Experiment Design Using ARM Software



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Plan Experiments to Have:

- A reasonable chance of distinguishing anticipated treatment differences
- The optimum number of replicates required to meet objectives
- An efficient experimental design and randomization for desired precision
- Cost-effective utilization of the available experimental area

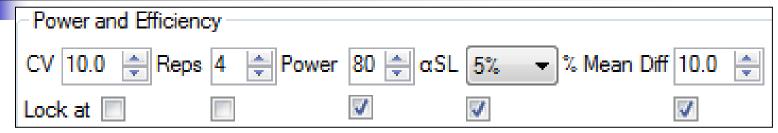
Why is Planning Critical?

- Can reduce costs by selecting optimum number of replicates and samples
- Expected treatment differences are typically < 10%, and frequently < 5%, so small precision gains can help to:
 - Distinguish an actual treatment difference (reject null hypothesis H₀)
 - Strengthen evidence of no treatment diff.)
 (do not reject null hypothesis H₀)

ARM 2015 Power and Efficiency Planner

Protocol Settings								
General Design Treatment Application Layout								
Randomized Complete Block (RCB)	•	Power a	nd Efficiency					
Factors: 1 🖨 Treatments	Merge Factor	CV 10.0	🗧 Reps 4	🔷 Power 80 🚖	αSL <mark>5% ▼</mark>	% Mean Diff 10.0	* *	
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			11				40	55
		1	0 17				64	85
		1	2 24				92	120
		1	4 32				124	160

Power and Efficiency Planner



- "Lock at" to keep 3-4 columns constant
- Calculates table of possible values for "unlocked" columns (e.g. Rep or CV)
- Values entered by protocol writer are carried into trials created from protocol, conveying protocol expectations to trialist

Power and Efficiency Planner

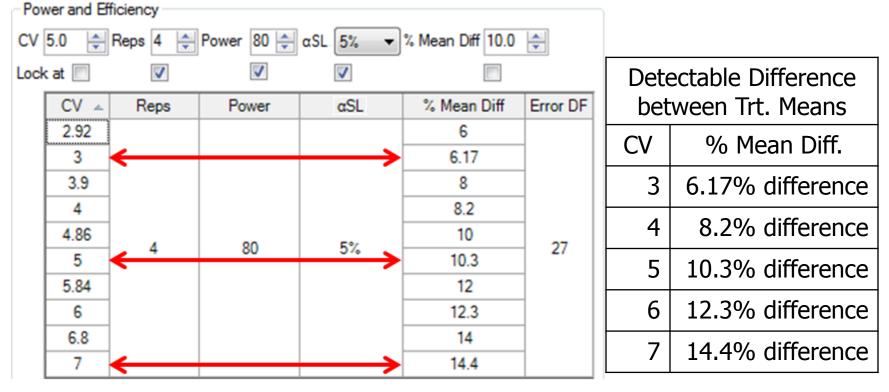
Plan replicates to achieve required precision 5 treatments with CV=5, 10% mean diff.

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		2		50%		-	Z	TU-3070	0.4-0.3
									_

January 2015

Power and Efficiency Planner

CV effect on minimum detectable % mean difference at 5% aSL for 10 treatments, 4 reps



7

Randomization Quality Review

Goal is to improve experiment precision:

- 1. Arrange replicates as squares, not strips
- 2. Equalize treatment distribution
 - a. Balance average distance from all other treatments
 - **b.** Balance "Edge effect" across treatments
- 3. Randomize all replicates

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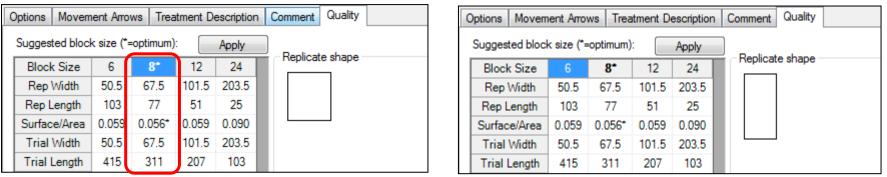
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Arrange Replicates as Squares not Strips

"Optimum" is smallest surface-to-area ratio

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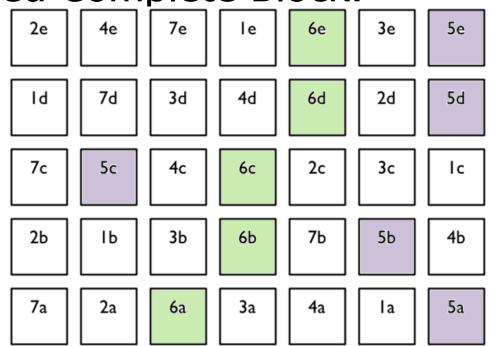


Substantially reduces avg. dist. between trt.

Equalize Treatment Distribution

"Undesirable" layout of 7 treatments and 5 replicates in Randomized Complete Block:

- Trt. 6 in middle 3 columns of all reps
- Trt. 5 in right 2 cols for all but one plot



January 2015 Example from Federer, "Experimental Design" 1955 11

Uses "Average Distance of Treatment" Comparison (ADTC)

- van Es and van Es, "Spatial Nature of Randomization and Its Effect on the Outcome of Field Experiments", Agron J, 85:420-428 (1993).
- Goal is to create spatially-balanced designs.
- Comparison between treatments 1 and 2 is taken from 5 plots for each treatment.
- Measure the plot-to-plot distance for each plot containing treatment 1 to the paired plot within replicate containing treatment 2, for a total of 5 distances.
- ADTC for treatment pair 1-2 is average of the 5 distances.
- Repeat this comparison for all treatment pairs.

Unequal Treatment Distribution

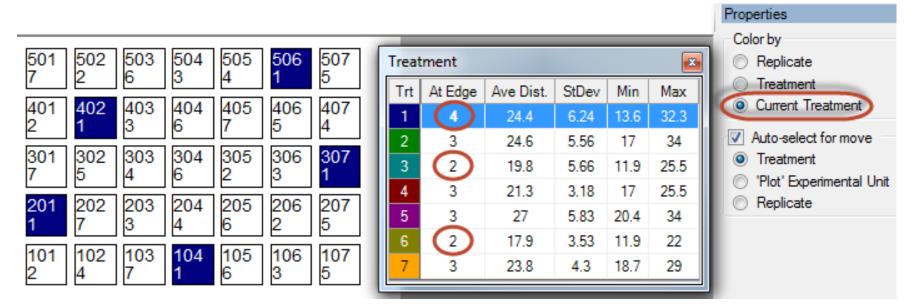
- Average distance from 17.9 to 24.6
- Ranges from 11.9(T3,T6) to 34(T2,T5)
 Error variances for treatments may not be homogeneous

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	-						Trt	At Edge	Ave Dist.	StDev	Min	Max
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2	4	'		0	0	5						

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Unbalanced "Edge effect"

Treatment 1 occurs at edge 4 times, T2 and T3 at edge only 2 times



Balanced Treatment Distribution and Edge Effect

Average distance from 21.3 to 24.4
Distances range from 18.7 to 27.2
"Edge effect" is balanced



Post-hoc Power Analysis

- In example, LSD can distinguish 25% mean difference (largest existing difference is 18%)
- Current AOV Trt P(F) is 0.2979, so use 0.30+ significance level to separate treatment means
- Need 8+ replicates to reject null hypothesis at 0.05 significance January 2015

Crop Variety	CEZANNE
Trt	
No.	24
2	85.33 a
3	81.67 a
4	98.00 a
5	95.33 a
LSD P=.05 (% mean diff)	21.808 (25%)
Standard Deviation	10.915
CV	12.12
Grand Mean	90.083
Minimum Replicates (power = 80)	8
Largest Mean Difference (% mean diff)	16.333 (18%)
Treatment F	1.541
Treatment Prob(F)	0.2979

Summary

Software tools can help improve trial quality and efficiency:

- Plan appropriate number of replicates
- Improve quality of randomizations
- Analyze results to improve planning of follow-up experiments