A NOTE ON QUALITATIVE-CUM-QUANTITATIVE DESIGNS

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Summary

The work regarding the designs suitable for different situations for qualitative-*cum*-quantitative experiments was done in the past by Fisher (1935), Yates (1937) and Kempthorne (1951). They, however, concentrated on the development of suitable designs when one of the factors was of qualitative nature, while others were of quantitative type. But these designs were cumbersome both in method of construction and analysis. In the present paper a method for the construction of qualitative-*cum*-quantitative asymmetrical factorial designs for the situation when two qualitative factors are associated with one quantitative factor along with other quantitative factors. The method is illustrated by constructing a suitable design for $2 \times 4 \times 3 \times 2$. The method of analysis for the design is also discussed.

1. Introduction

The pioneer work for the development of qualitative-*cum*-quantitative designs was initiated by Fisher (1935) and subsequently contributions were made by Yates (1937), Kempthorne (1951), Sardana (1961) and Sardana & Narayan (1967). In these designs, the required number of experimental units were large and their method of construction was cumbersome. The method of analysis was also not straight-forward. Further, these designs had limited applications, because the type and number of qualitative factors associated with their quantitative factors were one in each case. Basant Lal and Das (1973) and Basant Lal & Bhargava (1977) suggested a simple method of construction and analysis for such designs. In the present paper, the method presented by Basant Lal and Bhargava (1977) for the construction and the analysis for such designs are extended for the situations where two qualitative characters are associated with one quantitative factor tried with another quantitative factor.

The situation would however be explained through an example; let there be two qualities (q_0, q_1) of nitrogen, namely, Urea and

Ammonium Sulphate each at three levels n_0, n_1 and n_2. Further, these qualities are applied through four methods, namely, m_0, m_1, m_2 m_3. Another quantitative factor included in the experiment is phosphate having two levels p_0 and p_1. Thus, qualitative-*cum*-quantitative factorial is of the type 2×3×4×2.

2. Method of Construction and Analysis

The method of construction consists of as a first step to supress the lowest level of the quantitative factor having its quality or qualities and thereafter the reduced design is linked to some symmetrical factorial design of the type S^n and the design is constructed in block of size S^k. To the resultant design some dummy treatment combinations are augmented to each block. The method of construction is, however, illustrated through an example for the design of the type 2×3×4×2. The design will be constructed in a single replication with 10 plot blocks.

The zero level of N is supressed and the resultant factorial scheme becomes of the type 2×2×4×2. Now, this design is linked to 2^5 having 8 plots/block. Therefore, in one replication, there are four blocks, The design with five factors each at two levels in four blocks is obtained, after confounding QNM and NMP, is given below:

Q	N	X_1	X_2	P	Q	N	X_1	X_2	P	Q	N	X_1	X_2	P	Q	N	X_1	X_2	P
1	0	0	1	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	1
0	1	0	1	1	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0
0	0	1	0	1	0	0	1	0	0	0	0	1	1	1	0	0	1	1	0
1	1	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	1	0
1	0	1	1	1	1	0	1	1	0	1	0	1	0	1	1	0	1	0	0
0	1	1	1	0	0	1	1	1	1	0	1	1	0	0	0	1	1	0	1
1	1	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1

The treatment combinations corresponding to the pseudo factors (X_1, X_2) are linked to the four levels for the method of application as below: 00=0, 01=1, 10=2 and 11=3. The levels of nitrogen (N) are changed, from zero to one and 1 to 2 *i.e.* zero level is coded as one and level 1 as 2 in the above design. The last step consists of augmenting some dummies which in the present case consists of addition of two dummy treatments in each block namely, 0000 and 0001. The resultant design is as follows :

Q	N	M	P	Q	N	M	P	Q	N	M	P	Q	N	M	P
1	1	1	0	1	1	1	1	1	1	0	0	1	1	0	1
0	2	1	1	0	2	1	0	0	2	0	1	0	2	0	0
0	1	2	1	0	1	2	0	0	1	3	1	0	1	3	0
1	2	0	1	1	2	0	0	1	2	1	1	1	2	1	0
1	1	3	1	1	1	3	0	1	1	2	1	1	1	2	0
0	2	3	0	0	2	3	1	0	2	2	0	0	2	2	1
1	2	2	0	1	2	2	1	1	2	3	0	1	2	3	1
0	1	0	0	0	1	0	1	0	1	1	0	0	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1

However, it can be seen that apart from the effects chosen for the system of confounding, some other effects are also affected. This can be seen by the method given by Das & Giri (1979) that these affected effects can be estimated independently of the effects chosen for confounding.

As pointed out in the proceeding paragraphs that in the suggested designs the additional affected effects are independently estimable of the effects taken for the system of confounding, this property makes the method of analysis simple and also similar to the one adopted for quantitative designs.

In the present case the main effect for sources of Nitrogen (Q) and method (M) of application of nitrogen (which are related to the application of nitrogen only) can, however, be obtained by considering only those sets of treatment combinations which involve non-zero level of nitrogen. As for example, for three sources of nitrogen the algebraic expression for the contrast is as follows :

$$t_i = q_i(n_1+n_2)(p_0+p_1)\sum m_j \qquad i=0,1 \text{ and } j=0,1,2,3$$

The interaction (QN) between the qualities of nitrogen and its different levels is also obtained by considering the treatment combinations having non-zero level of nitrogen. The algebraic expression for this is as follows :

$$t_j = q_i(n_1-n_2)(p_0+p_1)\sum m_j \qquad j=0,1,2,3 \quad i=0,1$$

The similar expression can, however, be obtained for the interaction (MN) between method of application of nitrogen and its level. However, for two factors interaction between Q or M with P the algebraic expression given above is modified accordingly.

In case of three factors interaction like QNP, the treatment combinations considered also belong to non-zero level of nitrogen. The algebraic expression for QNP is however given below :

$$QNP=(q_0-q_1)(n_1-n_2)(p_0-p_1)\sum m_j \qquad j=0,1,2,3$$

This can however be modified accordingly for other three factors interaction under consideration.

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