

# A large network of soybean fields analyzed to determine yield-limiting factors and improve soybean crop in France

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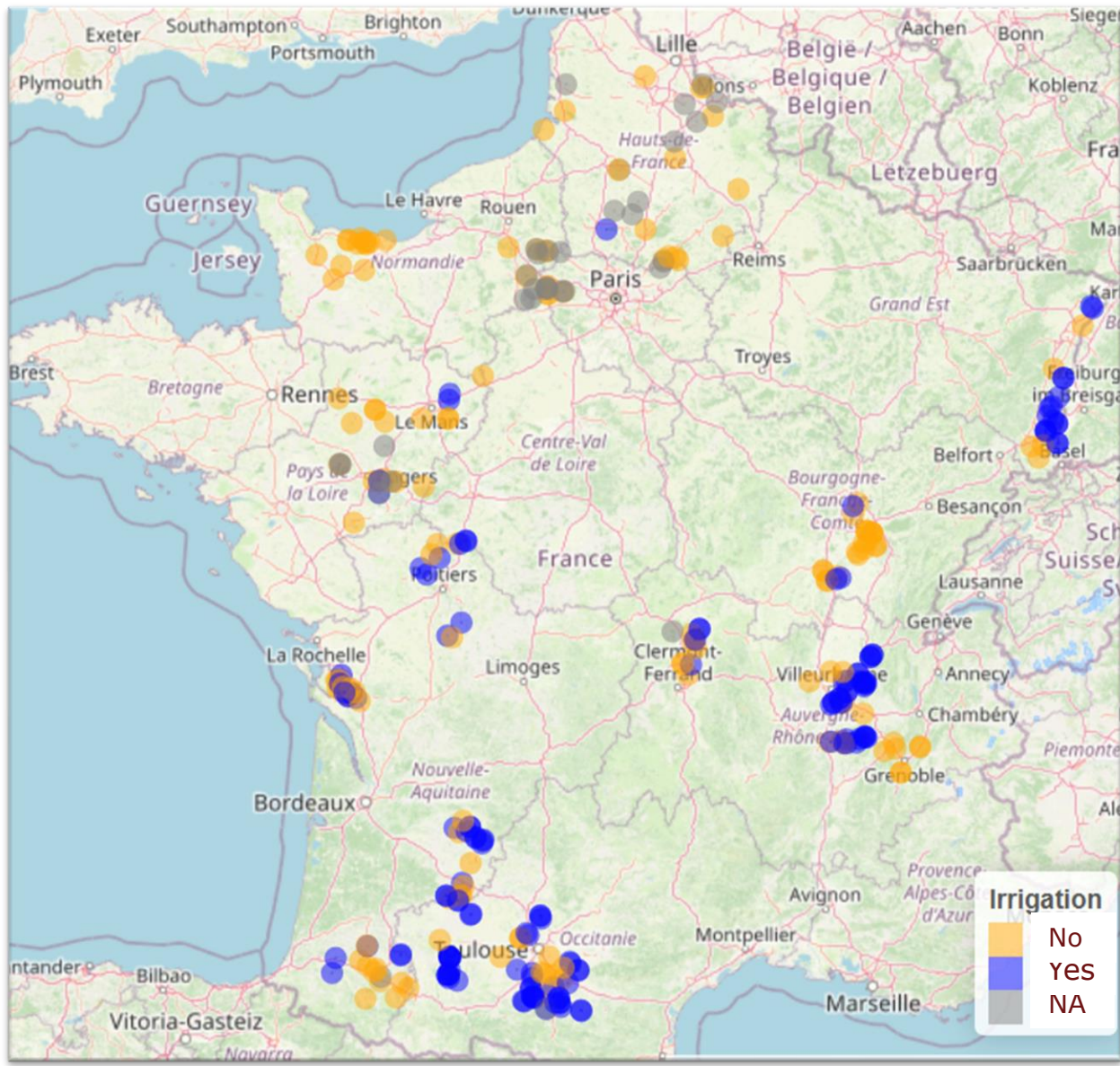
## Background

- Increase of soybean crop areas in France, especially in new production areas → necessity to continue to increase competitiveness and sustainability.
- Cap Protéines (2021-2022): a large French research, development and transfer project to increase national crop protein production.



## Objectives

- Reducing failures and increasing the efficiency of soybean production, to ensure that soybean remains a profitable and sustainable crop.
- **Acquire references and identify, analyze and classify key limiting factors of yield.**



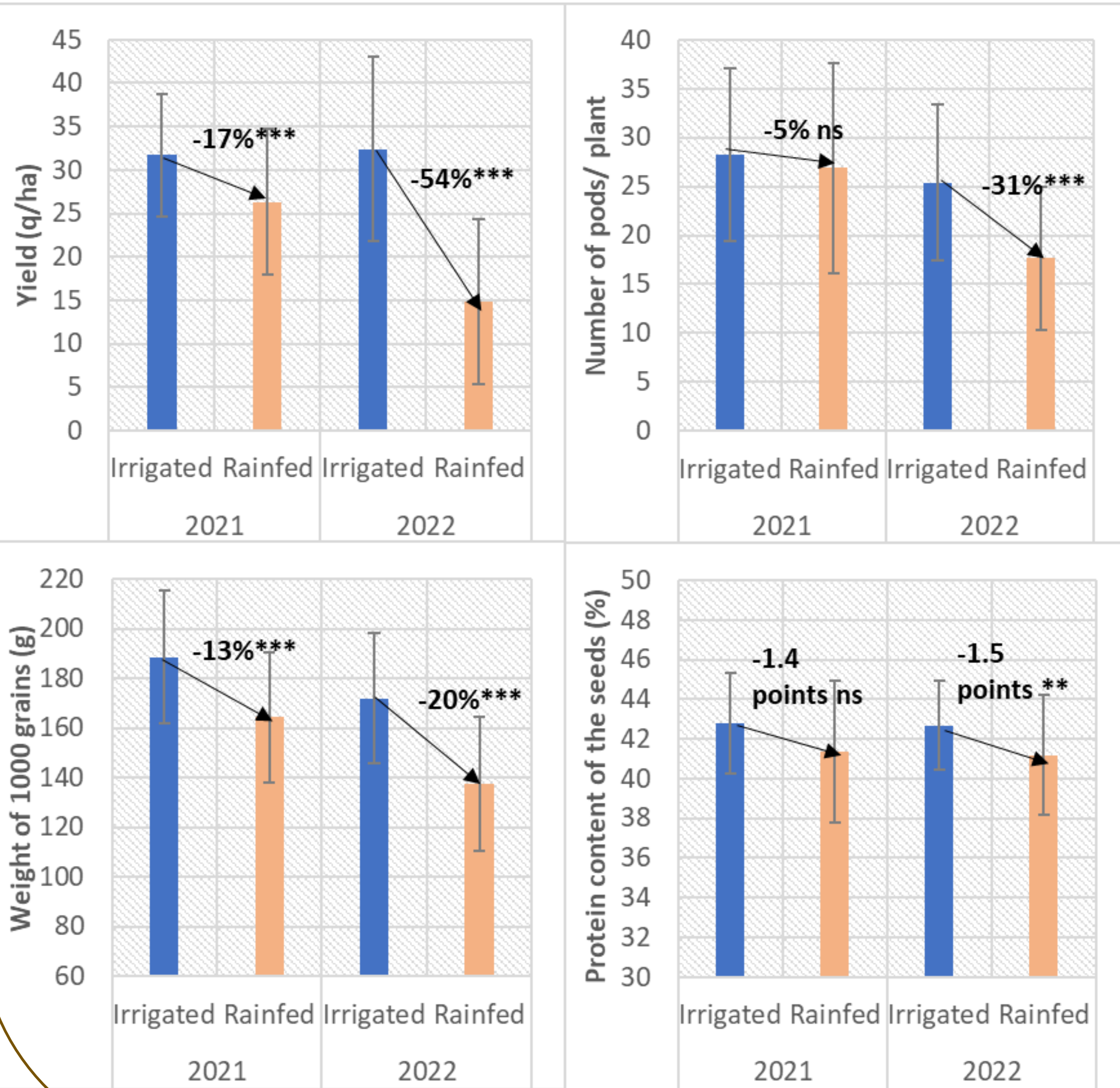
## Material and methods

- Monitoring of 322 agricultural fields over 2 years, representative of various conditions.
- Numerous measurements during growth at emergence, flowering, maturity and harvest.
- Large dataset under real conditions but with interactions between multiple factors.
- Two contrasting climate years during soybean cycle  
 2021 : wetter and moderate temperatures  
 2022 : very dry conditions and higher temperatures

	Irrigation (% of fields)	Sowing date	Sowing density (seeds/m <sup>2</sup> )	Emergence rate (%)	Harvest date
France (mean)	50	May 10th	57	72	Oct 1st
Min. area mean	0	May 1st	45	59	Sept 22nd
Max. area mean	76	May 16th	79	81	Oct 10th

## Results and discussion

- Lower yields in rainfed fields vs irrigated fields due to reductions in pod number and thousand grain weight.
- Severe water deficits in 2022 → larger yield gap

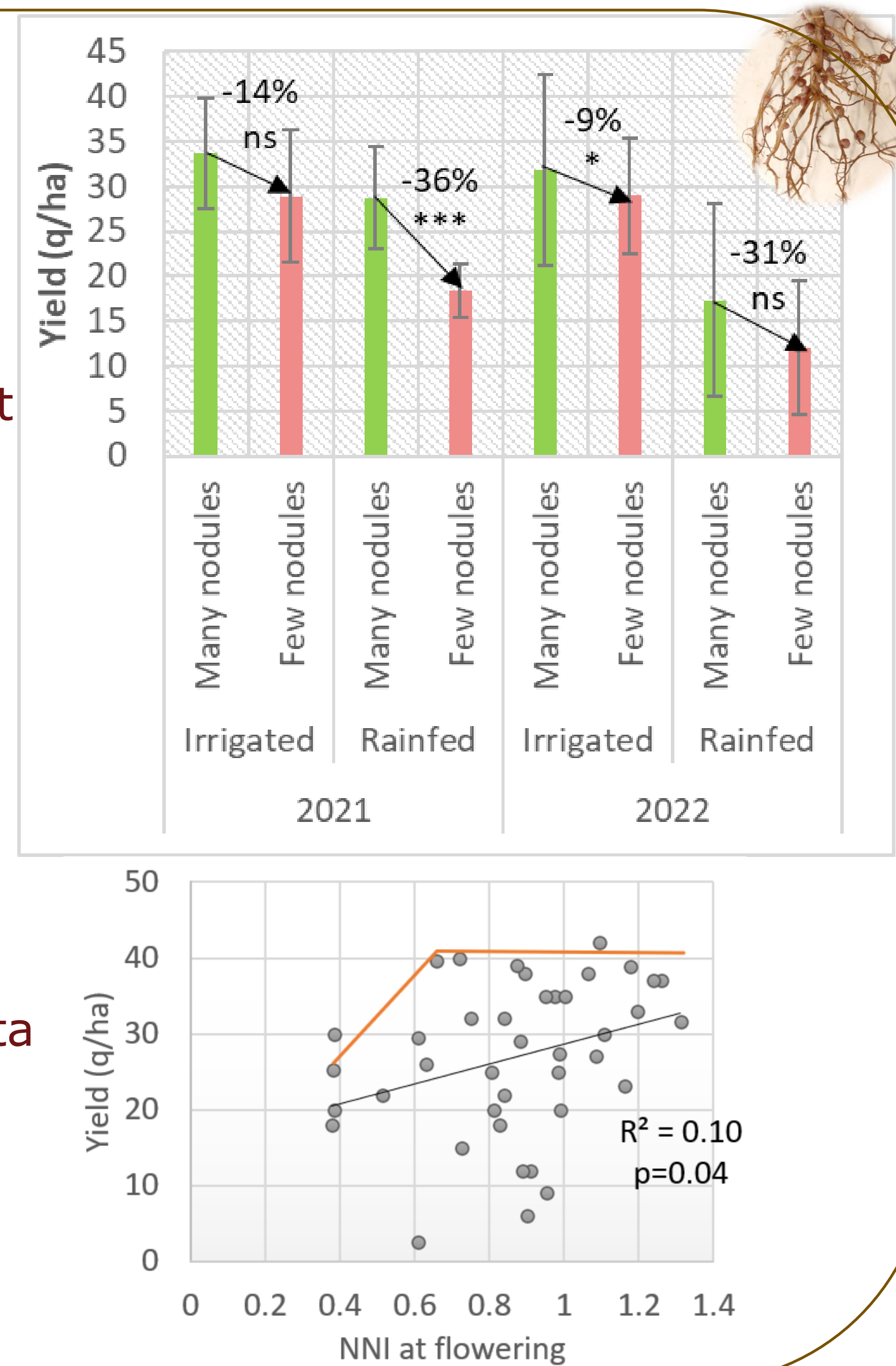


Fields from the main regions with both irrigated and rainfed management

• Significant water stress during flowering, fruiting, and seed filling, especially in rainfed fields.

• Proper water management practices are crucial to mitigate the effects of water availability on yield.

- Nodulation at flowering significantly impacts yield.
- Stronger impact in rainfed conditions.
- In irrigated conditions, effect likely due to nodulation deficiencies unrelated to water availability → inoculation failure, planting quality issues or Nitrogen content in soil.
- Nitrogen nutrition index (NNI) correlates with yield.
- NNI < ~0.6 particularly impacts on yield → more data needed for confirmation.
- Data with NNI > 0.6 still exhibit low yield → presence of other limiting factors



Limiting factors 2021-2022	Number of fields	Thresholds for calculation	Average yield difference 2021-2022	Impact level 2021-2022
Presence of weeds at flowering	315	«very weedy» vs «no weed»	-49%	5
Quantity of nodules at flowering	170	« Few » vs « Many »	-35%	4
Quantity of incoming water flow-mat (mm)	167	<100 vs >280	-34%	4
Height of first pod (cm)	297	<10 vs >18	-33%	4
Presence of pests at early/late stage	304	Damage >20% vs 0	-31%	4
Uniformity of stand	315	« very het. » vs « very hom. »	-27%	3
Nitrogen Nutrition Index at flowering	49	>0.6 vs >0.95	-25%	3
Root depth at flowering	91	« <15cm » vs « >15 cm »	-15%	2
Stand density (early stage) (plants/m <sup>2</sup> )	97	<40 vs 40-65	-14%	2
Fresh biomass at flowering (g/m <sup>2</sup> )	202	<1400 vs >2500	-8%	1
Presence of diseases at flowering	312	Damage >20% vs 0	ns	1

- Ranking based on yield differences using thresholds to define high and low classes.
- All main yield limiting factors directly or indirectly linked to water availability.
- Stand density includes seeding density effects that varies by region and maturity groups and likely diminished effect → incorporate seeding density into this indicator.
- No significant correlation between fresh flowering biomass and yield; minimal impact of diseases on yield.

## Conclusions and perspectives

- Initial approach to identifying yield limiting factors in 2021-2022, despite confounding effects and many missing data.
- Multifactorial analysis approaches will be employed to refine the results and better account multiple factors.
- Additional years of climatic data will be incorporated to consolidate these results and threshold values → renewed for another 3 years.