

Judgement Post-Stratification for Covariate Adjustment in Pairwise Comparisons in Block Designs



Sam Rogers¹, Omer Ozturk², Olena Kravchuk¹

¹The University of Adelaide, Adelaide, South Australia, Australia

²Ohio State University, Columbus, Ohio, United States

Judgement Covariates

Judgement covariates rank expected responses independently of treatments.

- Moisture or elevation gradients allow simple within-block rankings.
- Baseline measures give reliable pre-treatment ranking information.
- Frost, heat or lodging events guide within-block rankings.
- Weed, insect or disease pressure supports practical plot ordering.
- Spray sequence or timing creates partial treatment ordering.

contrast	Least Square					JPS, K=L=4				
	estimate	SE	df	lower.CL	upper.CL	estimate	SE	df	lower.CL	upper.CL
Car - Chl	13.700	2.613	15	5.211	22.189	13.700	2.410	18.155	6.049	21.351
Car - Con1	11.275	2.613	15	2.786	19.764	10.321	2.410	18.155	2.670	17.971
Car - Con2	7.500	2.613	15	-0.989	15.989	7.633	2.410	18.155	-0.017	15.284
Car - Cym	-1.000	2.613	15	-9.489	7.489	-1.050	2.410	18.155	-8.701	6.601
Car - See	22.437	2.613	15	13.949	30.926	20.967	2.410	18.155	13.316	28.617
Chl - Con1	-2.425	2.613	15	-10.914	6.064	-2.475	2.410	18.155	-10.126	5.176
Chl - Con2	-6.200	2.613	15	-14.689	2.289	-6.550	2.410	18.155	-14.201	1.101
Chl - Cym	-14.700	2.613	15	-23.189	-6.211	-13.900	2.410	18.155	-21.551	-6.249
Chl - See	8.737	2.613	15	0.249	17.226	9.746	2.410	18.155	2.095	17.396
Con1 - Con2	-3.775	2.613	15	-12.264	4.714	-3.406	2.410	18.155	-11.057	4.244
Con1 - Cym	-12.275	2.613	15	-20.764	-3.786	-11.865	2.410	18.155	-19.515	-4.214
Con1 - See	11.162	2.613	15	2.674	19.651	11.162	2.410	18.155	3.512	18.813
Con2 - Cym	-8.500	2.613	15	-16.989	-0.011	-8.471	2.410	18.155	-16.121	-0.820
Con2 - See	14.938	2.613	15	6.449	23.426	14.881	2.410	18.155	7.231	22.532
Cym - See	23.438	2.613	15	14.949	31.926	22.073	2.410	18.155	14.422	29.724

Figure 2: Final yield pairwise comparisons.

JACboostR package

R package for judgement-adjusted contrasts

- Start: judgement covariates available, or ranking applied directly to residuals.
- CRD structure present → apply JACs for CRD analysis.
- Block design present with judgement covariates available.
- Single replication ($n_t = 1$) → rank within blocks only.
- Multiple replications ($n_t > 1$) → are blocks random effects?
- Random blocks → use block × treatment and within-block rankings.
- Fixed blocks → use within-block rankings.
- End: output parallel to Fisher's and Tukey's multiple comparisons.

Rank order in design

Judgement covariates create Latin-square-like structure orthogonal to blocks.

- Ranking plots forms additional strata within every block.
- Treatment allocation balances ranks, improving efficiency of contrasts.
- Environmental covariates define meaningful within-block rank groups.
- Order restriction preserves treatment randomisation.
- Outperforms Latin squares even when covariates are weak.

Spring oats example 1935

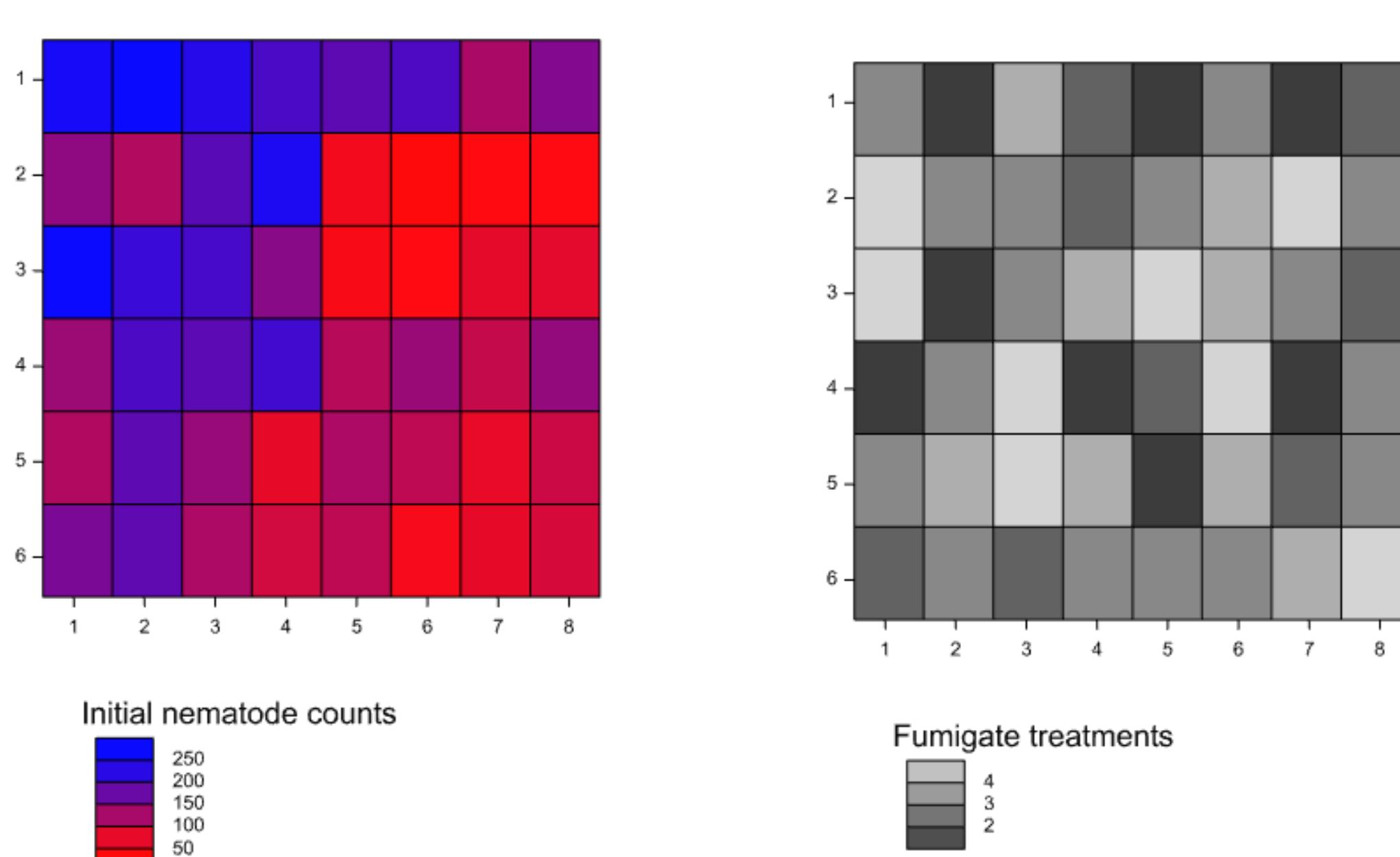


Figure 1: Baseline covariate (left) and Fumigants allocation (right)

Post-experiment adjustment

Judgement covariates rank plots, reducing variation within and between blocks.

- Rank each treatment pair within blocks for unbiased contrasts.
- Estimator remains valid regardless of covariate distributional properties.
- Block jackknife and bootstrap capture contrast variance accurately.
- Judgement-adjusted contrasts never lose efficiency versus least squares.
- Applicable for $n_t = 1$ and $n_t > 1$ block structures.

Future work

- Extend judgement-based ranking to multivariate or combined covariates
- Develop exact inference for JPS estimators
- Refine jackknife–bootstrap variance methods
- Incorporate replicated or partially replicated treatment structures into the general framework

Selected References

- [1] Ozturk, O., Jarrett, R., & Kravchuk, O. (2024). Order Restricted Randomized Block Designs. *JABES*.
 - [2] Ozturk, O., & Kravchuk, O. (2025). Post-Stratified Inference for Pairwise Treatment Comparisons in Randomized Block Designs. *JABES*.
 - [3] Ozturk, O., & Kravchuk, O. (202X). Mixed-Model Inference for Pairwise Treatment Contrasts with Judgement Covariates in Randomized Block Designs. Submitted to *Biometrical Journal*.
 - [4] Rothamsted Experimental Station. (1936). Other Experiments at Rothamsted: Report for 1935. Harpenden, UK: 1
- Australian Grains Research and Development Corporation's support through the Analytics for Australian Grains Research (AAGI) is acknowledged.

