

Colloquium PLP6921

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Office hours: Tuesdays 3.00 – 4.00 pm

Outline of the course

- Focus **Methods Selection and Critique**: experimental design and statistical analysis
- Secondary focus **Oral Presentations, but without Powerpoint**
- Themes:
 - Planning of experiments: exercise in Network Planning
 - Experimental design: examples of designs and data collection
 - Data analysis: overview of different types of data and the appropriate analyses
 - Analyze and critique papers with respect to design and analysis
 - Discuss papers with similar experiments as students will carry out
- Activities:
 - Read and present papers describing methods, papers with a faulty or correct design or statistical analysis
 - Two students (selected by lottery) will give their interpretations of the paper in 5-10 minutes.
 - We will critique faulty designs or analyses and discuss alternatives
- Grading:
 - Oral presentations (50% grades by students, 50% grade by teacher)
 - Active participation in discussions (grade by teacher)
 - Final grade: (oral pres. + partic.)/2.

Minimal requirements for analyses

- Some statistical analysis (also for molecular papers)
- Choose proper analysis for continuous versus categorical data
 - Continuous versus discrete functions
- Assumptions of ANOVA:
 - Treatment effects are additive
 - Errors are normally distributed
 - Errors are independent (randomization of units over treatments)
 - Variances are equal
- Don't use multiple comparisons if:
 - Factorial designs
 - Quantitative levels of one variable
- Describe the experimental design, including true reps and pseudoreps, and statistical analysis in the Methods section
- Report the results of the analysis in the Results section (not just the main effects and p-value, but also interaction effects, normality of residuals, etc)
- Don't use too many, insignificant digits (example: 5 ft = 1.524 meters)

Examples of faulty analyses

Table 3. Comparison of greenhouse disease indices from spring and fall soil sampling

Company A (1980)		Company A (1981)		Company B (1981)		Company C (1981)	
Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
64.9	62.7	54.9	57.4	54.9	60.0	70.6	62.7
64.2	54.3	54.3	55.6	53.7	63.4	66.4	62.0
60.0	60.0	48.4	58.7	53.7	62.7	63.4	62.7
43.9	62.0	44.4	62.0	52.5	65.6	62.7	80.0
53.1	65.6	41.0	58.1	51.4	60.0	62.7	56.8
50.2	53.7	40.4	62.0	51.4	55.6	59.3	62.7
46.7	53.7	35.1	30.0	48.4	56.8	59.3	50.8
43.9	62.0	30.7	51.4	38.6	60.0	58.1	43.3
30.0	62.7	27.3	56.2	34.4	58.7	51.4	62.0
27.3	51.4			42.3	60.7	49.0	54.9
Coef. corr. 0.61*		Coef. corr. 0.31		Coef. corr. 0.71*		Coef. corr. 0.39	

*Significant at $P = 0.01$.

$$\text{Disease index} = \left\{ \frac{\left(\begin{array}{c} \text{Disease} \\ \text{class} \end{array} \times \begin{array}{c} \text{Number of plants} \\ \text{in that class} \end{array} \right)}{\text{Total number of plants} \times 4} \right\} \times 100$$

Examples of faulty analyses

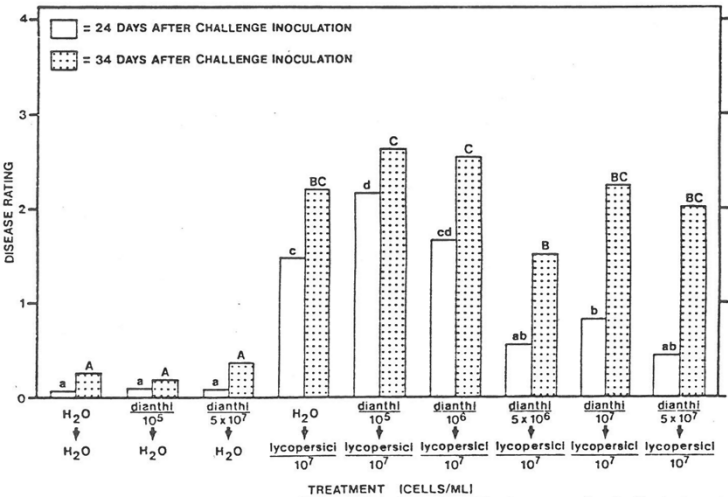


Fig. 1. Effect of pretreatment of tomato seedlings with water (H₂O) or with bud-cell suspensions of *Fusarium oxysporum* f. sp. *dianthi* on development of wilt induced by a subsequent challenge inoculation with water or with a bud-cell suspension of *F. oxysporum* f. sp. *lycopersici* race 1. Population density is given below each formula specialis. Challenge inoculation was 2 days after pretreatment. Bars represent mean disease rating (scale of 0-4) of 10 plants per treatment; 0 = no wilt symptoms, 4 = all leaves dead. Letters that are common over the same type of bar (solid or stippled) are not significantly different, *P* = 0.05.

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Examples of faulty analyses

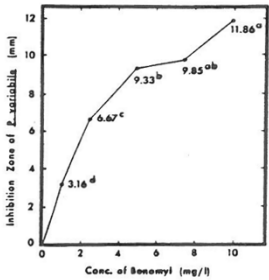


Fig. 2. Inhibition of *Penicillium variabile* (Poland Strain no. 2) by benomyl at 1, 2.5, 5, 7.5, and 10 mg/L. Values not followed by the same letter are significantly different at *P* = 0.05, according to Duncan's multiple range test.

Table 5. Apple scab, cedar-apple rust, and powdery mildew on four apple cultivars after fungicide applications at ultra-low-volume rates

Disease	Treatment ¹	Percent infection ²			
		Jonathan	McIntosh	Golden Delicious	Delicious
Apple scab	1	0.4 b ³	12.9 b	6.2 b	14.3 b
	2	0.0 b	8.1 b	3.8 b	9.3 b
	3	0.6 b	16.3 b	4.5 b	17.6 b
	4	1.5 a	69.4 a	66.0 a	34.2 a
Cedar-apple rust	1	14.3 b	0.0 a	8.1 a	0.0 a
	2	6.1 c	0.0 a	4.7 b	0.0 a
	3	10.0 bc	0.0 a	3.5 b	0.0 a
	4	20.0 a	0.0 a	9.1 a	0.0 a
Powdery mildew	1	3.4 c	1.3 c	1.4 c	2.0 b
	2	10.4 b	4.7 b	5.9 b	2.3 a
	3	7.7 bc	3.0 bc	2.4 c	0.5 b
	4	18.3 a	16.3 a	13.8 a	0.2 b

¹Data are the mean number of foliar infections per 100 leaves per replicate, three replicates per treatment.

²Treatments are formulations in Table 1.

³Within each cultivar and disease, means followed by the same letter are not significantly different at *P* = 0.05, according to Duncan's multiple range test.

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Examples of faulty analyses

Table 1. Population responses under greenhouse conditions of perennial ryegrass cultivars and selections to *Puccinia coronata*

Cultivar or selection	No. of tests ^a	Percent of plants in each class ^b										Rust rating ^c	Standard deviation ^d
		0	1	2	3	4	5	6	7	8	9		
Elka	6	99	1	0	0	0	0	0	0	0	0	0.0 a	0.0
H969	6	89	7	0	1	0	2	0	0	1	0	0.2 ab	0.9
Ruanui 909	3	70	25	5	0	0	0	0	0	0	0	0.3 abc	0.5
R-39 A	3	78	11	2	7	0	0	2	0	0	0	0.5 abc	1.0
Loretta	6	78	12	2	3	1	5	0	0	0	0	0.5 abc	1.1
U-103 ^e	3	77	7	7	5	2	2	0	0	0	0	0.6 abcd	0.9
Eliot	3	44	38	15	3	0	0	0	0	0	0	0.8 abcde	0.7
Donata	6	50	24	12	3	5	4	2	1	0	0	1.1 abcde	1.5
Prelude	3	54	15	13	6	2	6	2	2	0	0	1.3 abcde	1.6
Sprinter	6	51	24	6	4	7	4	1	3	0	0	1.3 abcdef	1.0
Cropper	6	50	18	6	12	4	5	6	0	0	0	1.4 abcdefg	1.6
Talbot	6	51	18	7	8	2	6	7	1	0	0	1.5 abcdefg	1.7
Premier	6	49	24	2	4	4	7	5	3	2	0	1.5 abcdefg	2.1
FRR-1	3	56	8	6	6	9	6	6	2	0	0	1.6 abcdefg	2.1
Fiesta	6	49	15	12	5	2	7	3	4	2	0	1.7 abcdefg	1.8
Delray	3	48	9	13	9	4	6	11	0	0	0	1.8 abcdefgh	2.1
R-35	6	46	15	3	13	4	6	9	3	1	0	2.0 bcdefgh	2.0
Capper	6	34	24	13	6	5	6	4	7	1	0	2.0 bcdefgh	1.7
Pennant	6	35	17	12	9	6	10	9	2	0	0	2.1 bcdefgh	2.0
Palmer	3	44	17	2	2	13	7	11	2	2	0	2.1 bcdefgh	2.5
Pelo	6	31	18	13	9	10	13	1	4	1	0	2.2 cdefgh	1.7
Goalie	3	27	26	7	7	9	11	7	4	2	0	2.4 defghi	2.3
Frances	6	23	24	14	10	6	11	4	8	0	0	2.4 defghij	1.9
Birdie	6	35	14	5	7	8	14	12	5	0	0	2.5 defghij	2.5
Dasher	6	31	20	5	7	7	6	15	7	2	0	2.5 efghij	2.4
S-321	6	13	15	22	13	16	13	7	1	0	0	2.7 fghijk	1.5
Grandstand	6	35	10	4	9	7	19	9	6	1	0	2.8 ghijk	2.2
Linn	6	17	20	12	10	7	20	9	5	0	0	2.9 ghijk	1.9
Acclaim	6	25	16	6	5	12	11	13	10	3	0	3.1 hijkl	2.5
Blazer	6	19	9	3	17	12	16	17	5	1	0	3.3 hijklm	2.2
Belle	6	18	10	5	13	16	20	7	11	1	0	3.4 hijklmn	2.2
Score	6	22	14	8	1	9	14	16	15	2	0	3.5 hijklmno	1.6
Pronto	3	19	8	4	15	13	13	12	15	2	0	3.6 hijklmno	2.4
Ranger	6	14	9	4	12	16	22	21	2	1	0	3.7 iklmno	2.0
Rex	6	16	7	8	9	15	18	15	12	1	0	3.8 iklmno	1.2

FRR-1	3	56	8	6	6	9	6	6	2	0	0	1.6 abcdefg	2.1
Fiesta	6	49	15	12	5	2	7	3	4	2	0	1.7 abcdefg	1.8
Delray	3	48	9	13	9	4	6	11	0	0	0	1.8 abcdefgh	2.1
R-35	6	46	15	3	13	4	6	9	3	1	0	2.0 bcdefgh	2.0
Capper	6	34	24	13	6	5	6	4	7	1	0	2.0 bcdefgh	1.7
Pennant	6	35	17	12	9	6	10	9	2	0	0	2.1 bcdefgh	2.0
Palmer	3	44	17	2	2	13	7	11	2	2	0	2.1 bcdefgh	2.5
Pelo	6	31	18	13	9	10	13	1	4	1	0	2.2 cdefgh	1.7
Goalie	3	27	26	7	7	9	11	7	4	2	0	2.4 defghi	2.3
Frances	6	23	24	14	10	6	11	4	8	0	0	2.4 defghij	1.9
Birdie	6	35	14	5	7	8	14	12	5	0	0	2.5 defghij	2.5
Dasher	6	31	20	5	7	7	6	15	7	2	0	2.5 efghij	2.4
S-321	6	13	15	22	13	16	13	7	1	0	0	2.7 fghijk	1.5
Grandstand	6	35	10	4	9	7	19	9	6	1	0	2.8 ghijk	2.2
Linn	6	17	20	12	10	7	20	9	5	0	0	2.9 ghijk	1.9
Acclaim	6	25	16	6	5	12	11	13	10	3	0	3.1 hijkl	2.2
Blazer	6	19	9	3	17	12	16	17	5	1	0	3.3 hijklm	2.2
Belle	6	18	10	5	13	16	20	7	11	1	0	3.4 hijklmn	2.2
Score	6	22	14	8	1	9	14	16	15	2	0	3.5 hijklmno	1.6
Pronto	3	19	8	4	15	13	13	12	15	2	0	3.6 hijklmno	2.4
Ranger	6	14	9	4	12	16	22	21	2	1	0	3.7 iklmno	2.0
Rex	6	16	7	8	9	15	18	15	12	1	0	3.8 iklmno	1.2
NK 100	6	11	12	10	6	16	14	18	10	3	0	3.9 iklmno	2.0
Enspora	6	13	6	5	11	21	16	16	8	3	1	4.0 jklmnop	1.8
Pennine	6	16	8	8	8	4	13	20	18	5	0	4.1 klmnop	2.2
Citation	6	13	14	6	5	10	11	19	13	7	2	4.2 klmnop	2.4
Barry	6	3	4	13	13	16	17	16	12	5	2	4.5 klmnopq	1.4
Yorctown II	6	1	3	4	13	23	30	22	4	1	0	4.5 klmnopq	1.2
Diplomat	3	0	0	0	25	27	23	17	8	0	0	4.6 klmnopqr	1.3
Regal	6	4	3	13	14	11	13	22	16	4	1	4.7 lmnopqr	1.8
Lp 20	3	6	2	4	2	21	23	29	8	5	0	4.8 lmnopqrs	1.8
Clipper	3	10	4	0	6	7	25	33	8	4	2	4.8 lmnopqrs	2.2
Belatrix	3	0	2	6	4	35	15	13	19	6	0	5.0 mnpqrs	1.0
Arno	6	2	3	11	8	4	21	28	17	6	0	5.1 mnpqrs	1.5
Caravelle	6	2	1	2	7	15	27	33	12	2	0	5.1 mnpqrs	1.3
Derby	6	2	1	2	13	13	24	22	16	6	1	5.2 nopqrs	1.3
Eton	3	2	2	2	10	8	21	30	19	6	0	5.3 nopqrs	1.6
Yorctown	3	0	2	0	6	17	21	35	19	0	0	5.4 opqrs	1.1
Omega	6	2	1	0	10	11	20	26	23	8	0	5.5 pqrs	1.6
Exponent	6	2	3	2	4	10	17	29	22	10	1	5.6 pqrs	1.2
Barclay	3	0	0	0	6	10	30	13	33	9	0	5.8 pqrs	1.3
NK-200	6	1	1	2	2	2	18	37	25	7	4	6.0 qrs	0.9
Manhattan	6	1	1	1	4	3	16	33	29	13	0	6.1 rs	1.1
Barcelona	3	0	0	0	2	0	13	42	23	17	4	6.5 s	0.8

^aSixteen plants were used in each test.

^bScale based on visual estimates approximating area of foliage rusted: 0 = no rust, 1 = trace, 3 = 10%, 5 = 30%, 7 = 50%, 9 = ≥70%.

^cMeans followed by the same letter are not significantly different from each other (Duncan's multiple range test, $P = 0.05$).

^dStandard deviation represents pooled variances from all tests.

^eU-103 is a selection of annual ryegrass, *Lolium multiflorum*.

Examples of faulty analyses

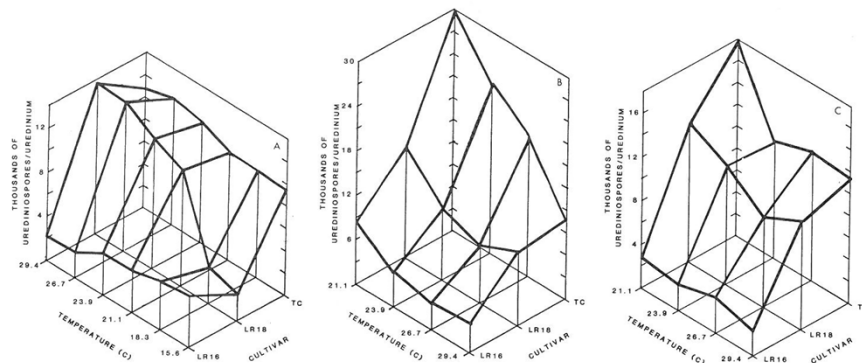


Fig. 4. Total urediniospore production during the entire infectious period by *Puccinia recondita* at several combinations of temperature and host cultivar inoculated at the A, seedling; B, heading; and C, anthesis growth stages. Seedling data are from seedling-only experiments.

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Examples of faulty analyses

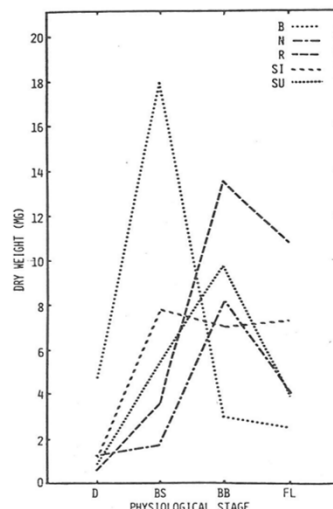


Fig. 1. Dry weight of *Fusicoccum* on sap from boxelder (B), Norway (N), red (R), silver (SI), and sugar (SU) maples. Sap was extracted from the trees at the dormant (D), bud-swell (BS), bud-break (BB), and full-leaf (FL) physiological stages. According to the H.S.D. multiple comparison test, $P = 0.05 = 6.3$.

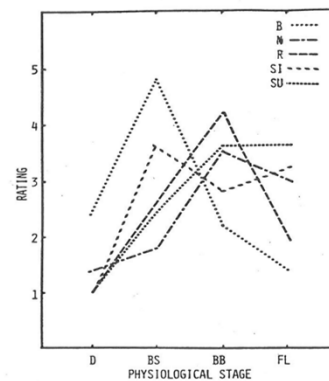


Fig. 2. Conidial production of *Fusicoccum* on sap from boxelder (B), Norway (N), red (R), silver (SI), and sugar (SU) maples. Sap was extracted from the trees at the dormant (D), bud-swell (BS), bud-break (BB), and full-leaf (FL) physiological stages. Conidial ratings in spores per milliliter: 1 = 0-150, 2 = 11,500, 3 = 26,000, 4 = 52,000, and 5 = 110,000. According to the H.S.D. multiple comparison test, $P = 0.05 = 1.34$.

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Examples of faulty analyses

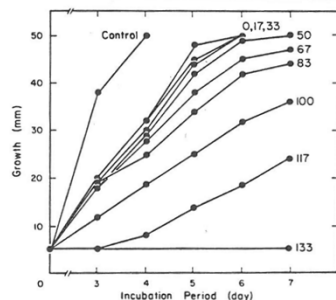


Fig. 3. Radial growth of *Physophthora megasperma* f. sp. *medicaginis* in the presence of various concentrations of medicarpin. Controls did not contain medicarpin or ethanol. Values included the 5 mm diameter of the inoculum disks.

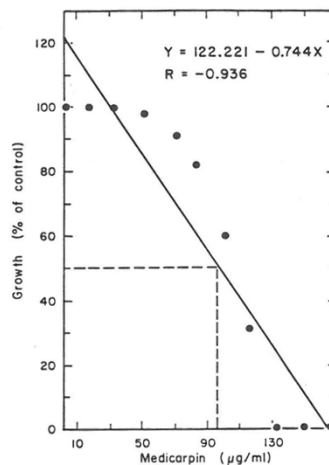


Fig. 4. Relation between amount of medicarpin in the medium and mycelial growth of *Physophthora megasperma* f. sp. *medicaginis*. All values calculated relative to fungus growth in medium supplied 42 µl ml⁻¹ ethanol but no medicarpin and the length of the growth period was 6 days. ED₅₀ = 97 µg ml⁻¹.

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Examples of faulty analyses

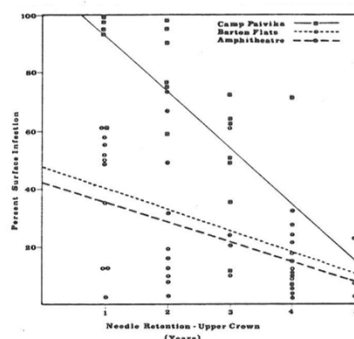


Fig. 1. Relationships between upper crown needle retention and percent surface infection of inoculated pine stumps by *Fomes annosus*. Data are for ponderosa pine at Camp Paivika and Barton Flats and Jeffrey pine at Amphitheatre in the San Bernardino Mountains of California. Stumps at Amphitheatre and Barton Flats were inoculated with isolate SV, and stumps at Camp Paivika were inoculated with isolate JL.

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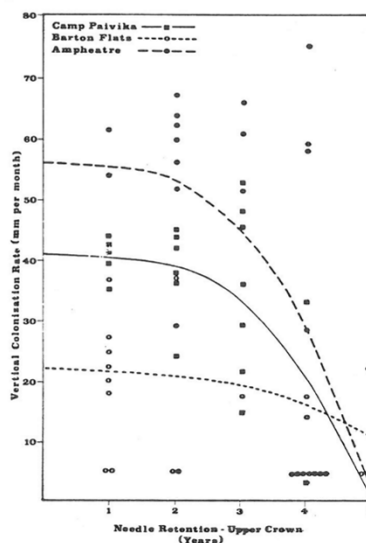


Fig. 2. Relationships between upper crown needle retention and vertical colonization rate of *Fomes annosus* in inoculated pine stumps. Data are for ponderosa pine at Camp Paivika and Barton Flats and Jeffrey pine at Amphitheatre in the San Bernardino Mountains of California. Stumps at Amphitheatre and Barton Flats were inoculated with isolate SV and stumps at Camp Paivika were inoculated with isolate JL.

Examples of faulty analyses

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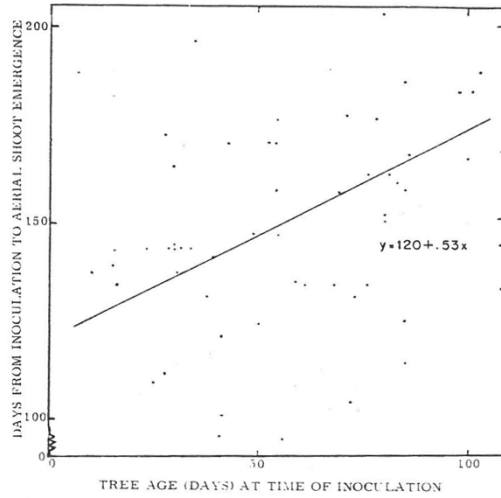


FIGURE 2. Relationship between tree age at time of inoculation of pine seedling with *Arceuthobium* and time for aerial shoot emergence. Significant at the 95% level.

Examples of faulty analyses

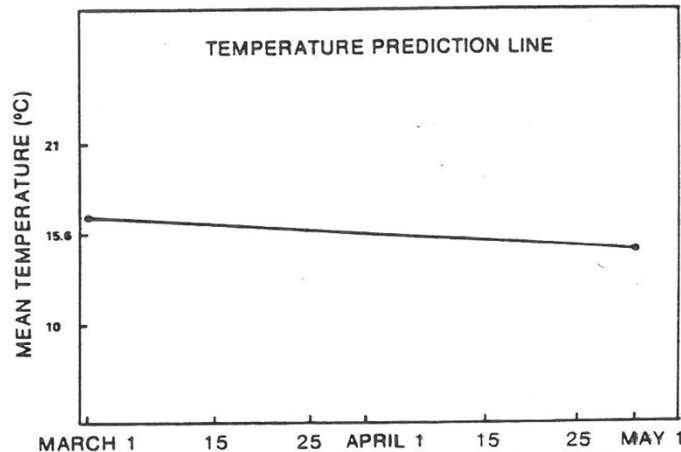


Fig. 1. Populations of *Erwinia amylovora* during bloom are usually detected in flower samples taken shortly after the mean temperature exceeds the prediction line.

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THE END

- Let's have fun!
- Next week: planning of experiments