Comparative analysis of crop phenotypes to assess cropping system diversification potential by introducing improved accessions of *Thinopyrum intermedium* in fields

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Introduction

The impact of intensive **annual crop production** on natural resources under the threat of climate change has led to a global increase in **environmental degradation** and **biodiversity loss**. A concept for mitigating such consequences is the development of **perennial grain cropping systems**. Their introduction into the fields aims at **diversifying** cropping systems by proposing a crop enabling **grain production** while ensuring a range of **ecosystem services** typically offered by perennial forages (permanent soil cover, high total biomass production and deeper root systems) (Ryan et al., 2018).

Thinopyrum intermedium L. (Intermediate wheatgrass), Kernza® is among the most advanced examples of recently developed perennial grain crops. However, few data are available to characterize *Th. int.* phenotypes and plant functional traits (PFT) compared to other grass crops. Such a comparison can help to unravel the potential differences between this new crop and the well-known crops grown in temperate European cropping systems.

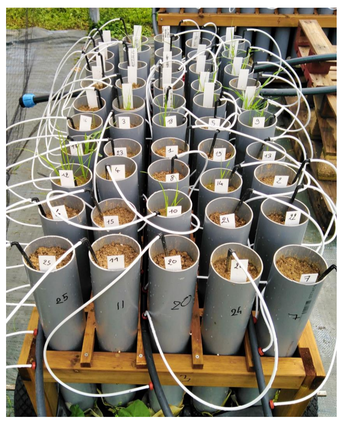
NAPERDIV Project

With an inter-disciplinary and multi-sectoral network of researchers and stakeholders across Europe, NAPERDIV will analyse (a) the agronomic performance of intermediate wheatgrass to assess and simulate its resilience against climate hazards, (b) the crop-associated microbiome and its functional benefits (growth promotion, disease suppression), (c) the resilience of the soil microbiome against drought under expected climate variability, and (d) the soil fauna, its benefits and indicator values for crop performance, system diversity and processes.

Experimental design

Functional comparison of 22 grass accessions

Grain crops	Forage crops	Thinopyrum intermedium
Avena sativa	*Brachypodium rupestre*	Wild accession (Iran)
Hordeum vulgare	*Briza media*	Wild accession (Kazakhstan)
Secale cereale	*Dactylis glomerata*	TLI Cycle 0
Triticum aestivum (5 var.)	*Lolium perenne*	TLI Cycle 5
Triticum spelta	*Phleum pratense*	TLI Cycle 8
x Triticosecale	*Poa annua*	
	Poa pratense	

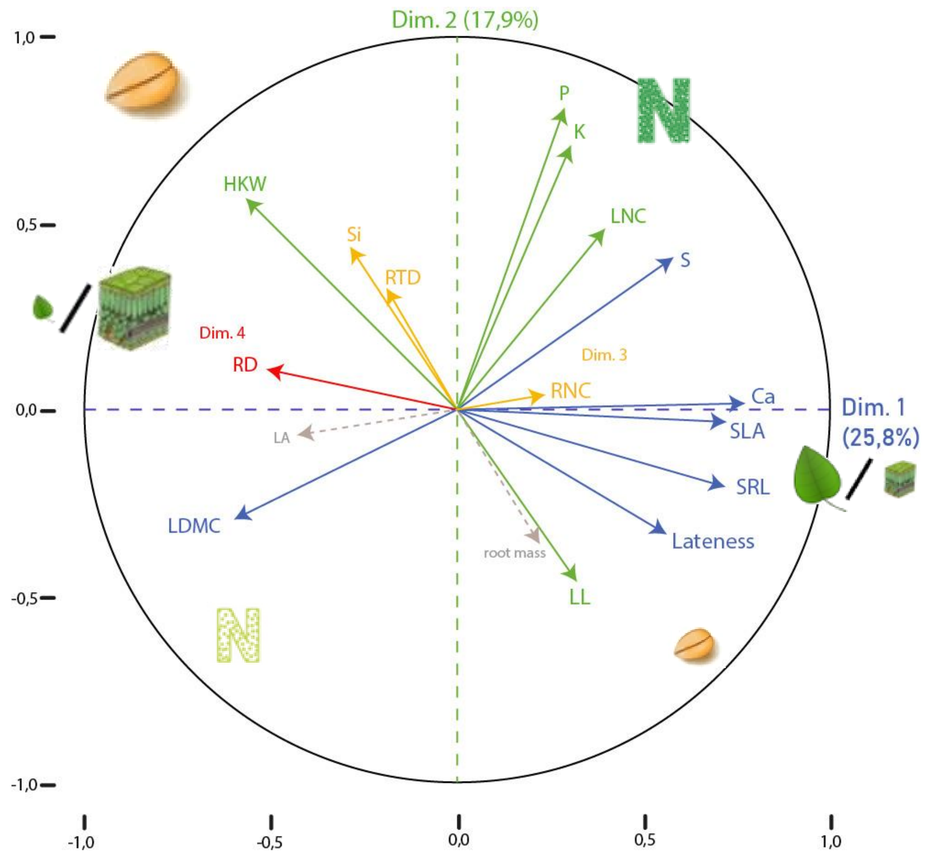


Functional traits measured

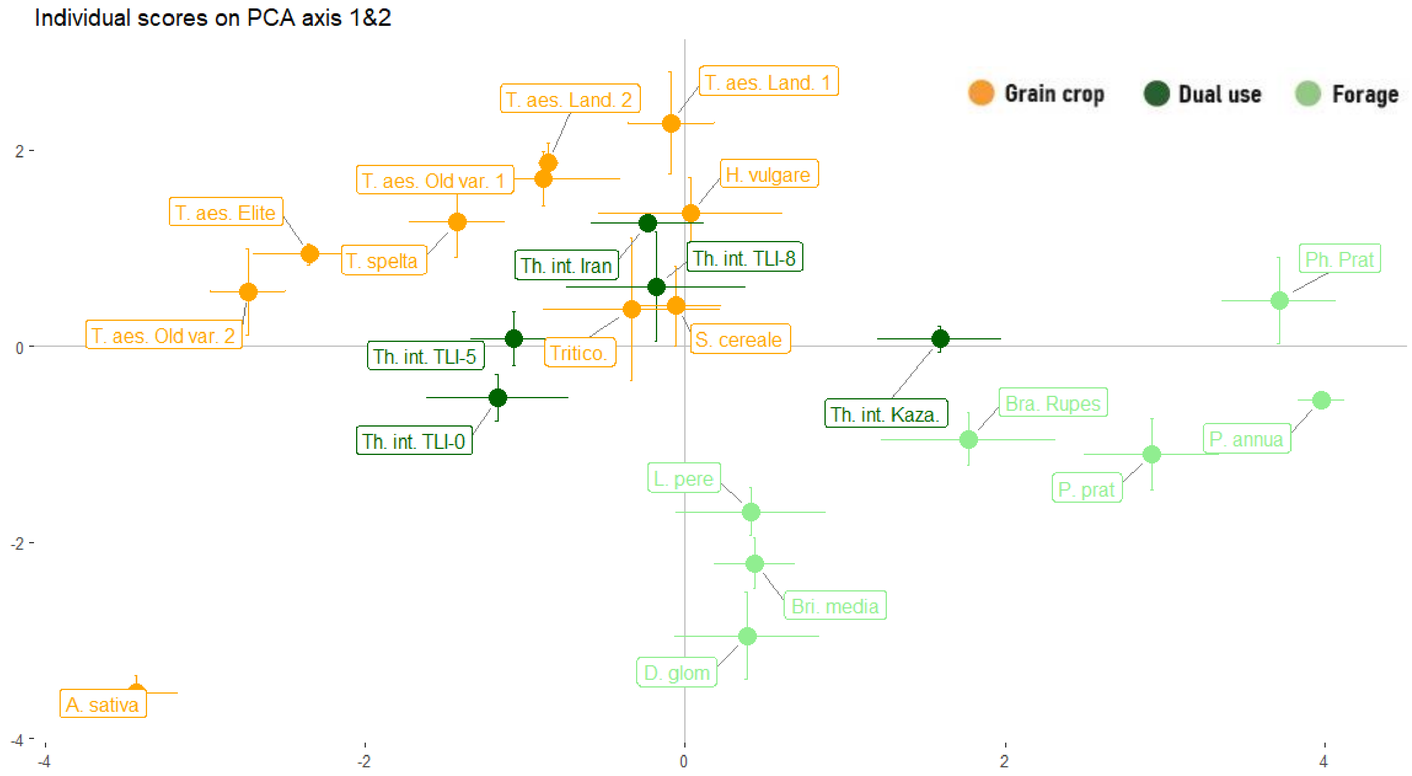
- Grain weight (g)
- Number of grains
- Number of spikes
- Leaf N, Si, Ca, P, K content ($mg.g^{-1}$)
- Specific leaf area ($m^2.kg^{-1}$)
- Leaf lifespan (GDD)
- Number of tillers
- Height (cm)
- Aboveground biomass (g)
- Root biomass (g)
- Root diameter (mm)
- Root tissue density ($g.cm^{-3}$)
- Specific root length ($m.g^{-1}$)

Results

Functional traits



Individual scores on PCA axis 1&2



Key points

- *Th. int.* root biomass was higher compared to other cereals (p-value < 0.001) and more like forage grasses.
- *Th. int*. individuals generally had lower specific leaf area (SLA) and specific root length (SRL) values compared to forage grasses, and higher root diameter (RD) values compared to forage and grain crops (p-value < 0.001).
- *Th. int*. accessions had intermediate levels of silicon (Si) between cereals and forage grasses.

→ Influence the dynamics of carbon storage in soil, soil exploration, and the mycorrhizal symbiosis (Massey, Hartley, 2006; Bergmann et al., 2020; Kim et al., 2022).
Th. int. accessions appear to express a trait syndrome identified in the literature about plants adapted to stressful conditions (Laughlin, 2023). This behavior may help in harsh conditions but can be detrimental to productivity, resource use efficiency in peak season, and to fodder values for animal feed.

(Unpresented data)

- The accessions of *Th. int.* had lower seed mass than the other cereals (p-value < 0.001).
- *Th. int.* had a similar range of values of above ground biomass than crops.
- *Th. int.* presented a delayed phenology compared to cereals.

→ *Th. int.* grain production is still not comparable to other grain crops.
Th. int. is more exposed to summer drought due to its phenology.

Conclusion

- Compared to other specialized crops, Th. int. accessions were generalists. They did not exhibit trait values that were particularly conducive to quantitative or qualitative production, while exhibiting traits conducive to stress tolerance.
- The selection process is mainly aimed at higher grain production, but further studies will be needed to assess potential changes in other plant functions and expected services in field.
- Further studies are needed to assess the correspondence between plant-level studies and traits, and performance and traits at the field canopy level, in line with advances in breeding.
- The choice of species to be domesticated and the criteria for selection process should be done conjointly with farmers to meet their objectives while ensuring ecosystem services.

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