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Relative Efficiency of Neighbouring Techniques Over Block Design for Field Experiments with Wheat on Sodic Soils

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Summary

An attempt has been made to study the relative efficiency of Papadakis's [8] method of analysis and Wilkinson nearest neighbour technique over block designs in a uniformity trial conducted with wheat on sodic soils at CSSRI, Karnal.

Key words : Papadakis's Method, Wilkinson Nearest Neighbour Technique, Block Designs, Uniformity Trial, Sodic Soil , ρ_1', ρ_2'

Introduction

Bartlett [1] has considered theoretical aspects of Papadakis's [8] method of analysis and suggested iteration using treatment estimates from the previous iteration to redefine the nearest neighbour covariate for the current plot. He has indicated that the technique may be efficient for controlling error in field experiments on patchy soils, Pearce and Moore [10] Pearce [11] and others have provided evidence of the method in reducing error. In particular, Kempton & Howes [6] estimated that Papadakis's analysis increased the precision of varietal differences in 118 breeders' trial of wheat by 8.7% relative to incomplete block analysis. However, Wilkinson et al [12] concluded that Papadakis's method is biased and very inefficient in the presence of substantial fertility trends. They have suggested another neighbouring technique which is a continuous form of local detrending in contrast to the stepwise (fixed) block detrending of classical method of analysis. It provides perhaps the resolution of long standing dispute between Gosset [4] and Fisher regarding the relative efficiency of systematic versus random arrangements. An attempt has been made to study the relative efficiency of these neighbouring techniques over block designs in a uniformity trial conducted with wheat on sodic soil at CSSRI, Karnal.

2. *Material and Methods*

Papadakis non-iterated and Wilkinson nearest neighbour techniques where applied over uniformity trial data on the grain yield of wheat conducted at CSSRI, Karnal and their relative efficiencies over block designs for different

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plot sizes which were formed by combining basic units. The field was harvested in 400 basic units. Each basic unit was 1.15 m^2. The dimension of the field was 20 m along E-W by 23 m along S-N. Rows were termed along E-W while columns were termed along S-N. Thus there were 20 rows and 20 columns. The technique of Papadakis was employed as suggested by Pearce & Moore [10] and Pearce [11]. This technique adjusts values by covariance on neighbouring plots.

For the application of Wilkinson technique, its justification was sought by obtaining serial correlations of different orders within each column and averaged over 20 columns. As the trend was non-stationery and autoregessive process of second order, Wilkinson et at [12] technique was applied. The following derivation was made and utilized in estimating error.

$$\hat{\sigma}_w^2 = \frac{2}{3} \times \frac{\Sigma y_i''^2}{\{n - r(1 + 2\alpha_1 \rho_i' + 2\alpha_2 \rho_2')\}}$$

where n = total no. of observations

$\alpha_1 = \frac{\alpha - 1}{\alpha}$, d is the no. of observations in each col.

$\alpha_2 = \frac{\alpha - 2}{\alpha}$,

$\rho_1' = -2/3$ serial correlation of order 1 of deternded data in the population

$\rho_2' = 1/6$ serial correlation of order 2 of detrended data in the population

r = no. of cols.

$y_i' = y_i - (y_{i-1} + y_{i+1})/2$

where i runs from 2 to $(\alpha - 1)$ the observation in each col. $y_i'' = y_i' - \bar{y}_i'$ where y_i'' is the deviation of y_i' from its respective column mean. $\Sigma\ y_i''^2$ is the sum of square of deviations. C.V(%) for different plot sizes have been computed under different experimental designs and neighbouring techniques.

3. *Results and Discussion*

It is observed from Table 1 that for plot size 1 × 2, C.V(%) for 20 plot block by using randomized complete block design is 50.4 whereas for the same plot size C.V(%) in incomplete blocks of 10-plots, 5-plots and 2-plots are 39.9, 30.6 and 21.5 respectively. However, Papadakis method of analysis (non-iterated) gave 16.8% C.V for the same plot size and C.V(%) was 12.3 by employing Wilkinson technique.

Table 1. C.V. (%) for different experimental designs and neighbouring techniques on the grain yield of wheat of uniformity trial at CSSRI, Karnal

	C.V.(%)			
Plot size & shape in basic units	Randomised complete block design	Incomplete block design	papadakis's method	Wilkinson technique
4 × 1*	39.7 (20 plot block)	27.2 (10 plot block) 22.2 (5 plot block) 13.9 (2 plot block)	22.8	11.6
1 × 2	50.4 (20 plot block)	39.9 (10 plot block) 30.6 (5 plot block) 21.5 (2 plot block)	16.8	12.3
4 × 2	39.4 (10 plot block)	26.7 (5 plot block)	22.6	17.5
1 × 4	47.6 (20 plot block)	42.1 (5 plot block) 28.1 (2 plot block)	22.0	8.1
1 × 10	45.5 (20 plot block)	23.2 (5 plot block) 17.2 (2 plot block)	26.0	8.8

Note : 4 × 1* means 4m along E-W by 1-15 m along S-N

Similarly for plot size 1 × 4, for 20-plot block in randomised complete block design, C.V(%) was 47.6. It was reduced to 42.1 and 28.1 in 5-plot block and 2-plot block of incomplete block designs respectively and C.V(%) were 22.0 and 8.1 by Papadakis's method of analysis and Wilkinson technique.

For plot size 4 × 1, in 20-plot block of randomised complete block design C.V(%) was 39.7. However, C.V(%) were 27.2, 22.2 and 13.9 in 10-plots, 5-plots and 2-plots block sizes of incomplete block designs. By employing Papadakis's method of analysis C.V(%) was 22.8 while it was 11.6 by using Wilkinson technique.

Further, for plot size 4 × 2 in randomised complete block design of 10-plot block, C.V(%) was 39.4. It was reduced to 26.7 in 5-plot block of incomplete block design. By applying Papadakis method of analysis, C.V(%) was 22.6. However, it was 17.5 in Wilkinson technique.

In randomised complete block designs of 20 plot block, C.V(%) was 45.5 for 1 × 10 plot size. It was reduced to 23.2 in 5 plot-block and 17.2 in 2-plot block of incomplete block designs. Papadakis's method of analysis yields 26% C.V. and Wilkinson technique yields 8.8% C.V. (Table 1).

For confirmation of Wilkinson technique, serial correlation of different orders within each column have been calculated for the uniformity trial data of wheat and the average values of these (over 20 columns) have been given. It is observed that there is a smooth trend in serial correlation declining from + ve to 0, 0 to -ve and then increasing form 0 to + ve, which is indicative of autoregessive process of second order, Further, serial correlations of orders 1 and 2 are highly significant (Table 2).

Table 2. Serial correlations of different orders within each column (average over 20 columns)

Order	Serial Correlation
1	0.732**
2	0.522**
3	0.337
4	0.129
5	0.049
6	–0.020
7	–0.146
8	–0.102
9	–0.001
10	0.099

Wilkinson technique is a logical extension of the Rothamsted 'fixed-block' technology to 'moving-blocks' and is one of the several spatial analysis. The other papers using a variety of estimation techniques such as Patterson & Hunter [9], Green et al [5], Williams [4], Besag and Kempton [2] and Gleeson & Cullis [3]. These neighbour analysis differ in the assumptions about trend, and their methods of estimation. Martin and Eccleston [7] have shown that non-binary designs can be more efficient for some dependence structures.

Therefore, incomplete block designs are recommended for field experimentation with wheat crop when it is possible to reduce C.V less than 15%. Where incomplete block designs are not possible or when there is a trend in the block, Papadakis's neighbouring technique may be employed for field experimentation in randomised block design when the no. of treatments happen to be large as suggested by Bartlett [1] and Pearce and Moore [10]

Wilkinson et al [12] have stated that iterated Papadakis method of analysis yields biased estimates of treatment contrasts and is inefficient in the presence of soil fertility trend in the block. Analysis of the uniformity trial data of wheat at CSSRI, Karnal confirms its superiority over papadakis's method. This technique is to be applied for field experimentation in randomised complete block designs such that any two treatments occurs as neighbours at most once and no treatment occurs more than once in a block. Use of NN-balanced designs Wilkinson and Mayo [13] is called for the application of this technique.

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REFERENCES

[1] Bartlett, M.S., 1978. Nearest neighbour models in the analysis of field experiments (with Discussion), *J.R. Statist.Soc B* **40**, 147–74.

[2] Besag, J. and Kempton, R., 1986. Statistical analysis of field experiments using neighbouring plots. *Biometrics* **42**, 231–51.

[3] Gleeson, A.C. & Cullis, B.R., 1987. Residual maximum likelihood (REML) estimation of a neighbour model for field experiments. *Biometrics* **43**, 277–88.

[4] Gosset, W.S, 1936. Co-operation in large-scale experiments (with discussion). *J.R. Statist. Soc. Suppl.* **3**, 115–36

[5] Green, P.J., Jemmison, C. & Seheult, A.H., 1985. Analysis of field experiments by least squares smoothing. *J. Roy. Statist. soc. Ser B* **47**, 299–315.

[6] Kempton, R.A. and Howes, C.W., 1981. The use of neighbouring plot values in the analysis of variety trials. *J.R. Statist. Soc. Appl. Statist.* **30**, 59–70.

[7] Martin and Eccleston, 1991. Efficient block designs for correlated observations. *Austral J. Statist.*, **33** (3), 299–311

[8] Papadakis, J.S., 1937. Method statistque peur des experiences sur champ. Bull. inst. Amel. Plantes, *Thessalonike* **23.**

[9] Patterson, H.D. & Hunter, E.A., 1983. The efficiency of incomplete block designs in National List and Recommended List cereal variety trial. *J. Agri. Sci., Cambridge* **101**, 427–33

[10] Pearce, S.C. and Moore, C.S., 1976. Reduction of experimental error in perennial crops using adjustment by neighbouring plots. *Expt. Agric* **12**, 267–72.

[11] Pearce, S.C., 1980. Randomised blocks and some alternatives; a study in topical conditions. *Trop. Agric.* **57**, 1–10.

[12] Wilkinson, G.A., Eckert, S.R., Hancock, T.W., & Mayo, 0, 1983. Nearest-neighbour (NN) analysis of field experiments (with discussion). *J. Roy. Statist. Soc. Ser B* **45**, 151–211.

[13] Wilkinson, G.N. and Mayo, 0, 1982. Control of variability in field trials : An essay on the controversy between "student" and Fisher, and resolution of it. *Utilitas Mathematica* **21**, B, 169–88.

[14] Williams, E.R., 1986. A neighbour model for field experiments. *Biometrika* **73**, 279–87.