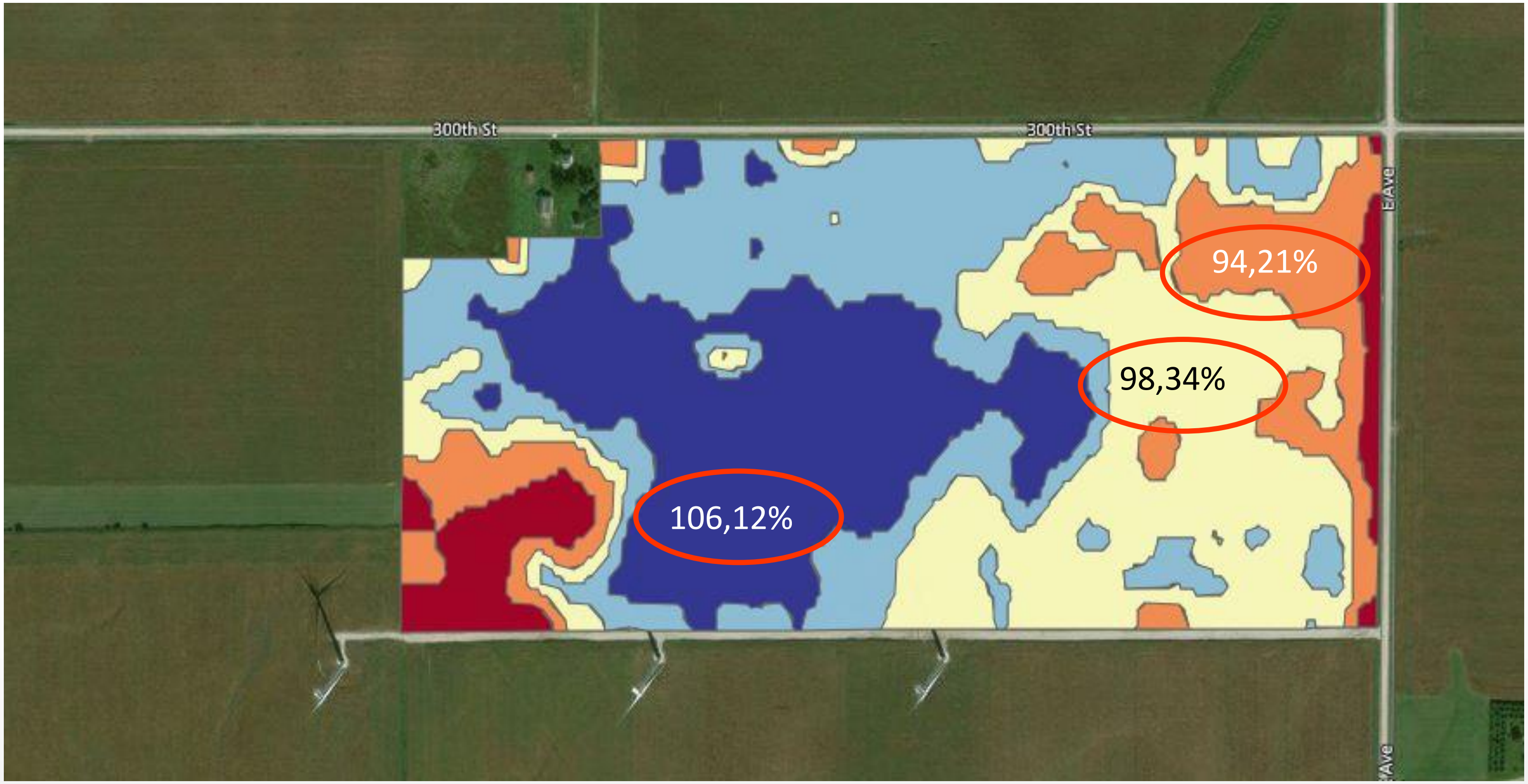
2. Methodology

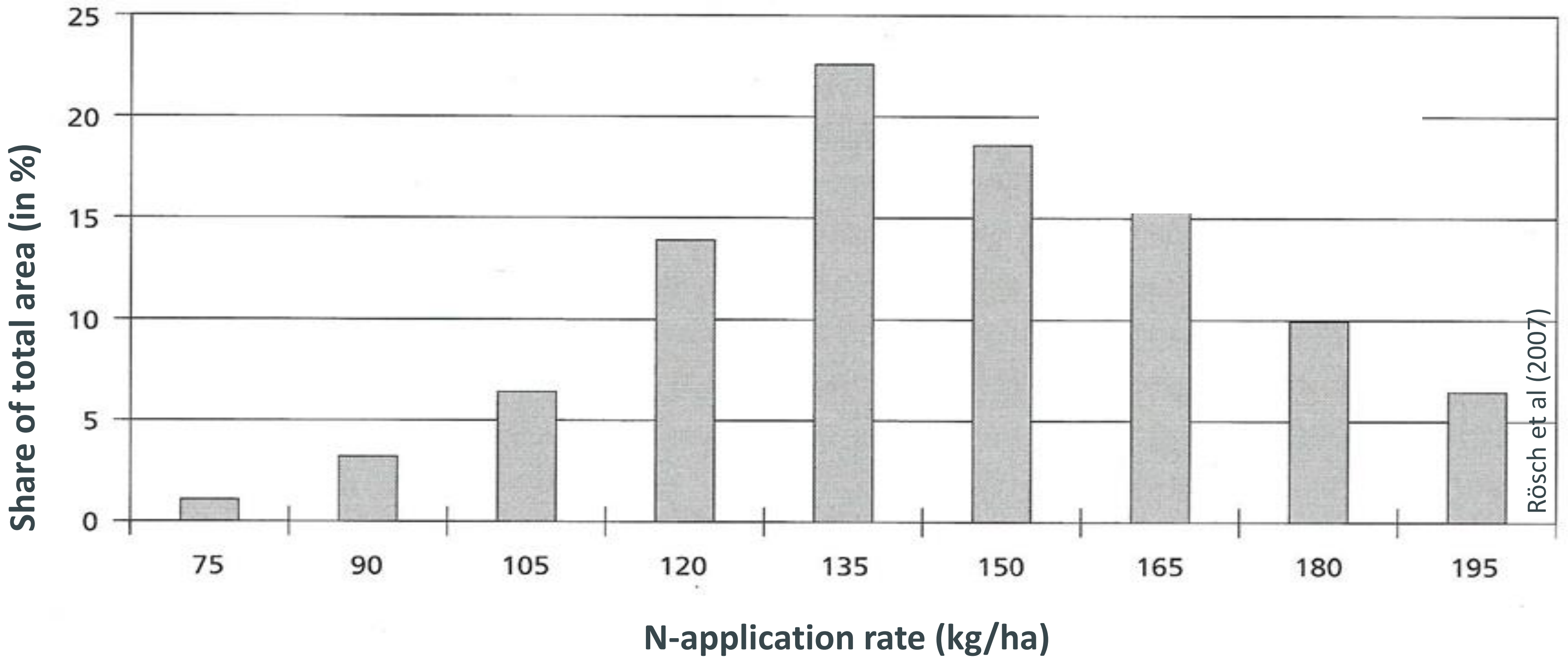


- **Biomass estimation based on satellite images from up to the last 5 years!**
- **Every color indicates <u>one</u> yielding zone**

2. Methodology (1)

1. Run case studies for different production systems and agro-eco-systems (USA, Canada, Sweden and Australia)
2. Approach *agri benchmark* partners to access information on specific fields close to the typical farm and their management history.
3. Use biomass estimation as a proxy to identify high, medium and low yielding zones within those fields (Greenspin).
4. Use literature data and expert assessment to assess physical changes in input use and impact on yields. To reflect uncertainty, 2 Scenarios are calculated: one conservative and one medium. An optimistic variant could not be calculated because maximum yield potential maps could not be generated from Greenspin data.
5. Use *agri benchmark* data to assess the economic impact from changes in input use and output quantities.

2. Methodology – example (2)

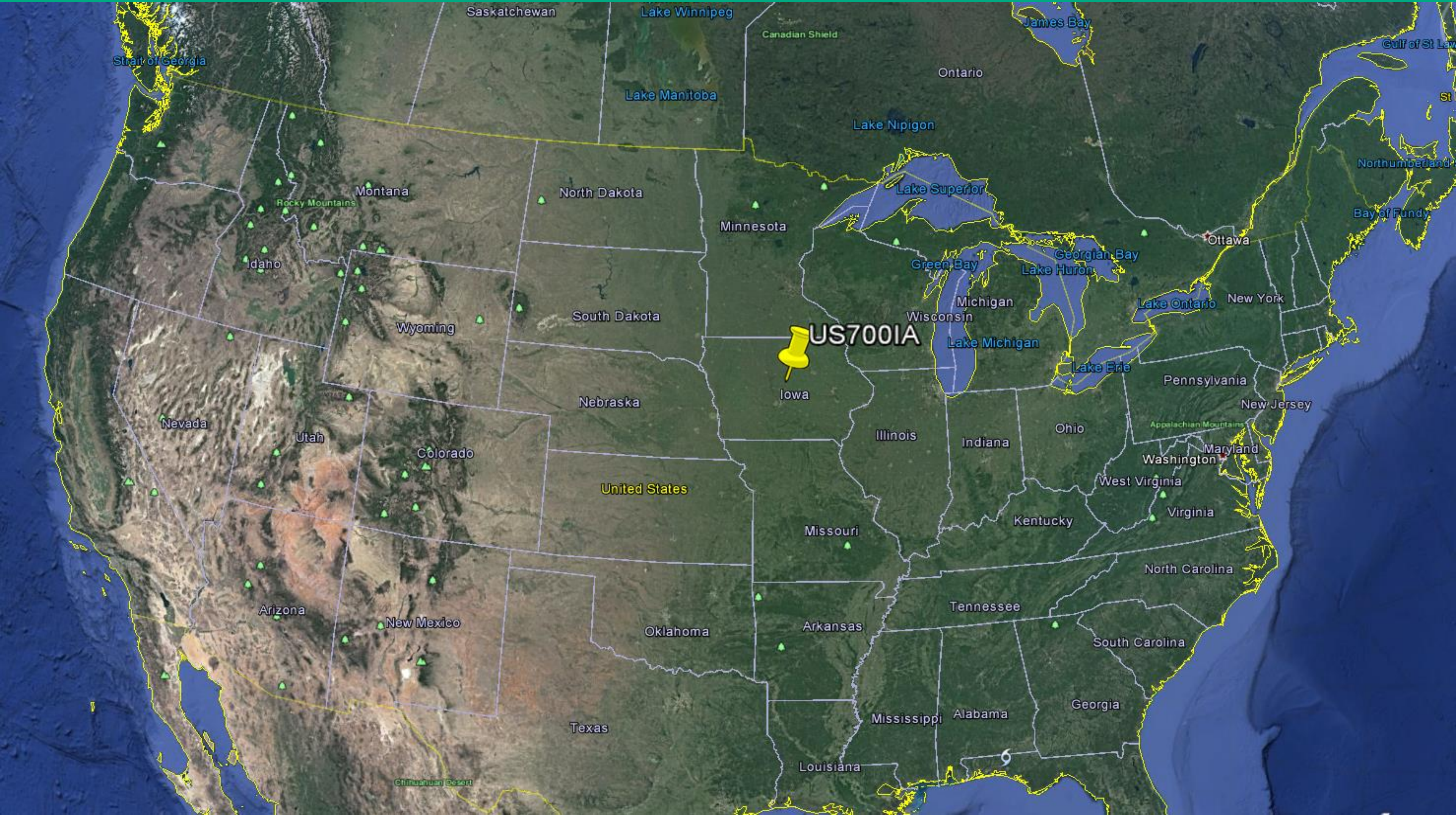


Trial data from Saxony-Anhalt, Germany in wheat on variable rate application for N yielded the following results:

(1) Initially, the flat N-rate applied was 154 kg N/ha

(2) VR application (75 kg/ha to 195 kg/ha) yielded 1.5 % more and reduced total N-use by 14 kg/ha or app. 10 %

3. Results - USA



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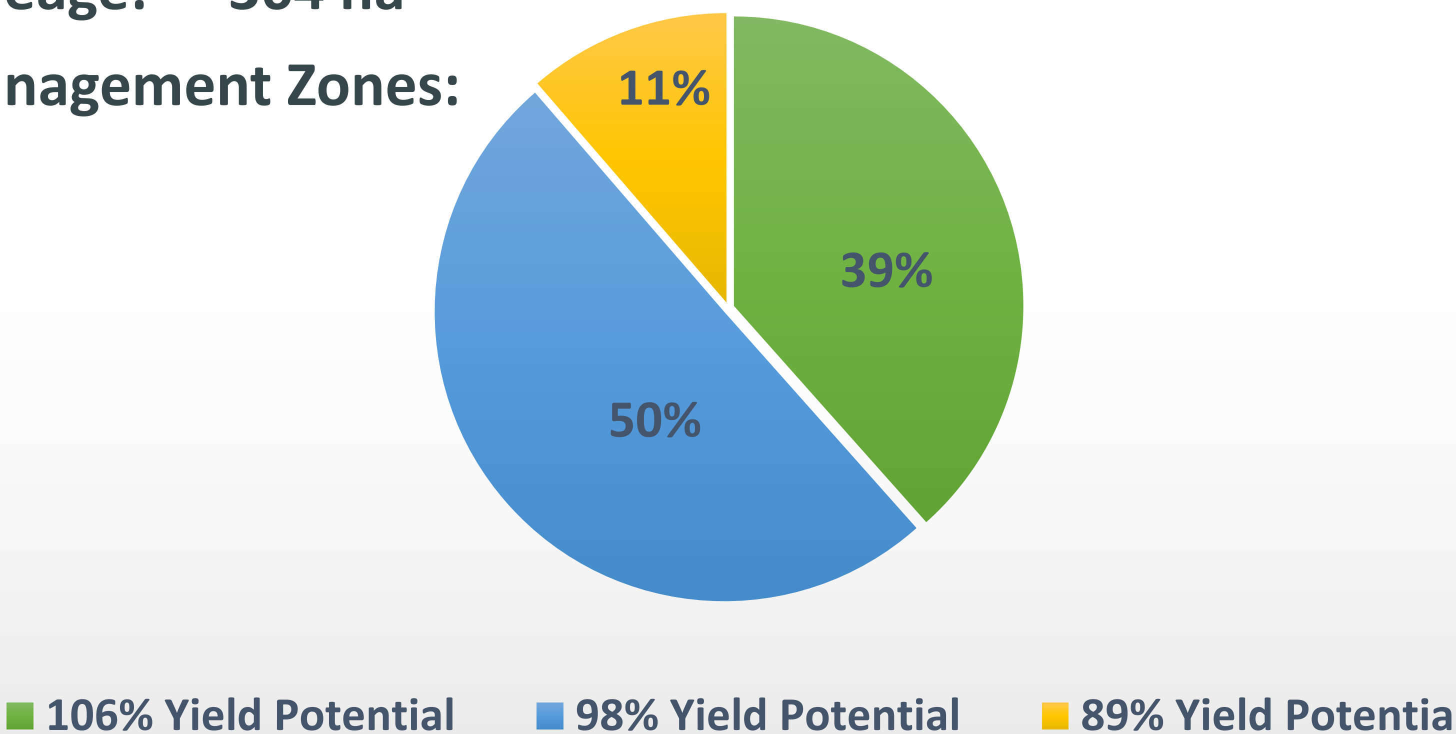
3. Results – USA (Iowa)

Typical Farm: US700IA - 728 ha

- Crop: Corn (after Soybean)
- Acreage: 364 ha
- Management Zones:



3. USA – Technologies assessed

- Variable Rate (VR) Seeding
- VR P/K application
- VR Nitrogen application
- VR Lime application

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3. USA - Potentials Variable Rate Seeding

- <u>Status Quo:</u> 22 kg/ha - 228 €/ha

- Input Savings Potentials

High Zone	(106%)	- 3,0%	**+ 4,9%**
Mid Zone	(98%)	+ 7,5%	
Low Zone	(89%)	+ 20,0%	

- Yield Potentials

High Zone	(106%)	+ 2,5%	**+ 1,5%**
Mid Zone	(98%)	+ 1,0%	
Low Zone	(89%)	+ 0%	

How to read these tables:

The percentage values in the input saving section indicate the changes in total seed input and simultaneously cost of input use (e.g. + 7,5% in the mid zone implies that 7,5% of seed cost will be saved; -3,0 % indicate an increase in seeding cost). Total saving in input cost (e.g. 4,9%) is the net effect over all zones, taking into account the share of the different yielding zones.
In this example the overall seed density is decreasing despite the fact that it is beeing increased in the high yielding zone.

Overall, VR Seeding increases the yields by e.g. + 1,5%. By planting extra 3,0% in the high zones, the yield in these zones increases by 2,5%. Equally an reduction of 20% in the low zones, results in no significant yield losses (e.g. + 0%)

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3. USA - Potentials Variable P/K Application

- Status Quo: 83 kg/ha - 93 €/ha

⇩

- Input Savings Potentials
  - High Zone (106%) - 6,1%
  - Mid Zone (98%) + 1,7%
  - Low Zone (89%) + 10,7%

  - 0,30%

- Yield Potentials
  - High Zone (106%) + 1,0%
  - Mid Zone (98%) + 0%
  - Low Zone (89%) + 0%

  + 0,38%

Specifics VR calculation in P/K :

Assuming that low yielding zones have been oversupplied with P&K in recent years respective soils are very rich in P&K. Hence, for a certain time periode it would be possible to eat on these reserves and to reduce or even stop P&K application. Because no data was available about the stored nutrients this temporary benefit has not been calculated. Rather it was just considered the reduction of P&K to adjust to actual yields. Hence, the economic benefit from PF is systematically understimated.

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3. USA - Potentials Variable Nitrogen Application

- <u>Status Quo:</u> 182 kg/ha - 139 €/ha

⇩

- Input Savings Potentials
  - High Zone (106%) - 6,9%
  - Mid Zone (98%) + 1,7%
  - Low Zone (89%) + 10,7%

  - 0,59%

- Yield Potentials
  - High Zone (106%) + 3,9%
  - Mid Zone (98%) + 0%
  - Low Zone (89%) - 0,5%

  + 1,4%

<u>Specifics of VR calculation in N</u>

Potentials for reducing N-input in corn are relatively low compared to an application in wheat. Therefore application N-input is slightly increased and yields go up.

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3. USA - Potentials Variable Lime Application

- Status Quo: 12 €/ha

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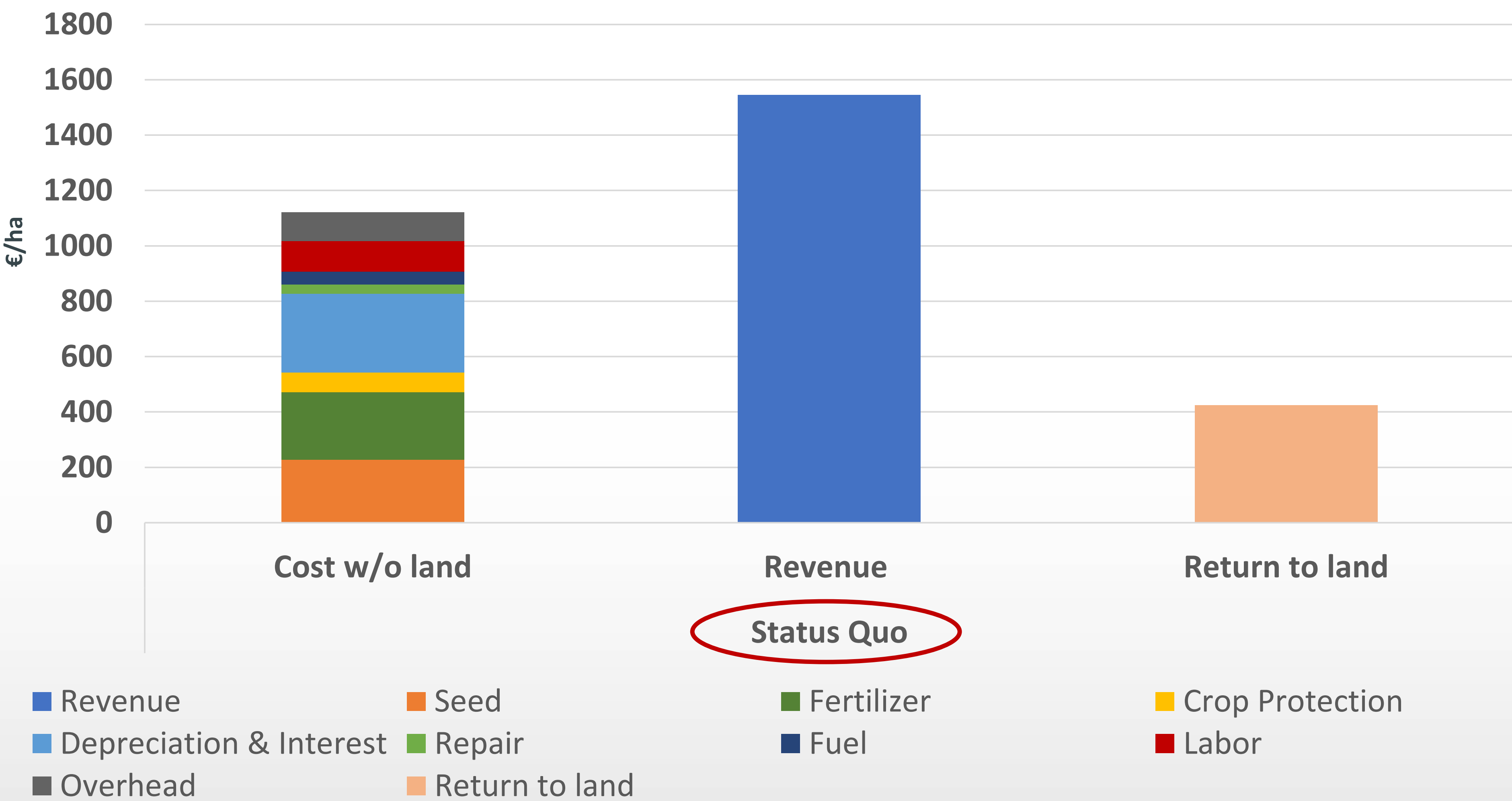
- Input Savings Potentials
  - High Zone (106%) + 15%
  - Mid Zone (98%) + 15%
  - Low Zone (89%) + 15%

  + 15%

- Yield Potentials
  - High Zone (106%) + 0%
  - Mid Zone (98%) + 0%
  - Low Zone (89%) + 0%

  + 0%

3. USA – Current Corn Economics (in €/ha)



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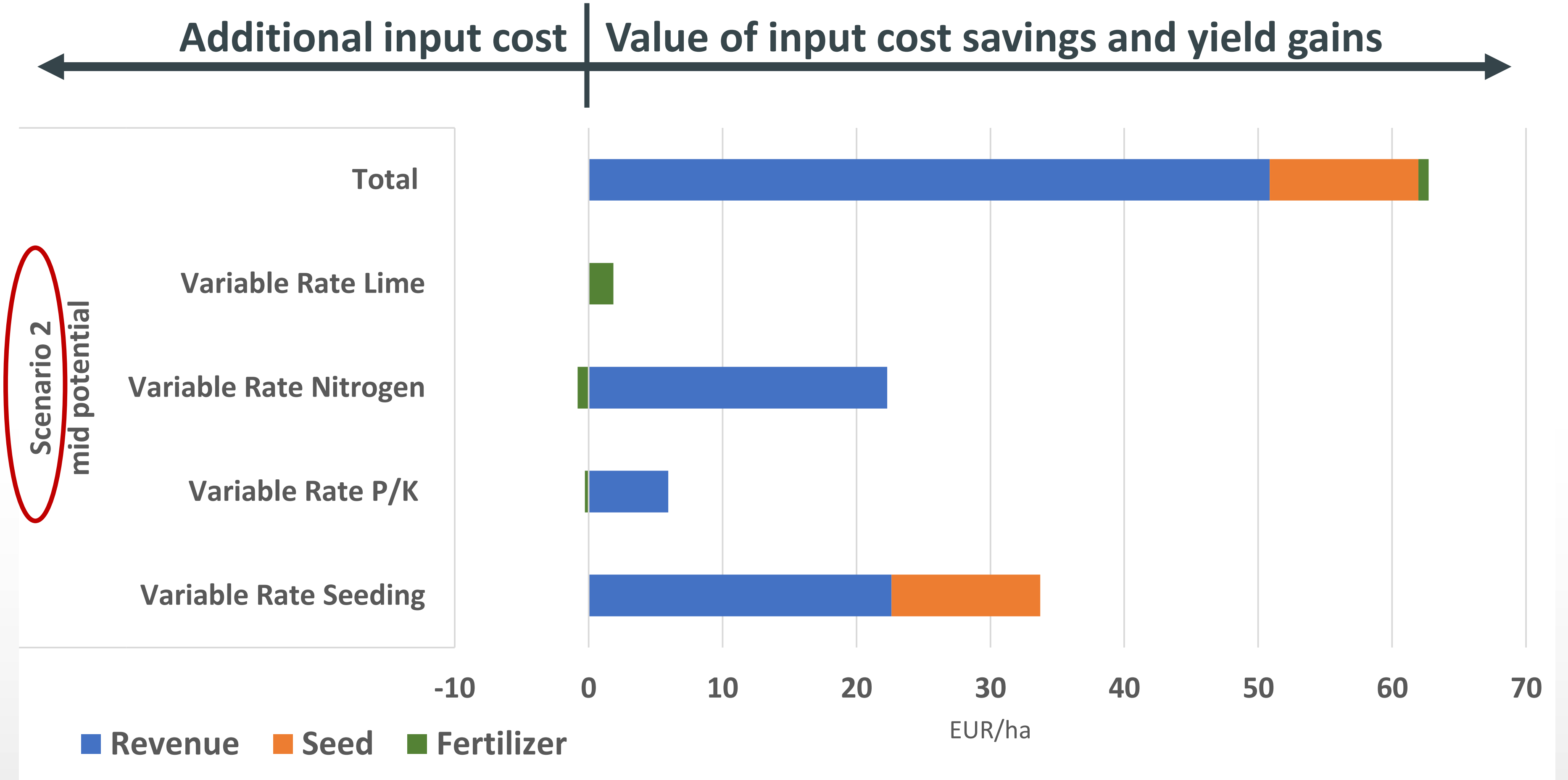
3. USA – Economic benefits from VR application (1)



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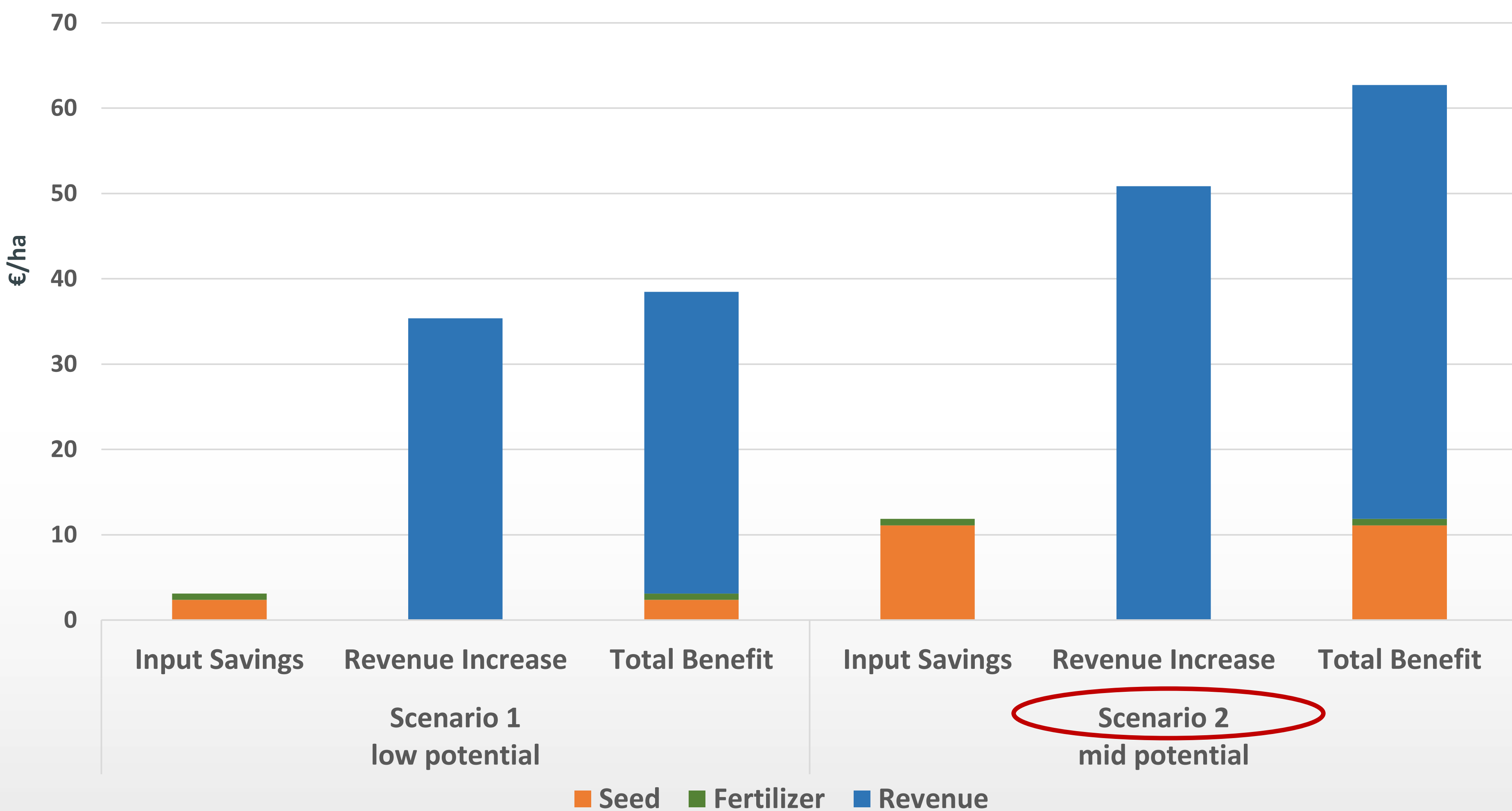
3. USA - – Economic benefits from VR application (2)



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3. Results - Sweden

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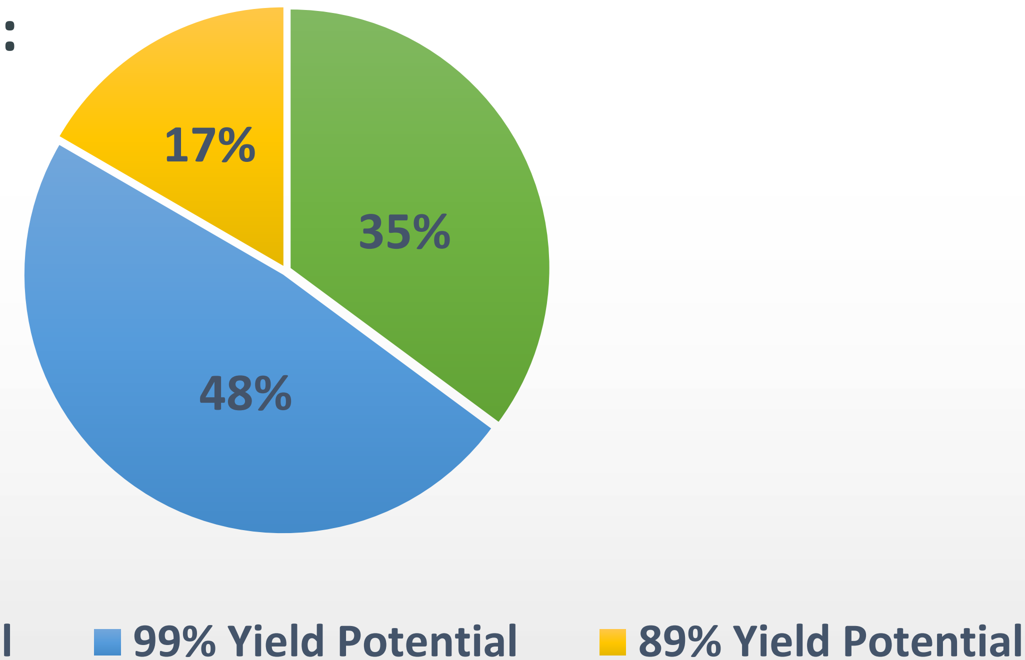
3. Results - Sweden

Typical Farm: **SE445SK - 442 ha**

- **Crop:** **Wheat** (after Rapeseed/Oats/Wheat)
- **Acreage:** **186 ha**
- **Management Zones:**



3. Sweden – Technologies assessed

- VR Seeding
- VR P/K application
- VR Lime application
- VR Nitrogen application
- VR Crop Protection (Fungicides)

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3. Sweden – Potentials Variable Rate Seeding

- Status Quo: 197 kg/ha - 83 €/ha

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- Input Savings Potentials
  - High Zone (105%) - 5,0%
  - Mid Zone (99%) + 7,5%
  - Low Zone (89%) + 20,0%

  + 5,2%

- Yield Potentials
  - High Zone (105%) + 1,5%
  - Mid Zone (99%) + 0,0%
  - Low Zone (89%) - 0,5%

  + 0,4%

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3. Sweden – Potentials Variable P/K Application

- Status Quo: 41 kg/ha - 29,73 €/ha

- Input Savings Potentials

High Zone	(105%)	- 5,2%	**+ 0,8%**
Mid Zone	(99%)	+ 1,4%	
Low Zone	(89%)	+ 11,3%	

- Yield Potentials

High Zone	(105%)	+ 1,0%	**+ 0,4%**
Mid Zone	(99%)	+ 0%	
Low Zone	(89%)	+ 0%	

3. Sweden – Potentials Variable Nitrogen Application

- Status Quo: 174 kg/ha - 144 €/ha

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- Input Savings Potentials

High Zone	(105%)	- 5,8%	**+ 0,5%**
Mid Zone	(99%)	+ 1,4%	
Low Zone	(89%)	+ 11,3%	

- Yield Potentials

High Zone	(105%)	+ 4,5%	**+ 1,5%**
Mid Zone	(99%)	+ 0%	
Low Zone	(89%)	- 0,5%	

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3. Sweden – Potentials Variable Lime Application

- Status Quo: 11 €/ha

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- Input Savings Potentials

High Zone	(105%)	+ 10%	
Mid Zone	(99%)	+ 10%	**+ 10%**
Low Zone	(89%)	+ 10%	

- Yield Potentials

High Zone	(105%)	+ 0%	
Mid Zone	(99%)	+ 0%	**+ 0%**
Low Zone	(89%)	+ 0%	

3. Sweden – Potentials Variable Fungicide Application

- Status Quo: 71 €/ha

- Input Savings Potentials
  - High Zone (105,2%) + 0,0%
  - Mid Zone (98,6%) + 6,6%
  - Low Zone (88,7%) + 16,5%

  + 5,9%

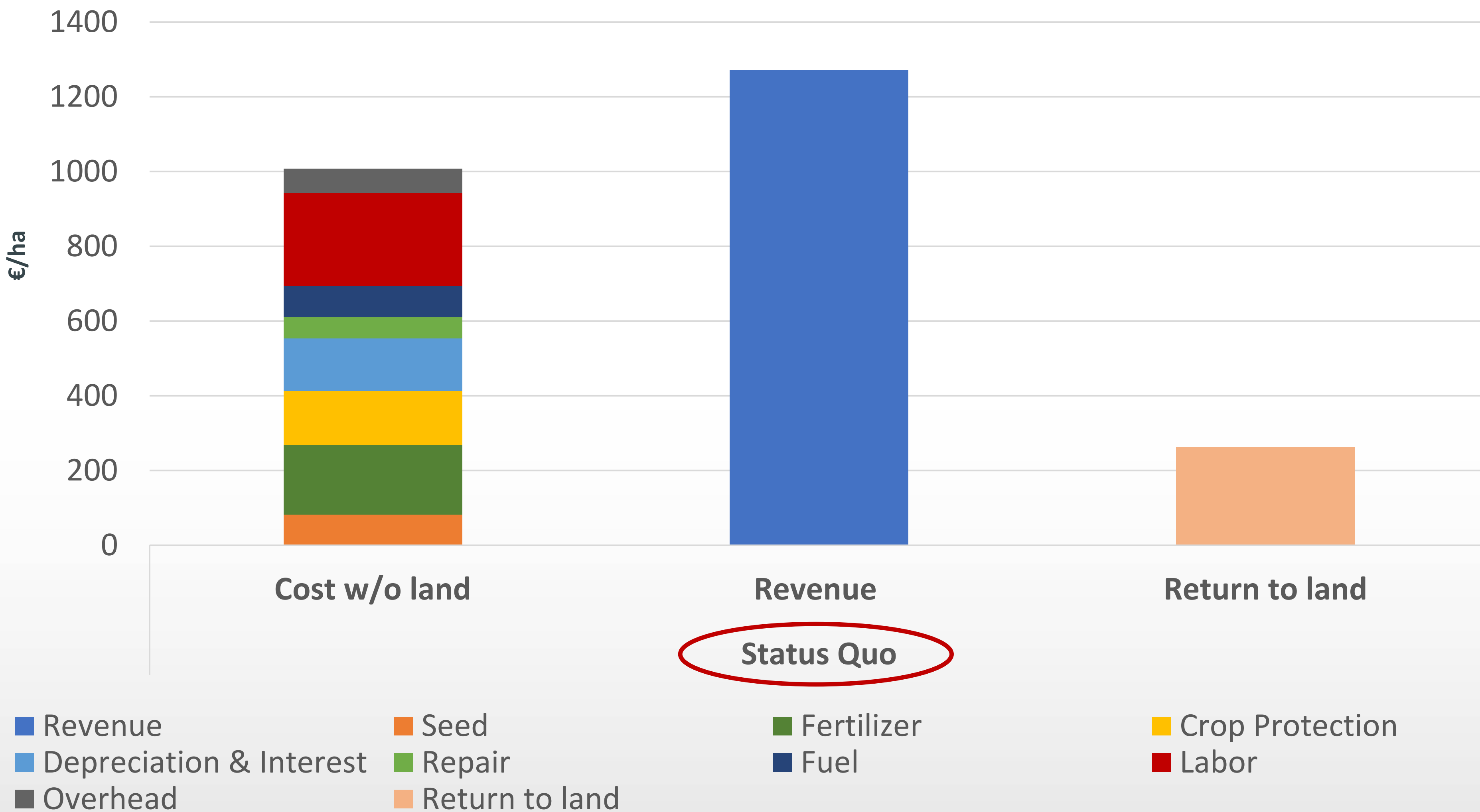
- Yield Potentials
  - High Zone (105%) + 0%
  - Mid Zone (99%) + 0%
  - Low Zone (89%) + 0%

  + 0,0%

Specifics of Fungicide VR calculation

It is assumed that current fungicide application strives to be sufficient to control infections in the most prone (i.e. high yielding) zones. Hence, no change in these zones and no yield impact. However, in less susceptible zones quantities are reduced without a yield penalty.

3. Sweden – Current Wheat Economics (in €/ha)



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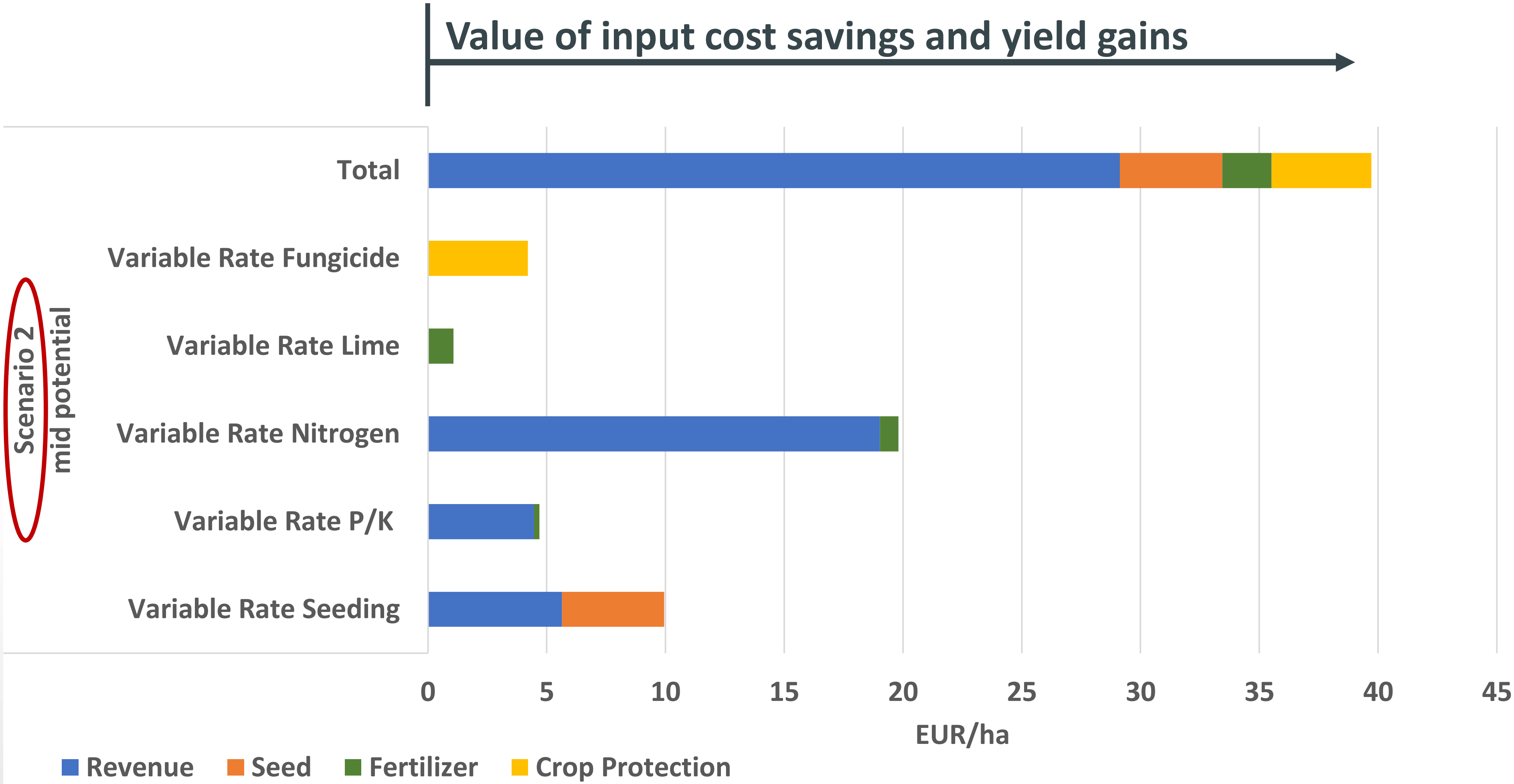
3. Sweden – Economic benefits from VR application (1)



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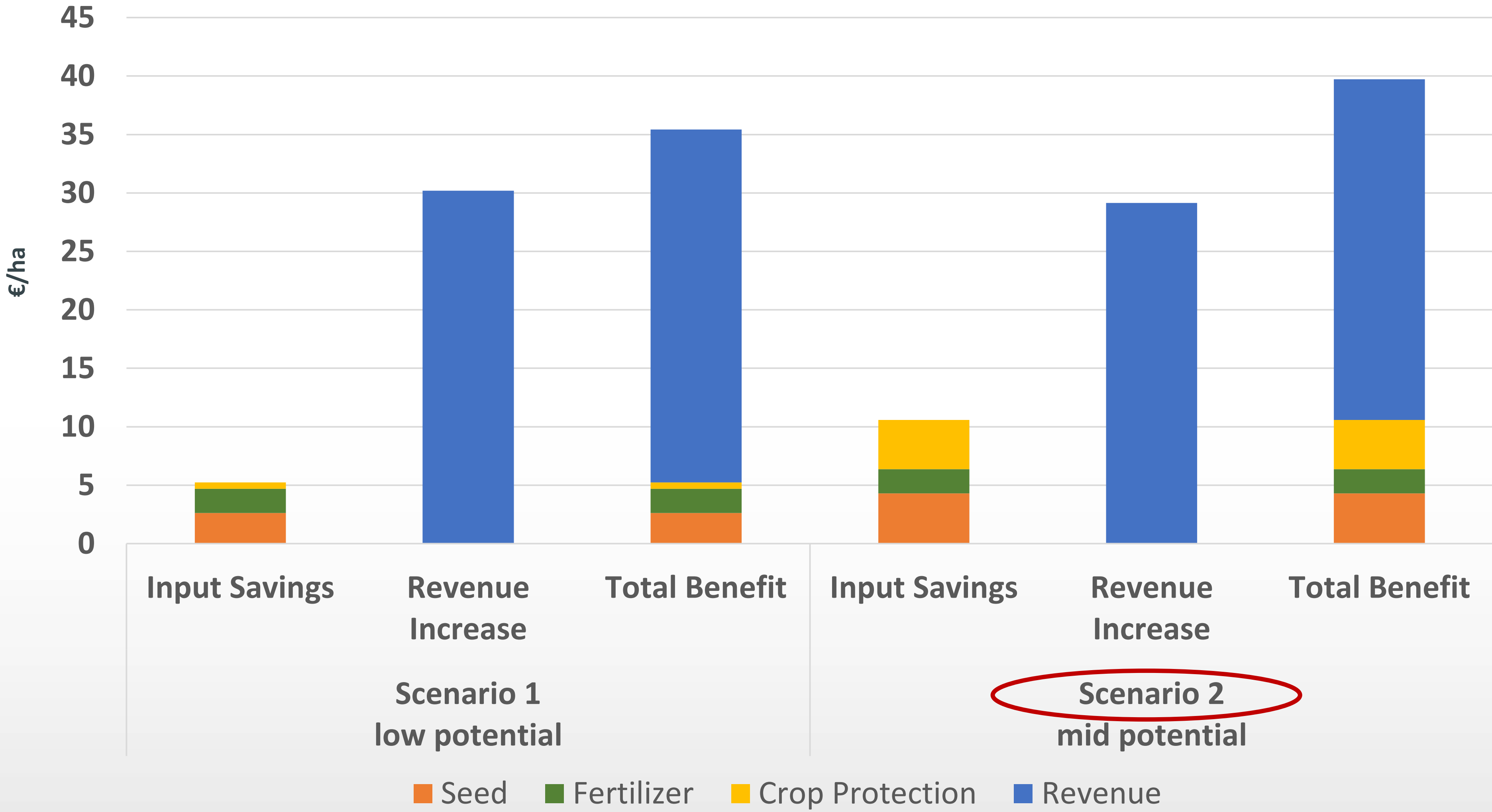
3. Sweden – Economic benefits from VR application (2)



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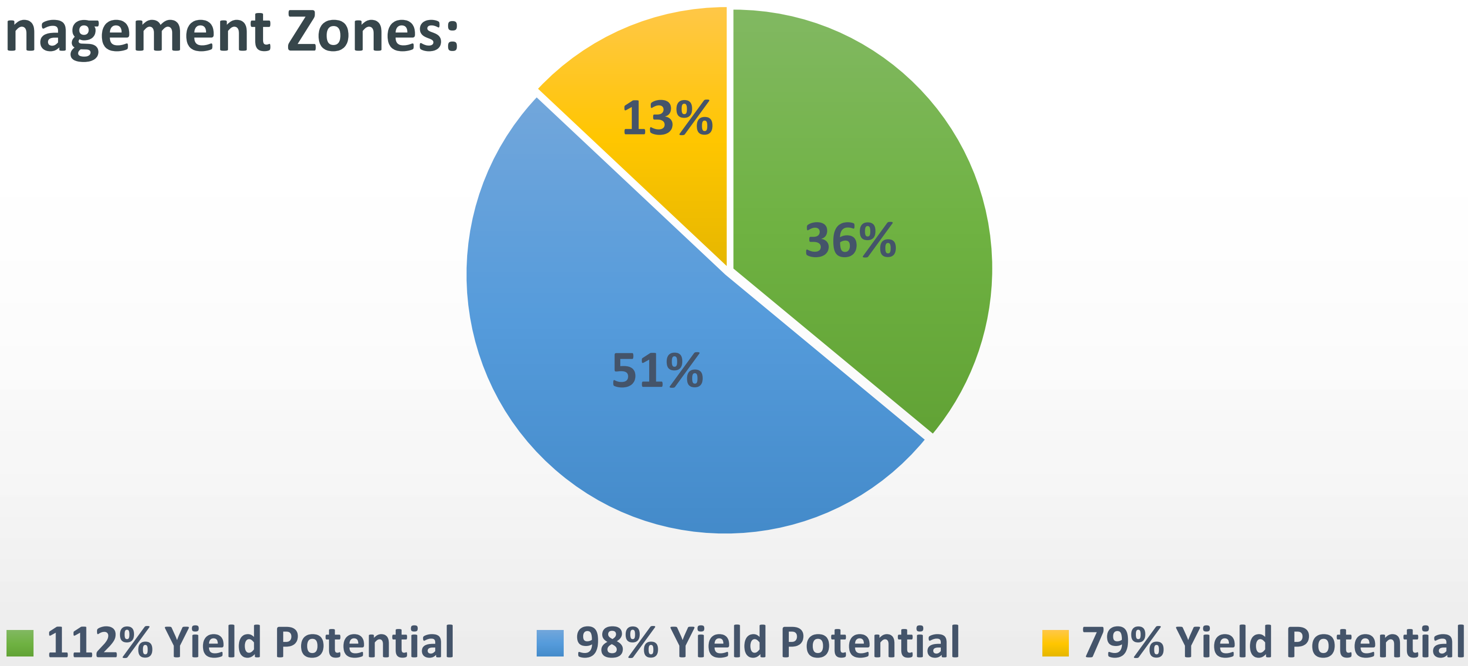
3. Results - Australia

3. Results – Australia (Western Australia)

Typical Farm: AU4000WB - 3298 ha

- Crop: Wheat (after Canola)
- Acreage: 1650 ha
- Management Zones:



3. Australia – Technologies assessed

- VR Seeding
- VR P/K application
- VR Lime application
- VR Nitrogen application

3. Australia – Potentials Variable Rate Seeding

- Status Quo: 50 kg/ha - 10 €/ha

⇩

- Input Savings Potentials

High Zone	(112%)	- 15,0%	**- 0,4%**
Mid Zone	(98%)	+ 5,0%	
Low Zone	(79%)	+ 20,0%	

- Yield Potentials

High Zone	(112%)	+ 3,5%	**+ 1,2%**
Mid Zone	(98%)	+ 0,0%	
Low Zone	(79%)	- 0,5%	

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3. Australia - Potentials Variable P/K Application:

- Status Quo: 14 kg/ha - 20 €/ha

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- Input Savings Potentials
  - High Zone (112%) - 12,4%
  - Mid Zone (98%) + 2,4%
  - Low Zone (79%) + 21,0%

  - 0,6%

- Yield Potentials
  - High Zone (112%) + 1,0%
  - Mid Zone (98%) + 0%
  - Low Zone (79%) + 0%

  + 0,4%

3. Australia - Potentials Variable Nitrogen Application:

- <u>Status Quo:</u> 27 kg/ha - 20 €/ha

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- Input Savings Potentials
  - High Zone (112%) - 27,7%
  - Mid Zone (98%) + 4,8%
  - Low Zone (79%) + 42,0%

  - 2,3%

- Yield Potentials
  - High Zone (112%) + 10,0%
  - Mid Zone (98%) + 0%
  - Low Zone (79%) - 4,0%

  + 3,1%

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3. Australia - Potentials Variable Lime Application:

- Status Quo: 4,50 €/ha

⇩

- Input Savings Potentials
  - High Zone (112%) + 30%
  - Mid Zone (98%) + 30%
  - Low Zone (79%) + 30%

  + 30%

- Yield Potentials
  - High Zone (112%) + 0%
  - Mid Zone (98%) + 0%
  - Low Zone (79%) + 0%

  + 0%

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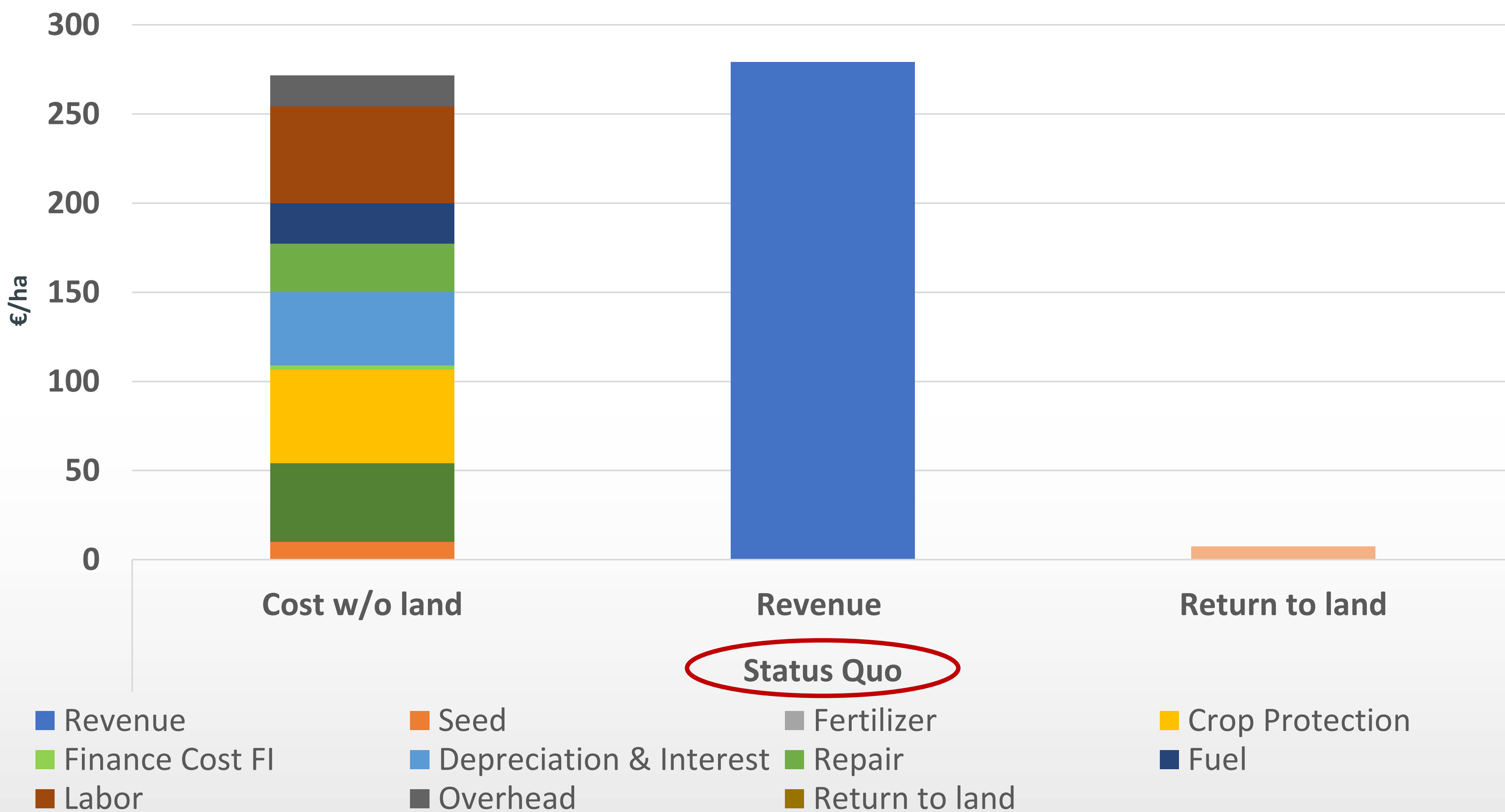
3. Australia – Current Wheat Economics (in €/ha)



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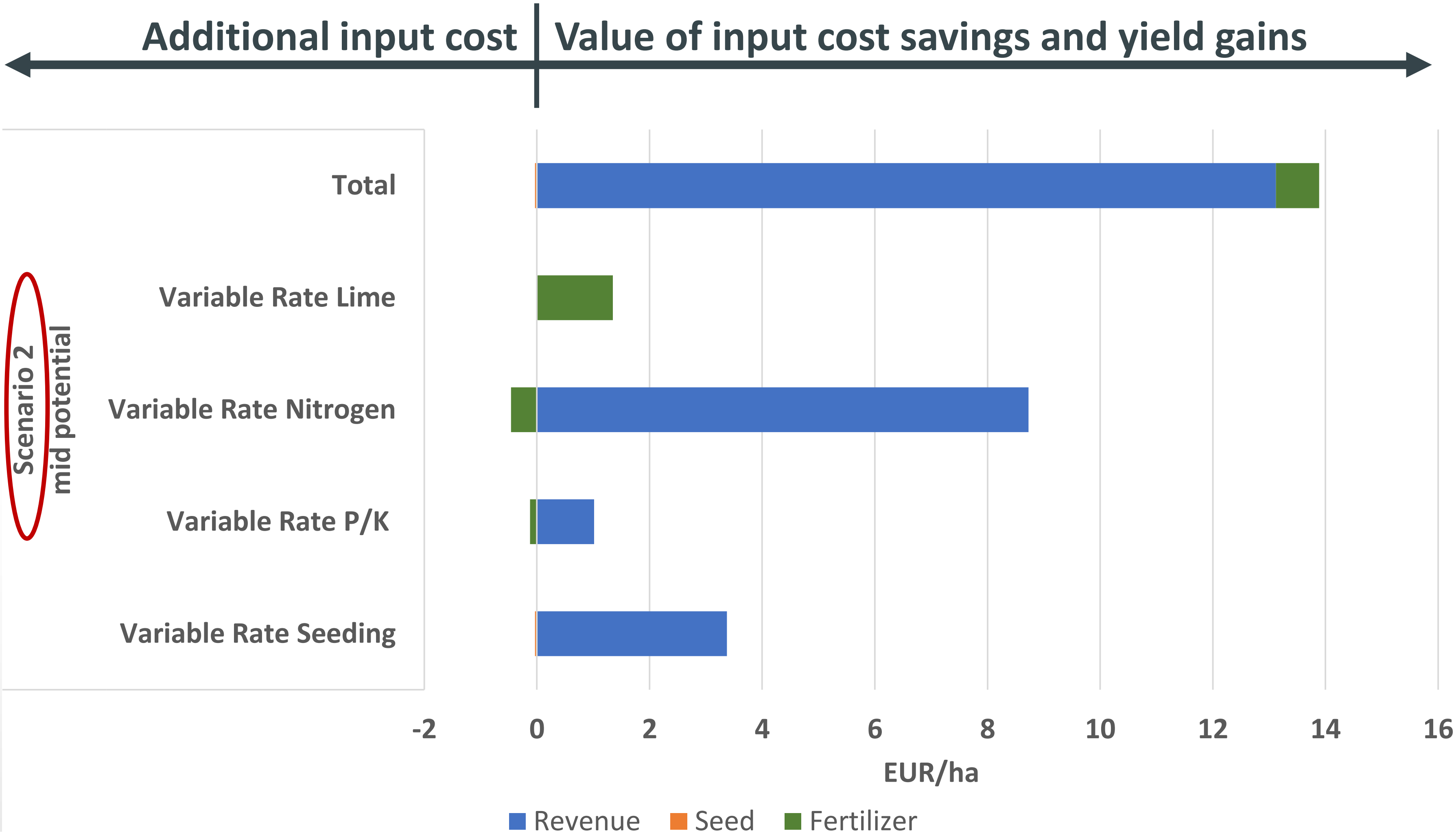
3. Australia - Economic benefits from VR application (1)



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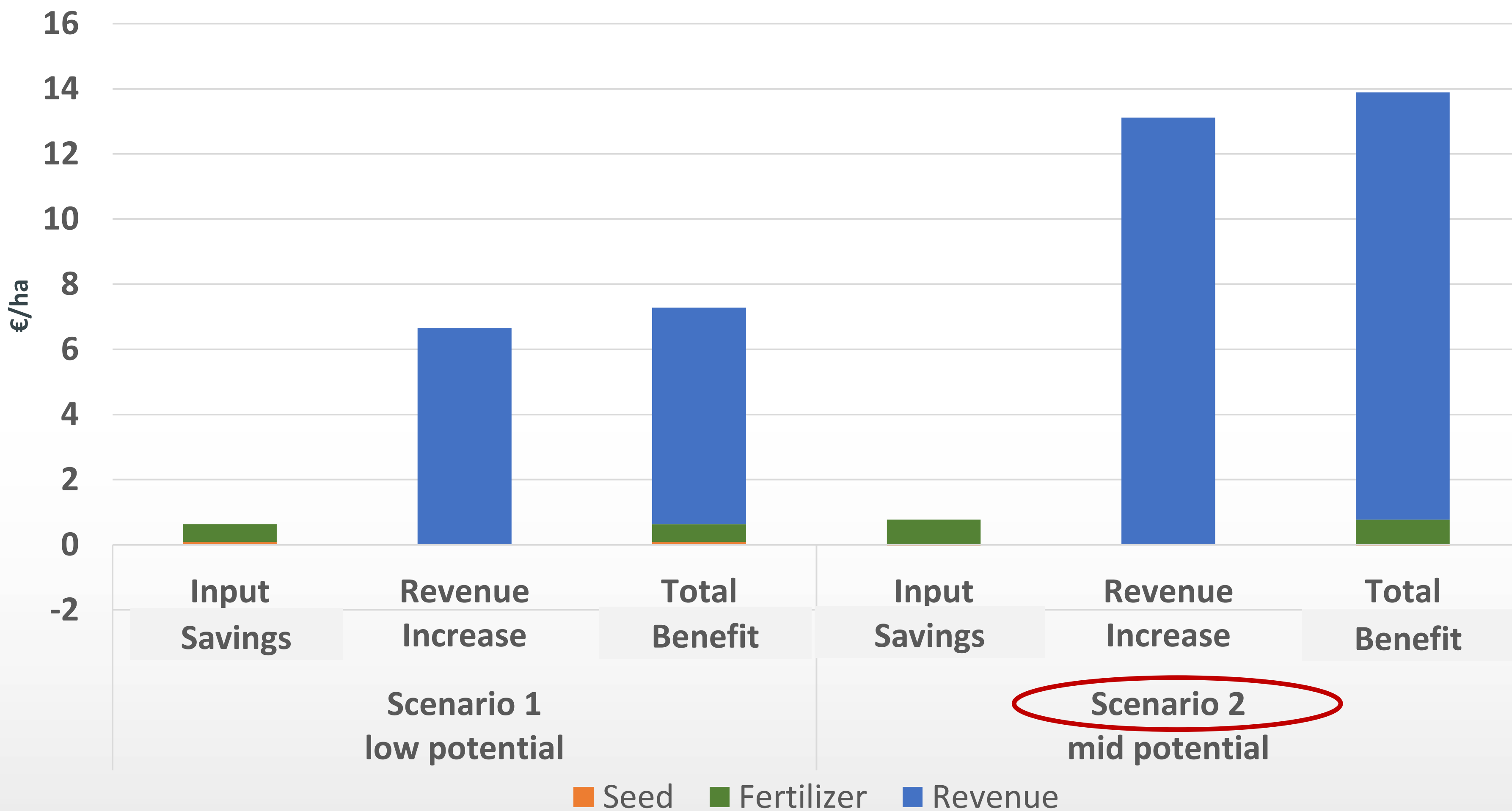
3. Australia - Economic benefits from VR application (2)



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3. Results - Canada

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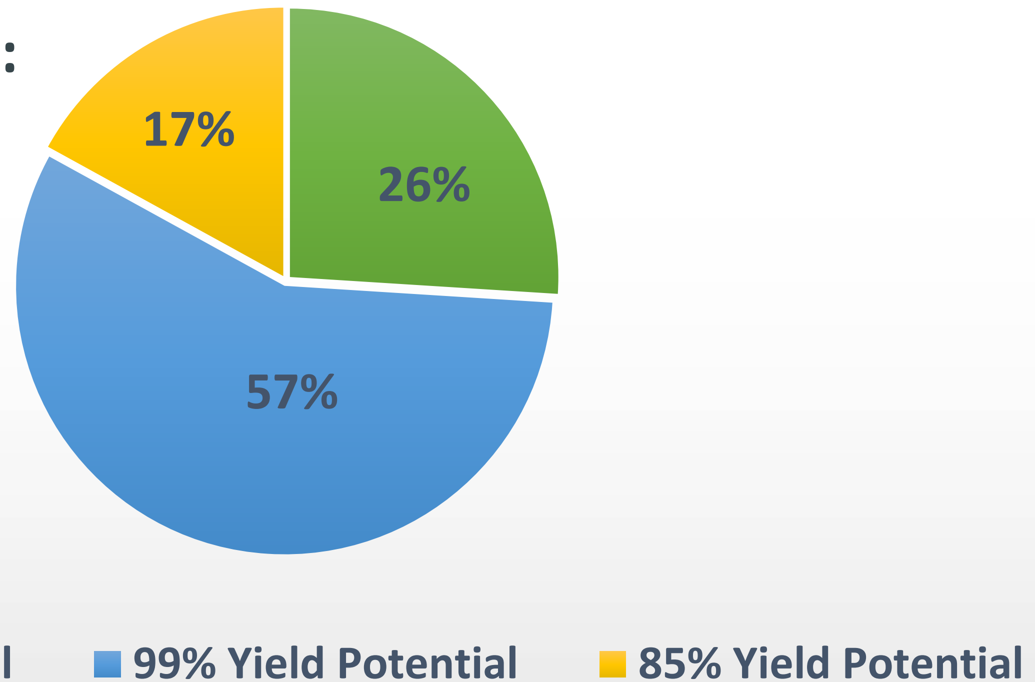
3. Results – Canada - NWM

Typical Farm: CA1100NWM - 1133 ha

- Crop: Wheat (after Canola)
- Acreage: 485 ha
- Management Zones:



3. Canada – NWM – Technologies assessed

- VR Seeding
- VR P/K application
- VR Nitrogen application
- VR Crop Protection (Fungicides)

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3. Canada (NWM) - Potentials Variable Rate Seeding

- Status Quo: 138 kg/ha - 40 €/ha

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- Input Savings Potentials

High Zone	(112%)	- 5,0%	**+ 4,1%**
Mid Zone	(99%)	+ 5,0%	
Low Zone	(85%)	+ 15,0%	

- Yield Potentials

High Zone	(112%)	+ 1,8%	**+ 0,5%**
Mid Zone	(99%)	+ 0%	
Low Zone	(85%)	+ 0%	

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3. Canada (NWM) - Potentials Variable P/K Application

- Status Quo: 71 kg/ha - 44 €/ha

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- Input Savings Potentials

High Zone	(112%)	- 12,1%	**+ 0,1%**
Mid Zone	(99%)	+ 1,3%	
Low Zone	(85%)	+ 14,8%	

- Yield Potentials

High Zone	(112%)	+ 1,5%	**+ 0,4%**
Mid Zone	(99%)	+ 0%	
Low Zone	(85%)	+ 0%	

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3. Canada (NWM) - Potentials VR Nitrogen Application

- Status Quo: 111 kg/ha - 70 €/ha

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- Input Savings Potentials
  - High Zone (112%) - 13,5%
  - Mid Zone (99%) + 1,3%
  - Low Zone (85%) + 14,8%

  $\}$ **- 0,31%**

- Yield Potentials
  - High Zone (112%) + 6,25%
  - Mid Zone (99%) + 0%
  - Low Zone (85%) - 0,5%

  $\}$ **+ 1,5%**

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3. Canada (NWM) - Potentials VR Fungicide Application

- Status Quo: 31 €/ha

- Input Savings Potentials

High Zone	(112,1%)	+ 0,0%	
Mid Zone	(98,7%)	+ 13,4%	**+ 12,2%**
Low Zone	(85,2%)	+ 26,9%	

- Yield Potentials

High Zone	(112%)	+ 0%	
Mid Zone	(99%)	+ 0%	**+ 0,0%**
Low Zone	(85%)	+ 0%	

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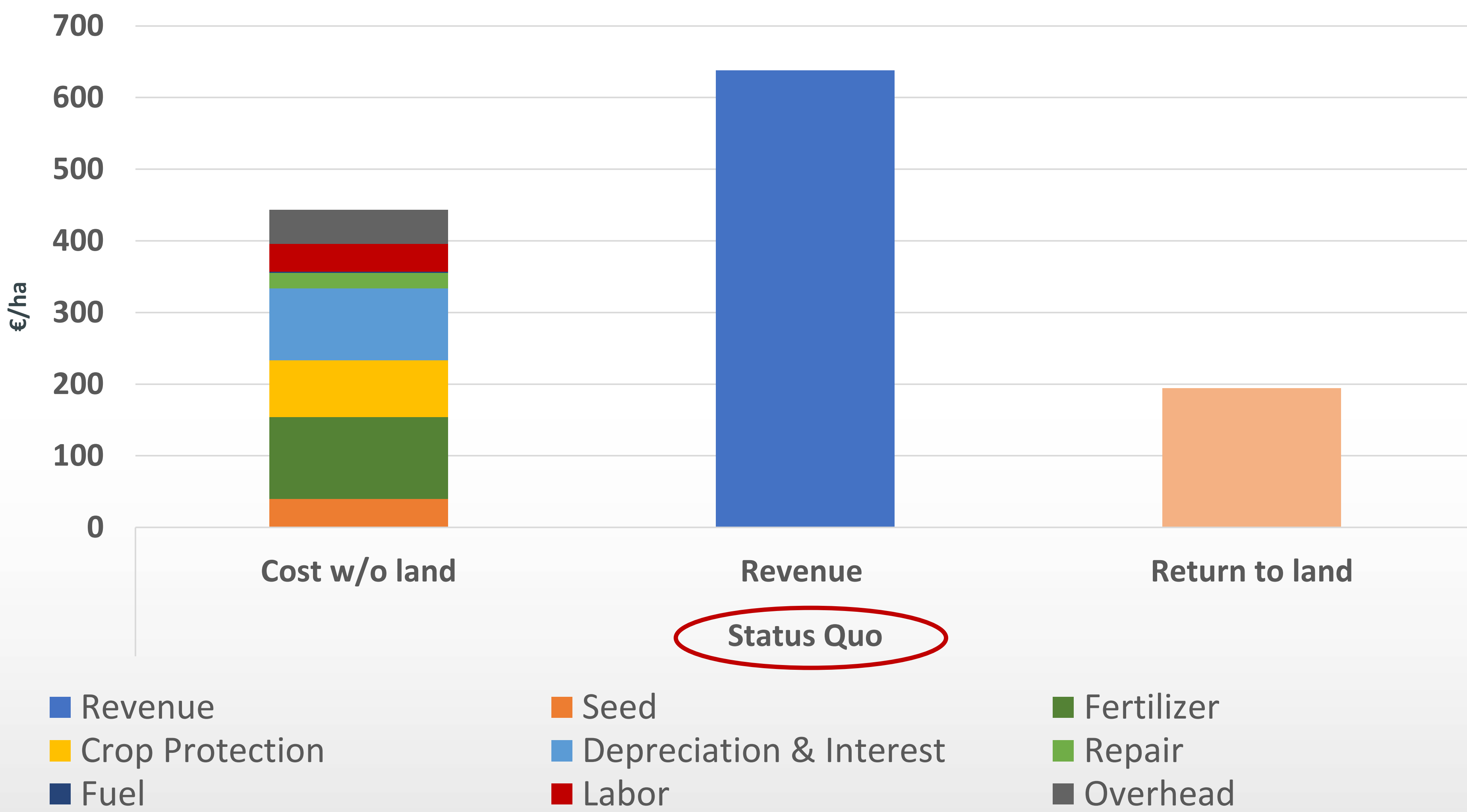
3. Canada (NWM) – Current Wheat Economics



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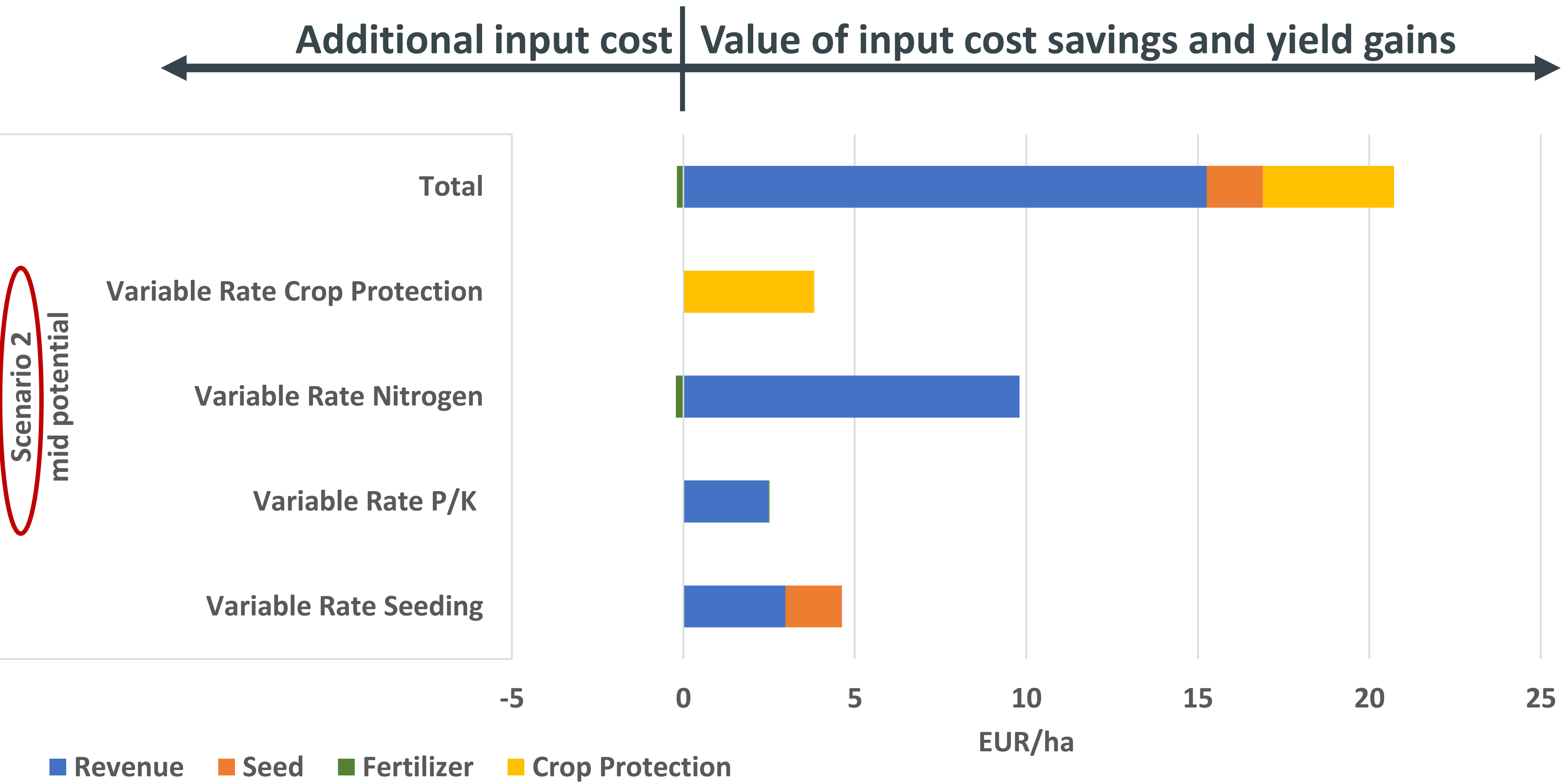
3. Canada (NWM) - Economic benefits from VR application (1)



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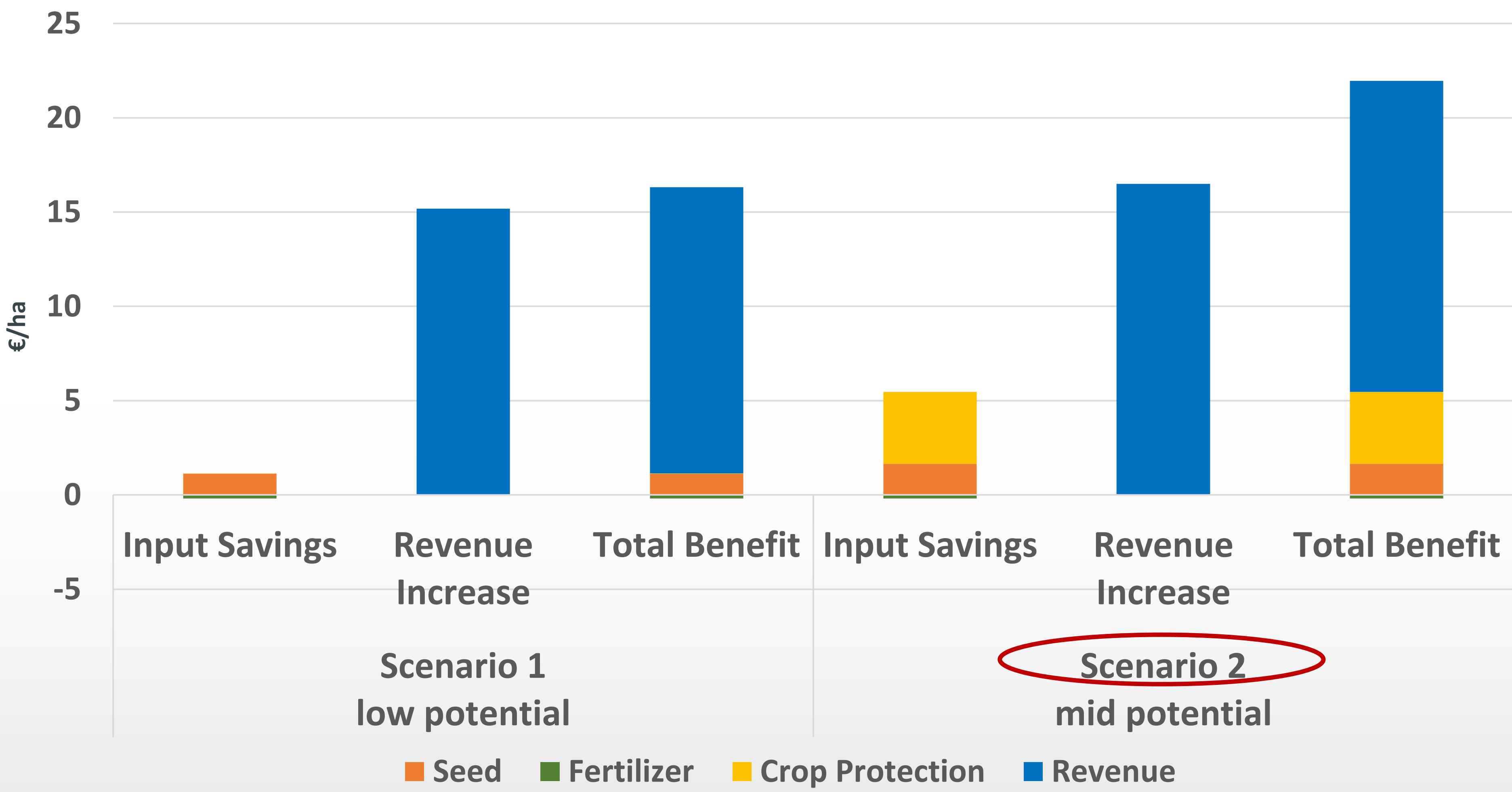
3. Canada (NWM) - Economic benefits from VR application (2)



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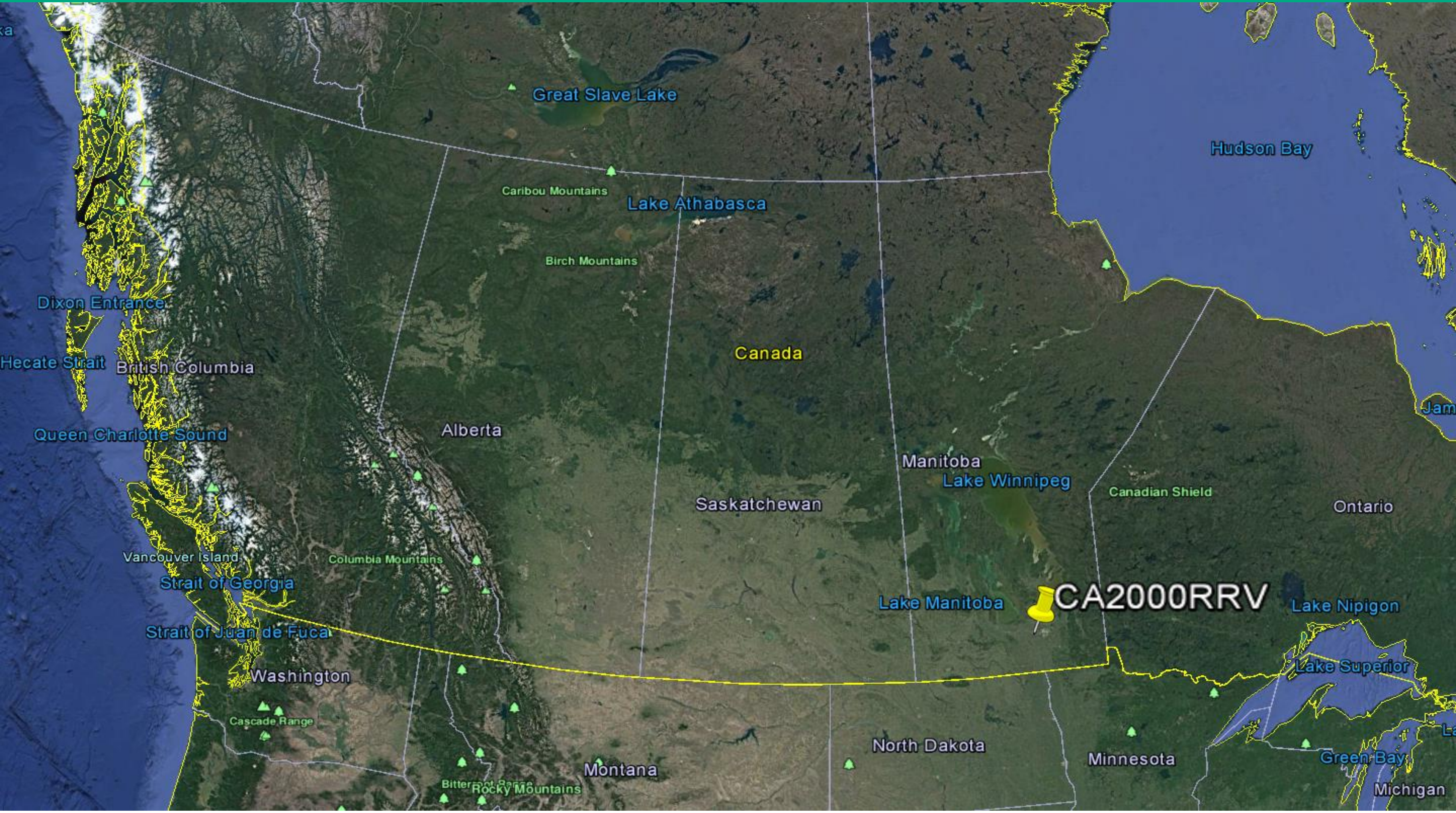
3. Results – Canada - RRV



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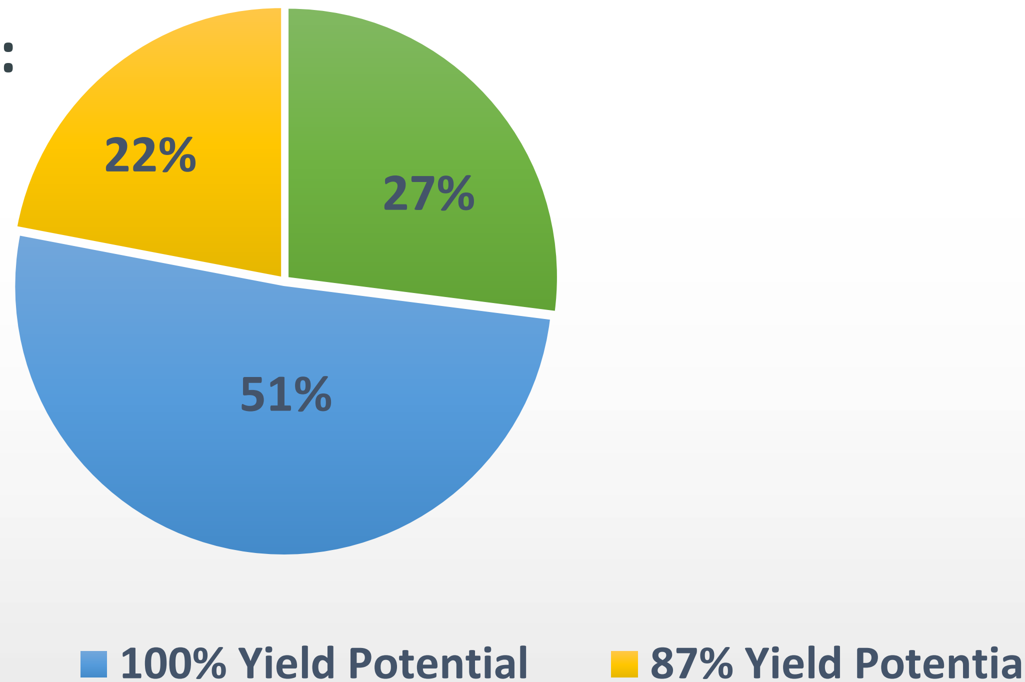
3. Results – Canada - RRV

Typical Farm: CA2000RRV - 2286 ha

- **Crop:** Wheat (after Soybean/Wheat)
- **Acreage:** 1005 ha
- **Management Zones:**



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3. Canada – RRV – Technologies assessed

- VR Seeding
- VR P/K application
- VR Nitrogen application
- VR Crop Protection (Fungicides)

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3. Canada (RRV) - Potentials Variable Rate Seeding

- <u>Status Quo:</u> 135 kg/ha - 43 €/ha

⇩

- Input Savings Potentials

• High Zone	(110%)	- 5,0%	
• Mid Zone	(100%)	+ 5,0%	**+ 4,4%**
• Low Zone	(87%)	+ 15,0%	

- Yield Potentials

• High Zone	(110%)	+ 1,5%	
• Mid Zone	(100%)	+ 0%	**+ 0,4%**
• Low Zone	(87%)	+ 0%	

3. Canada (RRV) - Potentials Variable P/K Application

- Status Quo: 60 kg/ha - 39 €/ha

⇩

- Input Savings Potentials

High Zone	(110%)	- 9,8%	**- 0,0%**
Mid Zone	(100%)	- 0,1%	
Low Zone	(87%)	+ 12,6%	

- Yield Potentials

High Zone	(110%)	+ 1,0%	**+ 0,3%**
Mid Zone	(100%)	+ 0%	
Low Zone	(87%)	+ 0%	

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3. Canada (RRV) - Potentials VR Nitrogen Application

- <u>Status Quo:</u> 119 kg/ha - 93 €/ha

⇩

- Input Savings Potentials

High Zone	(110%)	- 22,0%	**- 0,7%**
Mid Zone	(100%)	- 0,2%	
Low Zone	(87%)	+ 25,2%	

- Yield Potentials

High Zone	(110%)	+ 8,0%	**+ 2,0%**
Mid Zone	(100%)	+ 0%	
Low Zone	(87%)	- 1,0%	

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3. Canada (RRV) - Potentials VR Fungicide Application

- Status Quo: 45 €/ha

- Input Savings Potentials

High Zone	(109,8%)	+ 0,0%	
Mid Zone	(100,1%)	+ 9,7%	+ 9,8%
Low Zone	(87,4%)	+ 22,4%	

- Yield Potentials

High Zone	(110%)	+ 0%	
Mid Zone	(100%)	+ 0%	+ 0,0%
Low Zone	(87%)	+ 0%	

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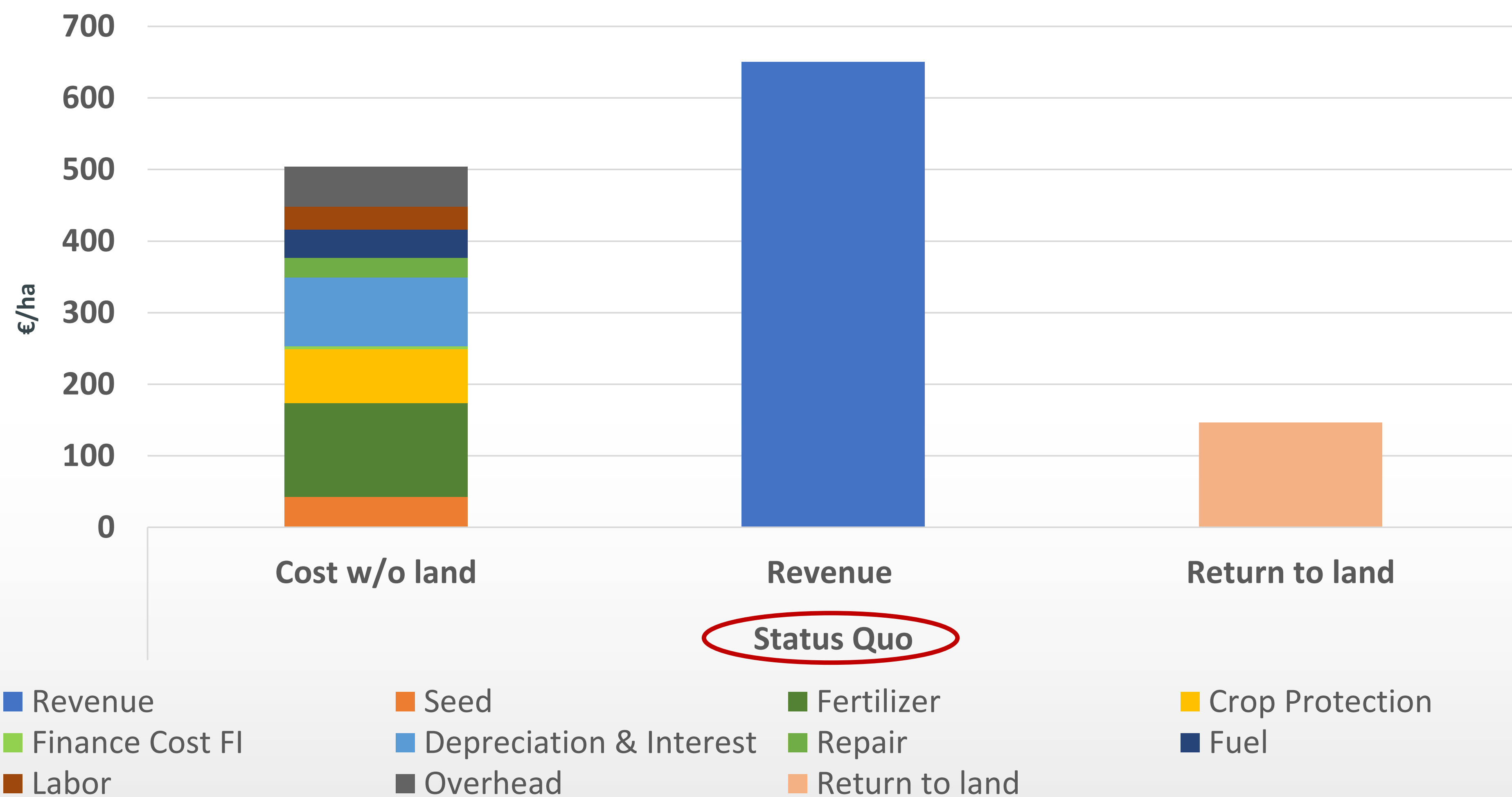
3. Canada (RRV) – Current Wheat Economics



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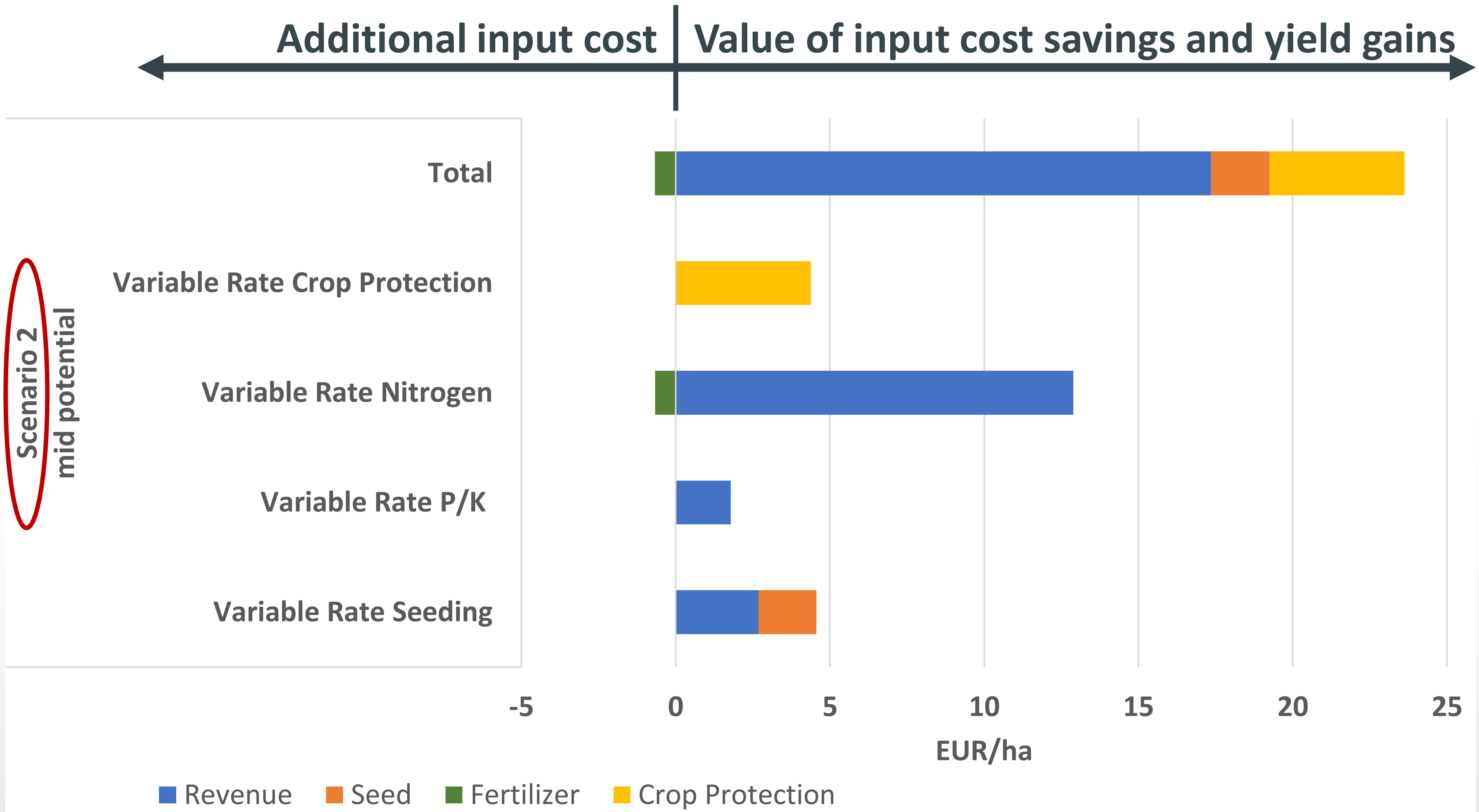
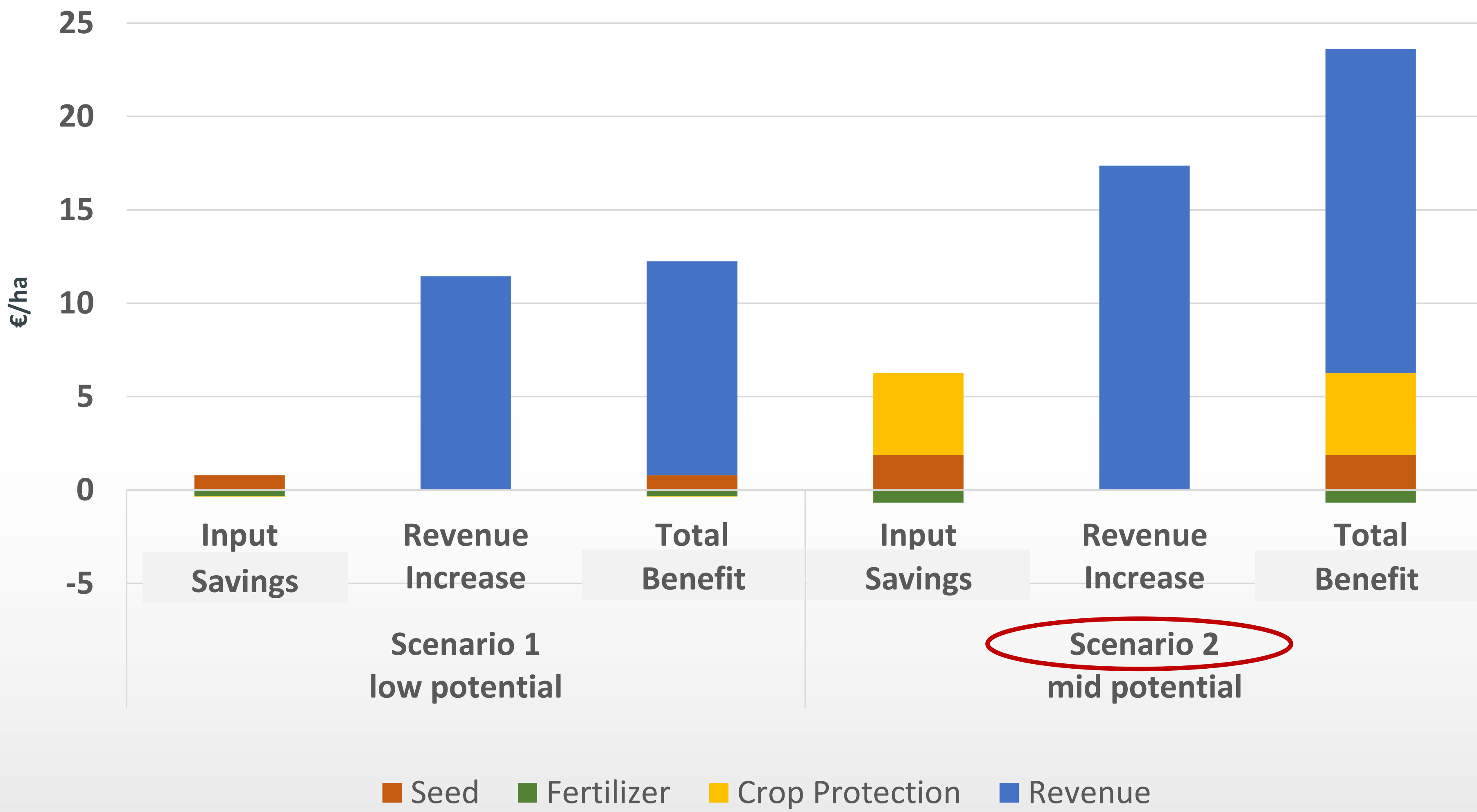
3. Canada (RRV) - Economic benefits from VR application (1)



3. Canada (RRV) – Economic benefits from VR application (2)



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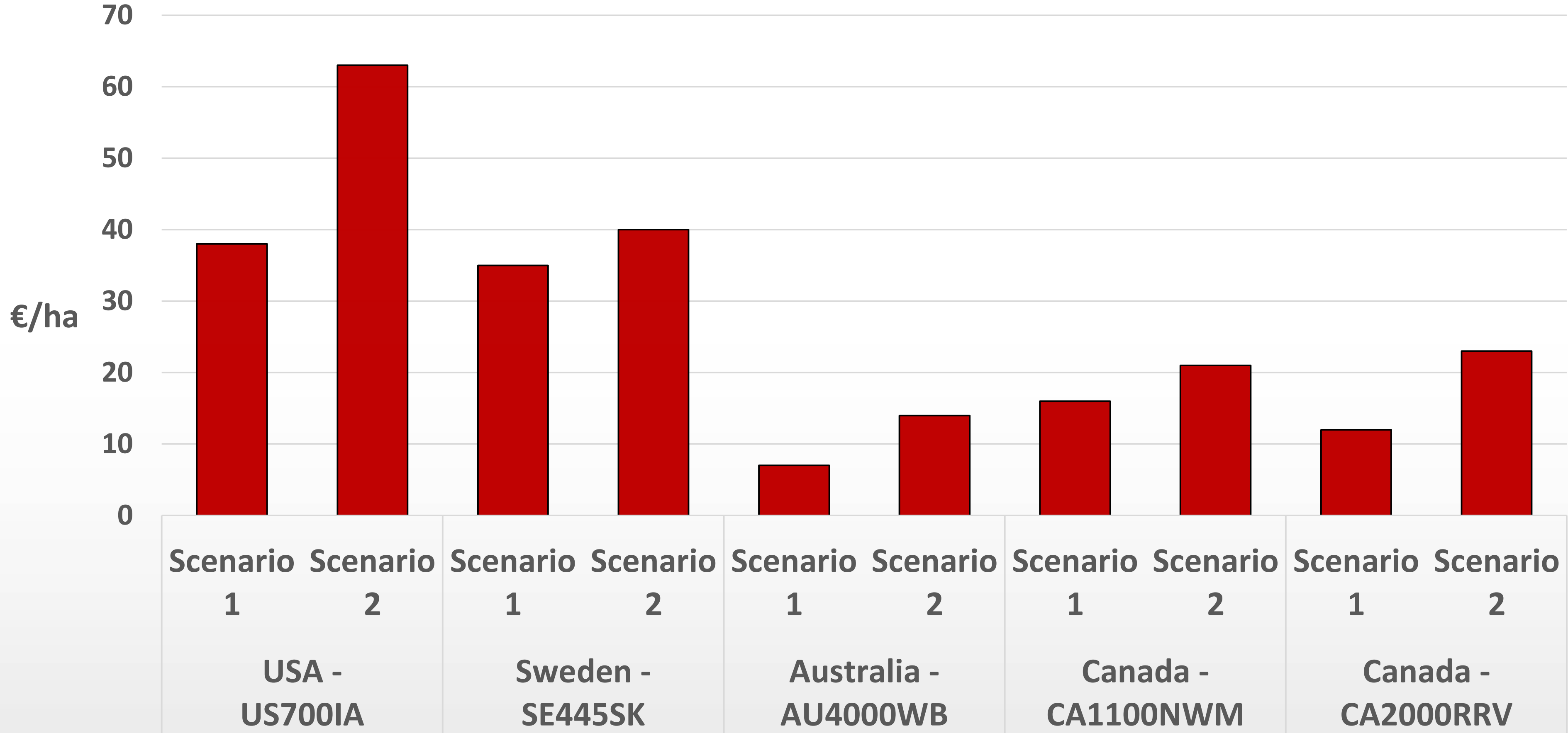
4. Summary

Total potentials of Precision Farming:



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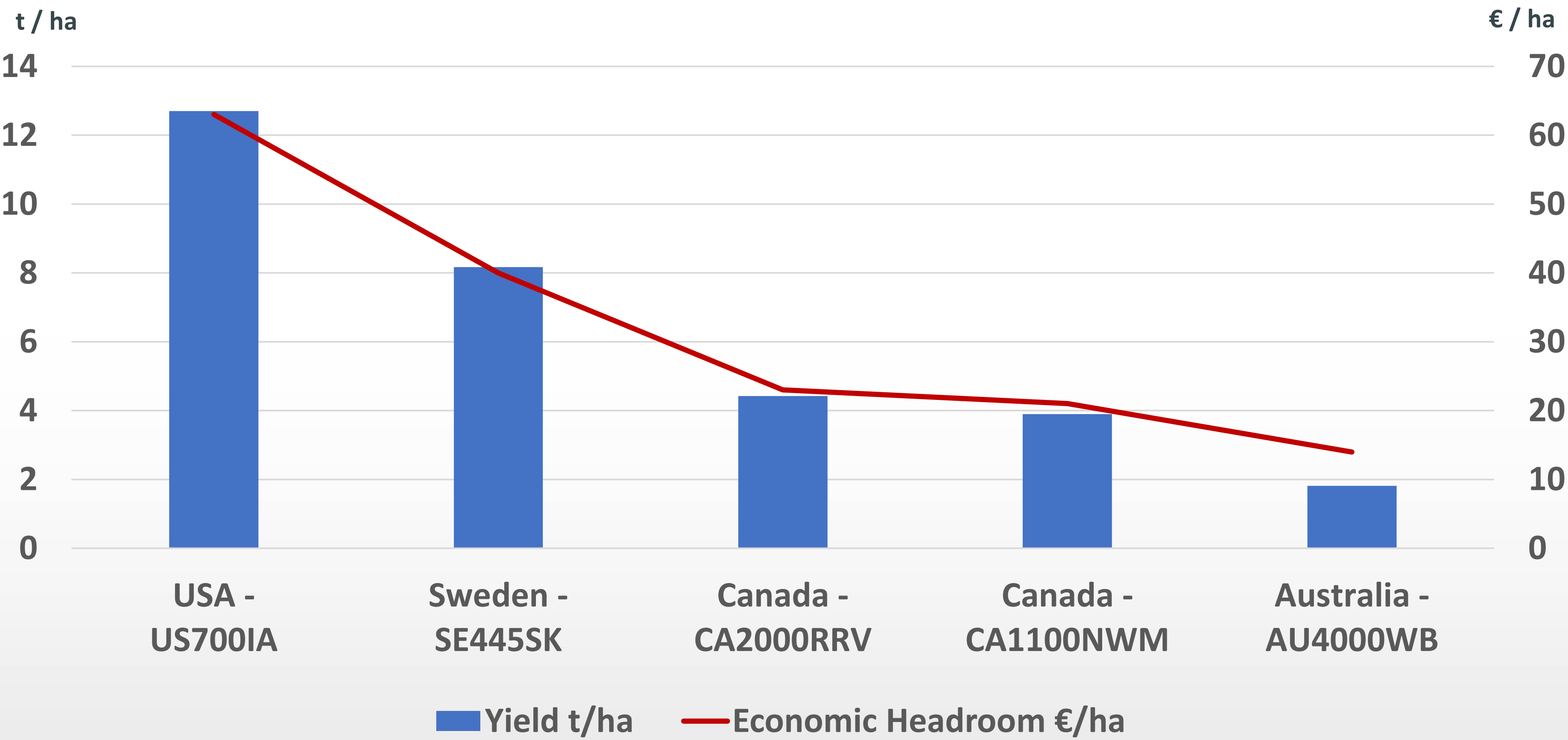
4. Discussion

Yields and economic benefit from PF:



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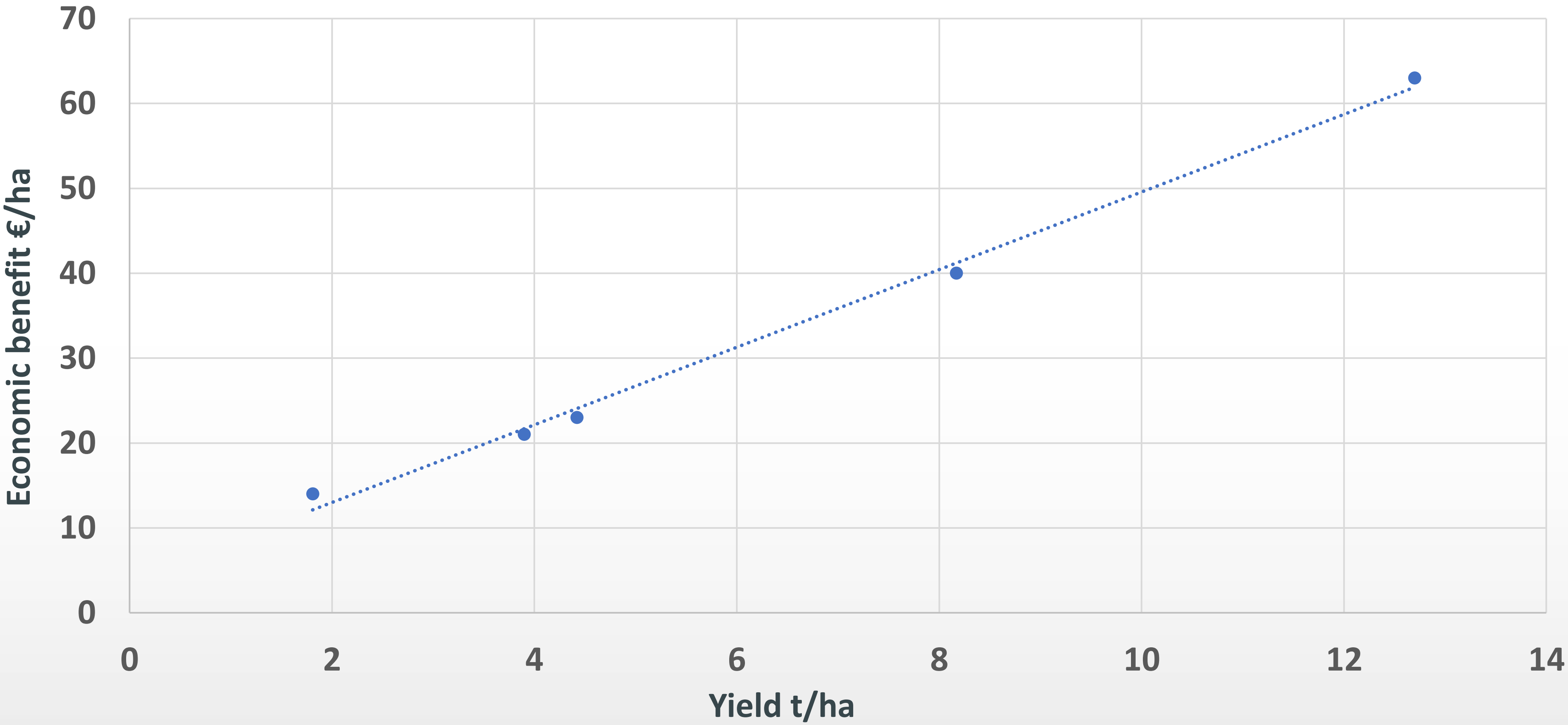
4. Discussion

Correlation of yields and economic benefit from PF :



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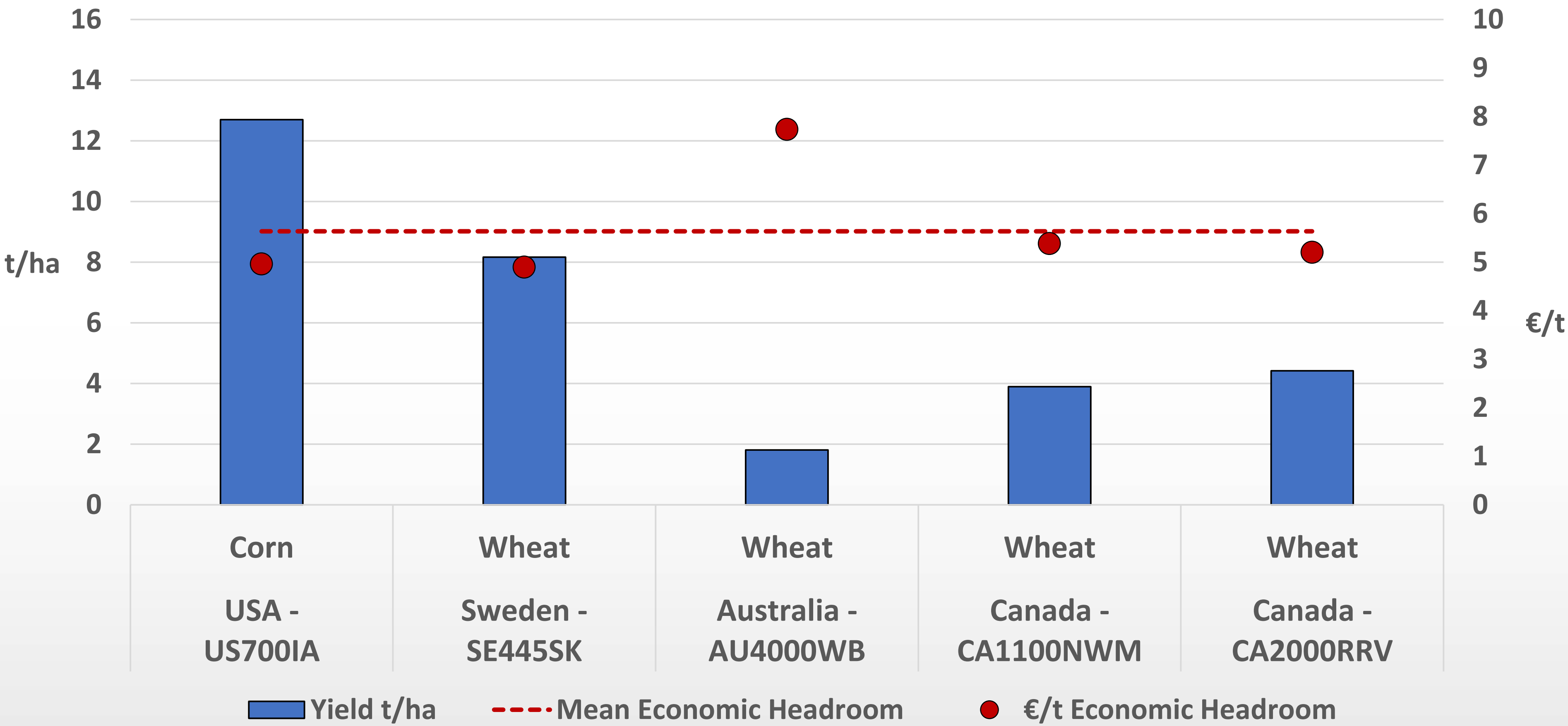
4. Discussion

Correlation yields and economic benefits from PF:



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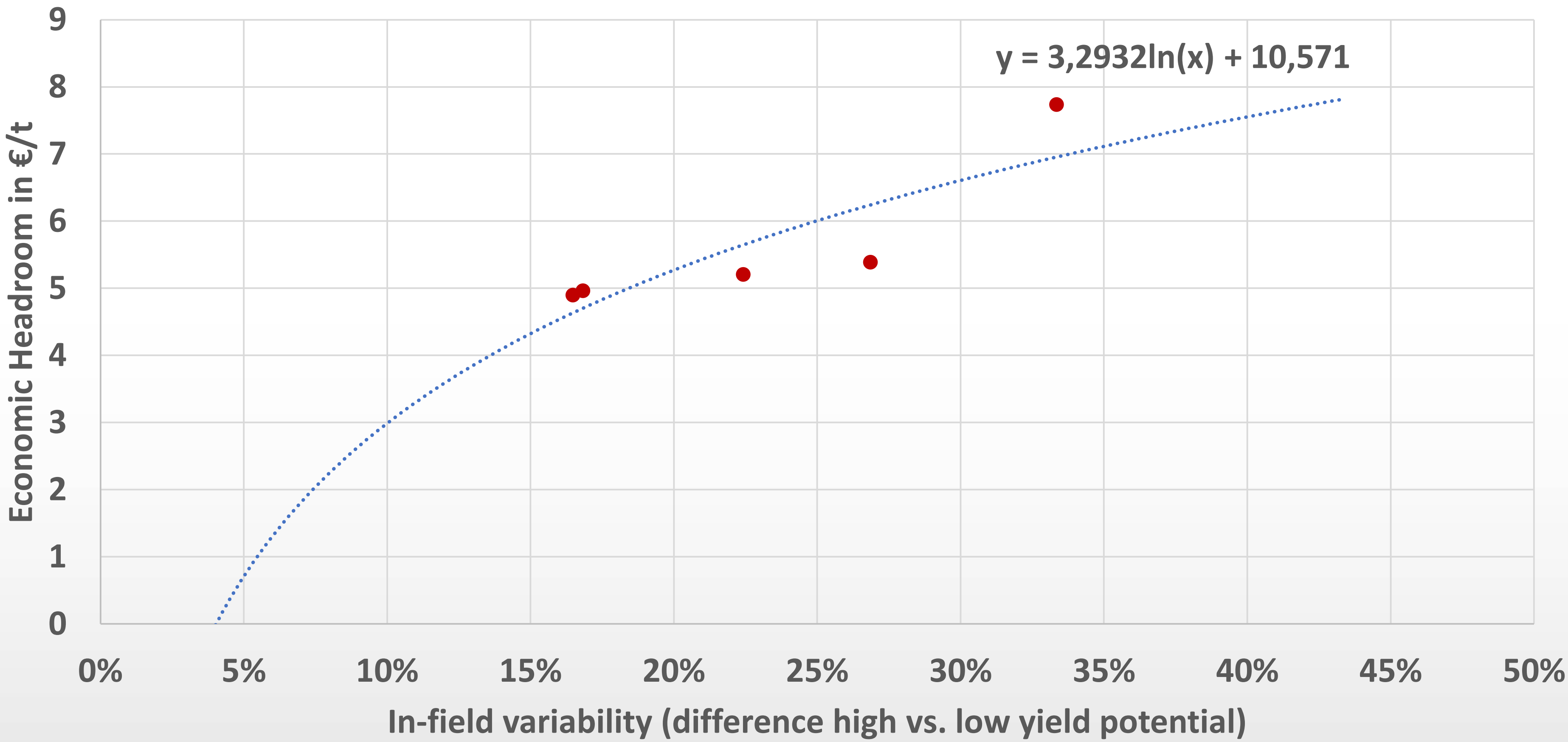
Result presentation for partners providing data to the project

agri benchmark

4. Discussion

Correlation yield and economic benefit from PF (€/t):



5. Conclusions

1. Revenue increase is driving PF potentials, savings in input use are less important
2. The higher yield levels, the higher potential per hectare.
3. Economic benefit per tonne is rather equal across the board.
4. Relative potentials correlate with field heterogeneity
5. Whether technology is profitable remains to be seen because no additional cost calculated so far.

5. Conclusions

6. Yield potential on-farm likely to be higher compared to this study because yield potential estimate was not available
7. On-Farm-Research (OFR) necessary to check results.

Let’s grow together.

Thank you for your interest in agri benchmark

jointly managed by: THÜNEN & global networks

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