# Fractal lattice design for studying plant interactions in the field

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## Introduction

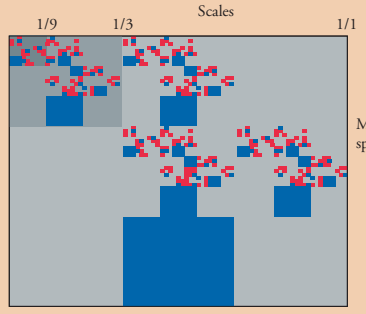
Inter-plant competition is an important mechanism influencing fecundity and community structure in both arable and natural ecosystems. Plant density is the most commonly used metric in competition studies. Recent research in plant competition has indicated the need to quantify the effects of spatial structure independent of plant density. A field experiment was designed to explore these effects. Three species were assessed in both block and interaction front configurations in an 8.1m square lattice: *Thlaspi arvense*, determinate annual; *Anchusa arvensis*, indeterminate annual; *Holcus lanatus*, perennial grass.

## Design

Pairs of species were arranged in a recursive fractal lattice which forced interactions between one species occupying a non-Euclidean interaction 'front' (red) and another species occupying blocks of different size (blue). Isolated plants, grown outside the plots, provided standards for zero-competition.

**Features of the design include**

- A well defined spatial structure from which neighbourhood factors can be calculated
- A range of edge features caused by blocks of different size, but with same internal density
- A near natural interaction front between pairs of species
- Over a 3-fold decrease in scale, density of the front species increased by 500%, that of the block species by 20%



Block structure (blue) embedded in fractal lattice (red)

## Neighbourhood space and competition

Increasing block size reduced plant biomass expressed as a fraction of isolated plant biomass, which was 20g for *Thlaspi arvense* and 320g for *Anchusa arvensis*.

| Block size | Thlaspi | Anchusa |
|---|---|---|
| 1 | **1** | **1** |
| 4 | **0.53** | **0.2** |
| 9 | **0.48** | **0.14** |
| 27 | **0.24** | **0.10** |
| 729 | **0.23** | **0.03** |

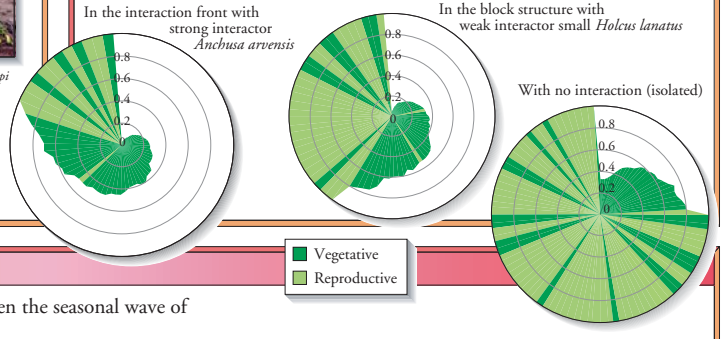

*Holcus/Thlaspi*


Sowing

## Spatial structure and plant development

Development of individuals was affected by position in the lattice well before canopy closure.

Figures show the circular rankings for *Thlaspi arvense* by number of leaf nodes at three levels of competition. The reproductive state is indicated.




## Conclusions

The experiment provided quantitative insight of the complex interactions between the seasonal wave of development in a population and the effective space that individuals occupied.

**Initial findings include**

- *Mean* biomass and fecundity at different scales were a linear function of mean neighbourhood space.
- Individuals reacted to spatial position before gross competition for resource occurred.
- Between-plant variation was cosiderably greater in the region of the interaction front that in the large block structures.
- *Individual* biomass and fecundity ranged very widely in response to temporal-spatial interactions.

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