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By Stanford L. Arner

PROFILE

**A computer program for displaying
the geometric relationships of the
responses in a factorial design**

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ABSTRACT

One procedure in analyzing the responses to factors in an experiment is to construct profiles of the means. Profiles are plots of the sample means of each level of one factor at each level of one or more of the other factors in the experiment. The construction of these profiles and tests of hypotheses about the mean responses is called profile analysis. This paper discusses profile analysis and presents a computer program which produces profiles of the experimental means.

ONE OBJECTIVE of designed experiments is to find the relationship of the response to various factors in the experiment. Profile analysis is a technique for studying the geometric relationships among the expected responses in a multifactor experiment. Profiles are line segments connecting the means for the levels of one factor (A) at each level of a second factor (B). If there is a third factor (C), there are three possible simple profiles: the AB profiles at each level of C; the AC profiles at each level of B; and the BC profiles at each level of A. Also, there are the two factor profiles combined over all levels of the third factor, and the one factor profiles combined over all levels of the other two factors.

To introduce profile analysis, an example of a three-way factorial experiment is presented. In this hypothetical experiment the height growth of two species of trees fertilized with two levels of nitrogen and three levels of phosphorus is measured. Let Y_{ijkm} be the height growth on the m^{th} tree of the i^{th} species (factor A), fertilized with the j^{th} level of nitrogen (factor B) and the k^{th} level of phosphorus

(factor C). The mean height growth of the M_{ijk} trees in the ijk^{th} factor combination is

$$\bar{Y}_{ijk} = \sum_{m=1}^{M_{ijk}} Y_{ijkm} / M_{ijk}.$$

Experimental values for the $\bar{Y}_{ijk}$ are presented in table 1. For demonstration purposes

Table 1.—Means for simple profiles

	A ₁			A ₂		
	C ₁	C ₂	C ₃	C ₁	C ₂	C ₃
B ₁	40	30	60	20	10	40
B ₂	60	50	20	40	30	0

we assume that these are population values. With real data the values obtained would be sample means rather than population means. The expected value of the sample means would be the population means; that is,

$$E(\bar{Y}_{ijk}) = \mu_{ijk}.$$

The simple profiles of interest might be the nitrogen by phosphorus profiles for each species. One of the nutrient factors (say phosphorus) is chosen for the horizontal axis, the

other (nitrogen) is chosen for the vertical axis. The 3 levels of phosphorus are then the points along the horizontal axis at which the mean responses $\bar{Y}_{ijk}$ are plotted for each level of nitrogen. Using the values in table 1, $\bar{Y}_{111}$ would be positioned at a height of 40 on the vertical axis directly above the first index point of the horizontal axis; $\bar{Y}_{121}$ would be directly above the first point at 60 on the vertical axis. The simple profiles for species 1 are the first set of profiles in figure 1, while those for species 2 are the second set.

The means for the two-way profiles combined over the third factor are:

$$\bar{Y}_{.jk} = \sum_{i=1}^2 \bar{Y}_{ijk} / 2$$

$$\bar{Y}_{i.k} = \sum_{j=1}^2 \bar{Y}_{ijk} / 2$$

$$\bar{Y}_{ij.} = \sum_{k=1}^3 \bar{Y}_{ijk} / 3$$

For example:

$$\bar{Y}_{.11} = (\bar{Y}_{111} + \bar{Y}_{211}) / 2 = (40 + 20) / 2 = 30$$

Figure 1.—Simple BC profiles for each level of factor A.

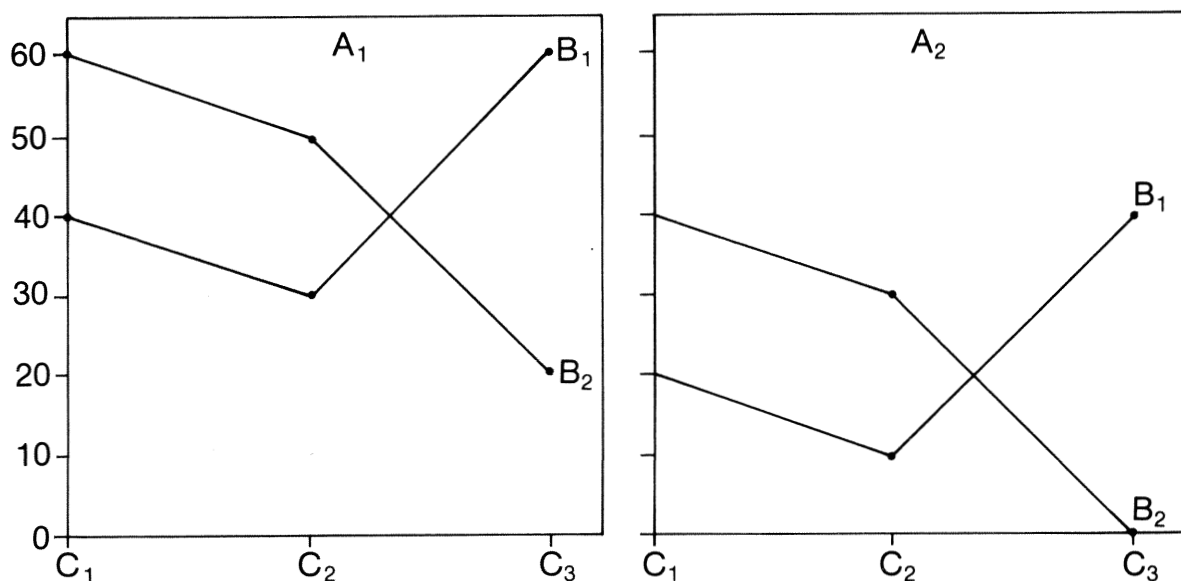
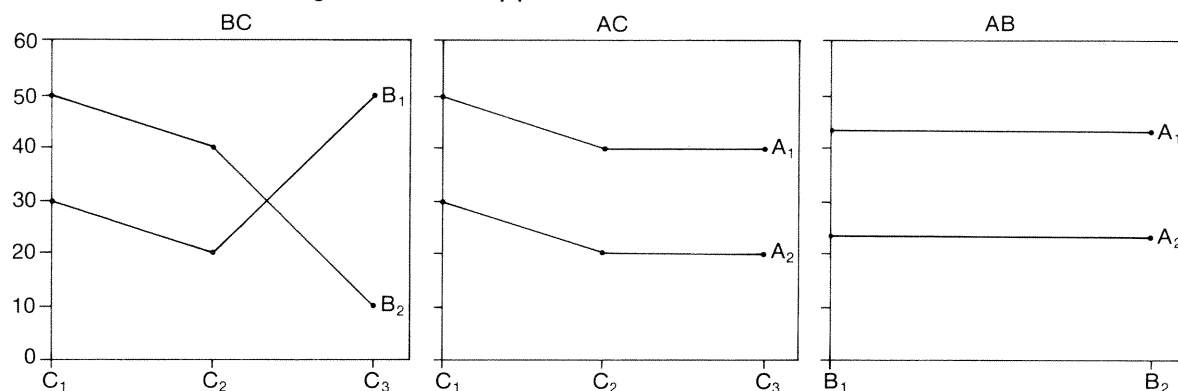


Table 2.—Means for two-way profiles combined over third factor

	A ₁ + A ₂				B ₁ + B ₂				C ₁ + C ₂ + C ₃	
	C ₁	C ₂	C ₃		C ₁	C ₂	C ₃		A ₁	A ₂
B ₁	30	20	50	A ₁	50	40	40	B ₁	43.33	23.33
B ₂	50	40	10	A ₂	30	20	20	B ₂	43.33	23.33

Figure 2.—Two-way profiles combined over third factor.



The values of the means combined over the third factor are given in table 2, and the combined profiles are given in figure 2.

The last sets of profiles are based on the means combined over two factors. These are:

$$\bar{Y}_{..k} = \sum_{j=1}^2 \bar{Y}_{.jk}/2 = \sum_{i=1}^2 \bar{Y}_{i.k}/2$$

$$\bar{Y}_{.j.} = \sum_{i=1}^2 \bar{Y}_{ij.}/2 = \sum_{k=1}^3 \bar{Y}_{.jk}/3$$

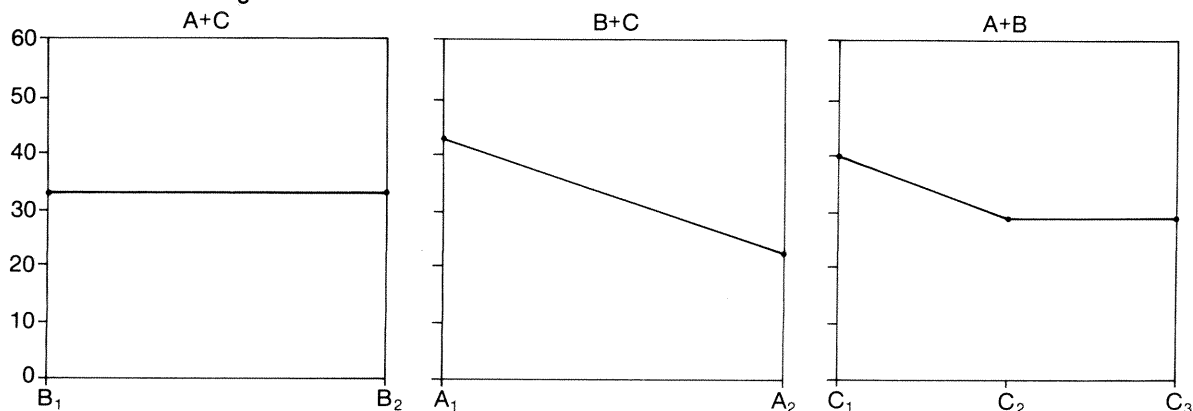
$$\bar{Y}_{i..} = \sum_{j=1}^2 \bar{Y}_{ij.}/2 = \sum_{k=1}^3 \bar{Y}_{i.k}/3$$

The values of the means combined over two factors are given in table 3 and the combined profiles are shown in figure 3.

Table 3.—Means for single factors combined over other two factors

B ₁	33.33	A ₁	43.33	C ₁	40
B ₂	33.33	A ₂	23.33	C ₂	30
				C ₃	30

Figure 3.—Profiles on one factor combined over other two factors.



Profile Analysis And The Factorial Model

The statistical model for a three way factorial design can be written

$$\mu_{ijk} = \mu + A_i + B_j + C_k + AB_{ij} + AC_{ik} + BC_{jk} + ABC_{ijk};$$

further

$$\sum_i A_i = \sum_j B_j = \sum_k C_k = 0$$

$$\begin{aligned} \sum_i AB_{ij} &= \sum_j AB_{ij} = \sum_i AC_{ik} = \sum_k AC_{ik} = \sum_j BC_{jk} \\ &= \sum_k BC_{jk} = 0 \end{aligned}$$

$$\sum_i ABC_{ijk} = \sum_j ABC_{ijk} = \sum_k ABC_{ijk} = 0;$$

The parameters are the main effects A, B, C; the two-way interactions AB, AC, BC; and the three-way interaction ABC.

For interpretation of the two-way interactions we look at the two-way profiles combined over the levels of the third factor. For example, the means combined over factor A are

$$\begin{aligned} \mu_{.jk} &= \sum_{i=1}^I \mu_{ijk} / I \\ &= (I\mu + \sum A_i + I B_j + I C_k + \sum AB_{ij} + \sum AC_{ik} + I BC_{jk} + \sum ABC_{ijk}) / I \\ &= \mu + B_j + C_k + BC_{jk}, \end{aligned}$$

since the restrictions imposed on the parameters result in all terms involving A summing to zero.

The $\mu_{.jk}$'s are the means plotted on the combined BC profiles which are used to determine if there is a BC interaction. The interaction is the degree to which the profiles are not parallel. If the profiles are parallel there is no interaction.

The BC interaction can be expressed in terms of $\mu_{.jk}$. If there is no BC interaction the distance between profiles is the same at each point along the horizontal axis. Therefore $\mu_{.1k} - \mu_{.2k}$ is constant for all k. For this example the hypothesis of no BC interaction is:

$$(\mu_{.11} - \mu_{.21}) - (\mu_{.12} - \mu_{.22}) = 0$$

$$(\mu_{.12} - \mu_{.22}) - (\mu_{.13} - \mu_{.23}) = 0$$

These linear combinations of means are functions of the BC interactions only since

$$\begin{aligned} \mu_{.11} - \mu_{.21} - \mu_{.12} + \mu_{.22} \\ &= (\mu + B_1 + C_1 + BC_{11}) - (\mu + B_2 + C_1 + BC_{21}) \\ &\quad - (\mu + B_1 + C_2 + BC_{12}) + (\mu + B_2 + C_2 + BC_{22}) \\ &= BC_{11} - BC_{21} - BC_{12} + BC_{22}. \end{aligned}$$

Likewise,

$$\begin{aligned} \mu_{.12} - \mu_{.22} - \mu_{.13} + \mu_{.23} &= \\ BC_{12} - BC_{22} - BC_{13} + BC_{23}. \end{aligned}$$

For this example (table 2),

$$\begin{aligned} (\mu_{.11} - \mu_{.21}) - (\mu_{.12} - \mu_{.22}) &= \\ (30-50) - (20-40) &= 0 \end{aligned}$$

$$\begin{aligned} (\mu_{.12} - \mu_{.22}) - (\mu_{.13} - \mu_{.23}) &= \\ (20-40) - (50-10) &= -60 \end{aligned}$$

implying that the BC interaction is not zero. The BC profiles (fig. 2), show that the profile segments between C_1 and C_2 are parallel and the segments C_2 and C_3 are not parallel.

The combined AB and AC profiles provide similar information about the AB and AC interactions. In the example, both the AB and AC profiles are parallel. Therefore there is no AB or AC interaction. The interactions associated with the combined profiles are called the overall interaction effects.

Now consider the simple BC profiles for one level of A, (fig. 1). The profiles are not parallel; that is, the BC interaction at a_1 and a_2 is not zero. These interactions are called simple interaction effects (denoted BC for a_1).

When each cell of the experiment has the same number of observations, the variation in the simple interactions is related to the variation in the overall interactions as follows:

$$SS_{BC \text{ at } a_1} + SS_{BC \text{ at } a_2} = SS_{BC} + SS_{ABC}.$$

In the example the variations due to the simple BC interactions are both positive, therefore one or both of SS_{BC} and SS_{ABC} are positive. We have seen that SS_{BC} is not zero. But what is the value of SS_{ABC} ?

For information about the variation due to the overall ABC interactions, we compare the

simple BC profiles. The three-way interaction is zero when the BC interactions for each level of A are similar. This could occur either when the simple profiles are parallel to each other or when both simple interactions are zero. For our data, the individual simple profiles are not parallel, but the sets are parallel to each other. Therefore the ABC interaction is zero.

In terms of means, the hypothesis of no three-way interaction is,

$$\left[\begin{array}{l} (\mu_{111} - \mu_{121}) - (\mu_{112} - \mu_{122}) = \\ (\mu_{211} - \mu_{221}) - (\mu_{212} - \mu_{222}) \\ (\mu_{112} - \mu_{122}) - (\mu_{113} - \mu_{123}) = \\ (\mu_{212} - \mu_{222}) - (\mu_{213} - \mu_{223}) \end{array} \right]$$

or,

$$\left[\begin{array}{l} ((\mu_{111} - \mu_{121}) - (\mu_{112} - \mu_{122})) - \\ ((\mu_{211} - \mu_{221}) - (\mu_{212} - \mu_{222})) = 0 \\ ((\mu_{112} - \mu_{122}) - (\mu_{113} - \mu_{123})) - \\ ((\mu_{212} - \mu_{222}) - (\mu_{213} - \mu_{223})) = 0. \end{array} \right]$$

For our example the values for the hypothesis are,

$$\left[\begin{array}{l} ((40 - 60) - (30 - 50)) - \\ ((20 - 40) - (10 - 30)) = 0 \\ ((30 - 50) - (60 - 20)) - \\ ((10 - 30) - (40 - 0)) = 0 \end{array} \right]$$

The hypothesis of no three-way interaction is a function of the ABC interaction only and can be expressed in these terms by substituting ABC_{ijk} for μ_{ijk} .

The interpretation of mean profiles can be extended to experiments with more than three factors. For instance, the four-way profiles could be created by plotting the two factor profiles at each combination of levels of the other two factors. Interpretation of parameters and tests of the statistical model for experiments involving more than three factors is difficult, however.

Table 4 summarizes the relationships that the sums of squares for the two-way and three-way interactions have with the form of the simple and combined two-way profiles. As an example, suppose the test results given

Table 4.—Relationship of simple and combined profiles to the variation due to two- and three-way interactions

Lines in combined profile	Lines in all other simple profiles compared to lines in each simple profile	Lines in each simple profile	Value of	
			SS_{AB}	SS_{ABC}
NP	NP	NP	>0	>0
NP	P	NP	>0	0
P	NP	NP	0	>0
P	P	P	0	0
P	NP	P	0	0

NP = The profiles are not parallel.

P = The profiles are parallel.

in the last line of table 4 are encountered. If the lines of the AB profile combined over factor C are parallel and the lines in each simple AB profile are parallel, even though the simple profiles are not parallel to each other, both SS_{AB} and SS_{ABC} are zero.

For a more detailed discussion of profile analysis, see Winer 1962, pp. 162-184.

DESCRIPTION OF THE COMPUTER PROGRAM—PROFILE

Program *Profile* is designed to show the relationships between the response and various factors in the experiment.

Any pair of factors can be chosen for the vertical or the horizontal axis. Further, a third factor can be designated such that profiles will be created for each level of this third factor. Also, specific levels of any of the factors can be selected so that a set of profiles is plotted for the one level only. If there are multiple observations for each level of the factors—for example, measurements on a variable at different time periods—the response vector can be designed as a factor using the different observations as the levels.

The scale for the levels of the factor on the horizontal axis can have unequal distances between levels. If the time periods are 1, 2, and 4, for example, the distance between levels 2 and 3 is twice the distance between levels 1 and 2.

The responses can be transformed by in-

section of a user-written FORTRAN subroutine.

The program is designed to handle data from multiple factor experiments. If there is a subclass for which no record is observed, then that cell is considered missing from the design. A missing cell is ignored in the calculation of a combined mean. Therefore the profile of the combined means must be interpreted with caution.

There is an option that is useful when the response variables are counts. In this case the absence of records implies a zero count for that cell. The cell is not considered missing from the design, and is therefore included in the calculation of a combined mean. If the design is incomplete, the missing cells can be identified by the user.

The differences between the two methods can best be illustrated by the calculation of cell means. Suppose there are two factors, each with two levels. If there is at least one observation in each cell the means are calculated as follows:

Normal Procedure	Counts Option
------------------	---------------

$\bar{Z}_{ij} = Z_{ij}/n_{ij}$	$\bar{Z}_{ij} = Z_{ij}/1$
--------------------------------	---------------------------

$\bar{Z}_{i.} = (\bar{Z}_{i1} + \bar{Z}_{i2})/2$	$\bar{Z}_{i.} = (Z_{i1} + Z_{i2})/2$
--	--------------------------------------

If there is no record for Z_{i2} and Z_{i2} is not designed as missing for the counts option;

$\bar{Z}_{1.} = \bar{Z}_{11}/1$	$\bar{Z}_{1.} = (Z_{11} + 0)/2$
---------------------------------	---------------------------------

$\bar{Z}_{2.} = (\bar{Z}_{21} + \bar{Z}_{22})/2$	$Z_{2.} = (Z_{21} + Z_{22})/2$
--	--------------------------------

Program Control Cards

1. Data Set Control Card

Column

1, 2 NS = Number of factors in design.

3, 4 NYR = Number of responses per observation (length of response vector).

5, 6 NF = Number of format cards (≤ 3).

7, 8 NFL = Input file number (5 is default).

9, 10 PM If PM=0 print all cell means of complete design.

If PM=1, skip.

11, 12 NT If NT = 0 no data transformation.

If NT = 1 transform data with user-written subroutine.

13, 14 ICNT If ICNT = 0 responses are measurements on some continuous variable.

If ICNT = 1 responses are frequency counts.

15, 16 NDES = Number of cells not included in design. (If ICNT=1 and some of the factor combinations are not included in the design of the experiment NDES is the number of cards to be read containing the factor levels for which the observation count is set to zero.)

21-25 LEVELS (1) = Number of levels of response factor after transformation.

26-75 LEVELS (L) = Number of levels of factor L; (L = 1 to NS). These are consecutive fields of length 5.

2. Variable Format Cards

These begin with a left parenthesis in column 1 of the first card which is followed by NS I format designations and NYR F or E format designations. A right parenthesis should follow the last F or E format field.

3. Missing Cell Cards (Optional)

One card for each missing criterion and/or cell in the design. The first 2 digit code designates the element of the response vector and the remaining 2 digit codes represent the factor levels of the missing values; card format (11 I2). Missing cell cards are needed when ICNT = 1 and NDES $\neq$ 0.

4. Data Cards

The data card format must conform to the variable format specifications. There are NS integers indicating the levels of the factors, followed by the response vector of length NYR. The factor level codes must be consecutive in-

tegers beginning with 1. If the codes are not consecutive integers a user transformation subroutine (TRANS) can be written to put the codes in the proper form. The response vector can also be transformed by this subroutine. If the data is on cards and if N is the number of cards per observation, N blank cards must follow last data card.

5. *Axis Title Card*

Cols.

- 1-28 YAXIS—Title for profile lines.
- 29-56 XAXIS—Title for factor on horizontal axis.
- 57-80 REPEAT—Title for factor given control value 116 on card 7.

6. *General Title*

Cols.

- 1-79 Title—general title for profile
- 80 0 or blank = further plots involving present data follow
- 1 = last plot for this data set (needed only if further data sets follow).

7. *Factor Control Card*

On this card the user specifies the profiles he wants plotted by assigning plotting codes to the factors in the experiment. One of the codes that appear below must be assigned to the response and one to each factor to indicate how each is used for the profiles.

The plotting codes are

- I = Profiles for Ith level of factor (or response).
- 113 = Profiles combined over levels of factor (or response).
- 114 = This factor (or response) used for vertical axis.
- 115 = This factor (or response) used for horizontal axis.
- 116 = Separate profiles plotted for each level of this factor (or response).

Codes 114, 115, and 116 can appear only once for each set of profiles. The NS+1 codes must be punched on the card in the following format. The remaining fields must be blank.

Cols.

- 1-5 Plotting Code for response vector.
- 6-10 Plotting Code for factor 1.
- 11-15 Plotting Code for factor 2.
-
-
-
- 56-60 Plotting Code for factor 10.
- 80 NES — horizontal scale indicator
- NES = 0 horizontal scale equally spaced.
- = 1 horizontal scale unequally spaced; scale card follows:

8. *Horizontal Scale Card* (optional, needed only if column 80 of card 7 is 1)

Cols.

- 1-5 Scale position for level 1
- 6-10 Scale position for level 2
- as many fields of 5 as needed.
- Repeat cards 5, 6, 7, and 8 if needed for each additional set of profiles. Repeat cards 1 to 8 for each additional data set.

DATA TRANSFORMATION ROUTINE

The option for the user to transform the data with a FORTRAN subroutine is provided. The placement of the routine depends upon the system that is being used. The IBM 360 or 370 series requires that this routine immediately precede the object deck.

Suppose in the example the three levels of phosphorus (factor C) are coded 0, 2, and 5. These codes need to be changed to 1, 2, and 3 respectively. Suppose also that the user wants to examine the response on the square root scale. The transformation routine could be,

```
SUBROUTINE TRANS (Y, I, N, DS)
REAL Y(N)
INTEGER DS, I(11)
Y(2) = SQRT (Y(1))
IF (I(4)-2) 1, 2, 3
1 I(4) = 1
GO TO 4
2 I(4) = 2
GO TO 4
3 I(4) = 3
4 RETURN
END
```

All arguments of the subroutine are trans-

ferred from the calling routine and are not specified by the user. The arguments N and DS should be explained further. N is the length of the response vector, DS is the number of the data set that is being read. If a job contains more than one data set for which different transformations are required, an IF statement must be inserted directing program flow to the appropriate transformations for each data set.

Notice that although the levels of the third factor are being recoded, the subscript for I is 4. If the j^{th} factor is being recoded the subscript of I must be $j + 1$. This is necessary since the response is considered the first factor by the program.

PROGRAMMING CONSIDERATIONS

Definitions:

1. NS = Number of factors.
2. $\text{MAX}(j + 1)$ = Highest level of j^{th} factor.
 $\text{MAX}(1)$ = Length of response vector.

$$\text{MAX}(1) = \frac{\text{NS} + 1}{2}$$
3. $\text{MXSTR} = \prod_{j=1}^{\text{MAX}(j)}$
4. NF = Number of format cards.
5. JMAX = Difference between largest and smallest relative levels of horizontal axis factor.

Restrictions:

1. $\text{NS} \leq 10$
2. $\text{MAX}(j) \leq 99$ all factors not used on vertical axis.
 ≤ 12 any factors used on vertical axis.
3. $\text{NF} \leq 3$
4. $1 \leq \text{JMAX} \leq 110$
4. $\text{MXSTR} \leq 5000$

If a problem is encountered where $\text{MXSTR} > 5000$ the following changes should be made in the main program:

1. Set MSTR = MXSTR.
2. Change dimension of Y and IC to Y (MXSTR) and IC (MXSTR).

DESCRIPTION OF OUTPUT

Information from the first control card is printed on the first page of output. Following this is the variable format for this data set and a listing of the factor means.

For each job concerning this data set the actual profiles are preceded by a page containing means to be used on the profiles and the control values for each factor.

A profile for each level of the factor or response selected for the vertical axis is then plotted at each level of the horizontal axis. Numbers or letters are used as plotting characters to represent the levels of the vertical axis factor; levels 1 to 9 are represented by the integers 1 to 9, level 10 by 0, level 11 by A, and level 12 by B. A line segment consisting of the appropriate plotting character joins each point along the horizontal axis.

Overplots occur if the mean values of two or more profiles at any point on the horizontal axis are the same. These are listed on the page following the profiles in the form $Z(I, J) = M$, where I is the level of the vertical axis, J is the point on the horizontal axis, and M is the mean value.

SAMPLE PROBLEM

The sample problem involves the same factors as discussed. The response vector is seedling height growth measured 1, 2, 4, and 8 years after application of the fertilizer. The data cards have a 1 punched in the field for the first factor. This dummy factor is included in order that a profile for any one of the factors alone can be plotted.

The first set of profiles uses the dummy factor for the vertical axis and plots the profiles for phosphorus at time 1, summing over the other factors. The second set of profiles plots the means for the two levels of N ($1 = \text{N present}$, $2 = \text{N absent}$) for each level of phosphorus at time 1, while the third and fourth profiles represent the nitrogen by phosphorus profiles for each species.

Profile 1 shows that the mean height growth for the trees treated with the 3rd level of phosphorus is greater than the growth of the trees treated with levels 1 and 2. Profile 2 demonstrates the nitrogen by phosphorus in-

teraction. The mean height growth for phosphorus levels 2 and 3 is greater when nitrogen is present, while the mean growth for phosphorus level 1 is greater when nitrogen is absent.

Profiles 3 and 4 illustrate the lack of three-way interaction. The nitrogen by phosphorus profiles for each species are parallel to each other. Finally, profile 5 demonstrates the use of an additional control card to read relative values of the horizontal axis. The heights were measured at times 1, 2, 4, and 8. Therefore

the horizontal axis distance between measurements 2 and 3 is twice the distance between times 1 and 2. This set of profiles also shows the increase in mean height growth with time, and the fact that the species 2 means are greater than the means of species 1 for each time period. Also, the difference is of the same magnitude in each time period.

Literature Cited

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1962. STATISTICAL PRINCIPLES IN EXPERIMENTAL DESIGN. New York: McGraw Hill.

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CONTROL DECK FOR SAMPLE PROBLEM

4 4 1 5 0 0 0 0
(412,7X,4F5.0)

1 1 1 1	0	5	10	20
1 1 1 2	32	37	42	52
1 1 1 2	28	33	38	48
1 1 1 3	60	65	70	80
1 1 2 1	40	45	50	60
1 1 2 2	9	14	19	29
1 1 2 2	11	16	21	31
1 1 2 3	40	45	50	60
1 2 1 1	20	25	30	40
1 2 1 2	45	50	55	65
1 2 1 2	55	60	65	75
1 2 1 3	80	85	90	100
1 2 2 1	60	65	70	80
1 2 2 2	32	37	42	52
1 2 2 2	28	33	38	48
1 2 2 3	60	65	70	80

DUMMY PHOSPHORUS
PROFILE TEST DATA PHOSPHORUS MAIN EFFECT TIME 1

1 114 113 113 115

NITROGEN PHOSPHORUS
NITROGEN X PHOSPHORUS COMBINED SPECIES TIME 1

1 1 113 114 115

NITROGEN PHOSPHORUS
NITROGEN X PHOSPHORUS EACH SPECIES TIME 1

1 1 116 114 115

SPECIES TIME PERIOD
SPECIES X TIME LEVELS OF N AND P COMBINED

115 1 114 113 113

1 2 4 8

SPECIES

1

OUTPUT FOR SAMPLE PROBLEM

PROFILE ANALYSIS, CONTROL INFORMATION FOR THIS DATA SET

```

NO. SUBSCRIPTS(FACTORS) =      4
NO. Y'S READ IN =           4
NO. FORMAT CARDS =          1
PRINT MEANS =                0
DATA FILE NO. =              5
COUNT OPTION, ICNT =        0
  
```

NO. CELLS NOT INCLUDED IN DESIGN FOR COUNT OPTION, NDES= 0

MAXIMUM VALUE OF EACH SUBSCRIPT, FIRST SUBSCRIPT REFERS TO LENGTH OF Y VECTOR ON DATA CARD
 KK(L) = 4 1 2 2 3 1 1 1 1 1 1

FORMAT OF DATA
 (4I2,7X,4F5.0)

TOTAL NO. OF RECORDS ON DATA SET = 16

FACTOR SUBSCRIPTS, FIRST IS NO. OF LEVELS OF OBSERVATION VECTOR

4 1 1 1 1 1 1 1 1 1 1	Y1 -Y12	MEAN	0.0	5.00	10.00	20.00
		NOBS	1	1	1	1
4 1 2 1 1 1 1 1 1 1 1	Y1 -Y12	MEAN	20.00	25.00	30.00	40.00
		NOBS	1	1	1	1
4 1 1 2 1 1 1 1 1 1 1	Y1 -Y12	MEAN	40.00	45.00	50.00	60.00
		NOBS	1	1	1	1
4 1 2 2 1 1 1 1 1 1 1	Y1 -Y12	MEAN	60.00	65.00	70.00	80.00
		NOBS	1	1	1	1
4 1 1 1 2 1 1 1 1 1 1	Y1 -Y12	MEAN	30.00	35.00	40.00	50.00
		NOBS	2	2	2	2
4 1 2 1 2 1 1 1 1 1 1	Y1 -Y12	MEAN	50.00	55.00	60.00	70.00
		NOBS	2	2	2	2
4 1 1 2 2 1 1 1 1 1 1	Y1 -Y12	MEAN	10.00	15.00	20.00	30.00
		NOBS	2	2	2	2
4 1 2 2 2 1 1 1 1 1 1	Y1 -Y12	MEAN	30.00	35.00	40.00	50.00
		NOBS	2	2	2	2
4 1 1 1 3 1 1 1 1 1 1	Y1 -Y12	MEAN	60.00	65.00	70.00	80.00
		NOBS	1	1	1	1
4 1 2 1 3 1 1 1 1 1 1	Y1 -Y12	MEAN	80.00	85.00	90.00	100.00
		NOBS	1	1	1	1
4 1 1 2 3 1 1 1 1 1 1	Y1 -Y12	MEAN	40.00	45.00	50.00	60.00
		NOBS	1	1	1	1
4 1 2 2 3 1 1 1 1 1 1	Y1 -Y12	MEAN	60.00	65.00	70.00	80.00
		NOBS	1	1	1	1

PROFILE ANALYSIS, MEANS OF PROFILE CELL PLOTS FOR JOB 1

FACTOR LEVELS 0 INDICATES THE LEVELS OF THIS FACTOR ARE TO BE THE LEVELS OF THE X AXIS
 * INDICATES THE FACTOR FOR WHICH A SEPARATE PROFILE PLOT IS PRODUCED FOR EACH OF ITS LEVELS.
 X INDICATES FACTOR FOR HORIZONTAL AXIS.
 Y INDICATES FACTOR FOR VERTICAL AXIS

		LEVELS OF X AXIS				
		1	2	3		
Y	X					
1	1	1	0	1	1	1
		Y1	-Y12	MEAN	30.00	30.00
				N OBS	4	4
						60.00
						4

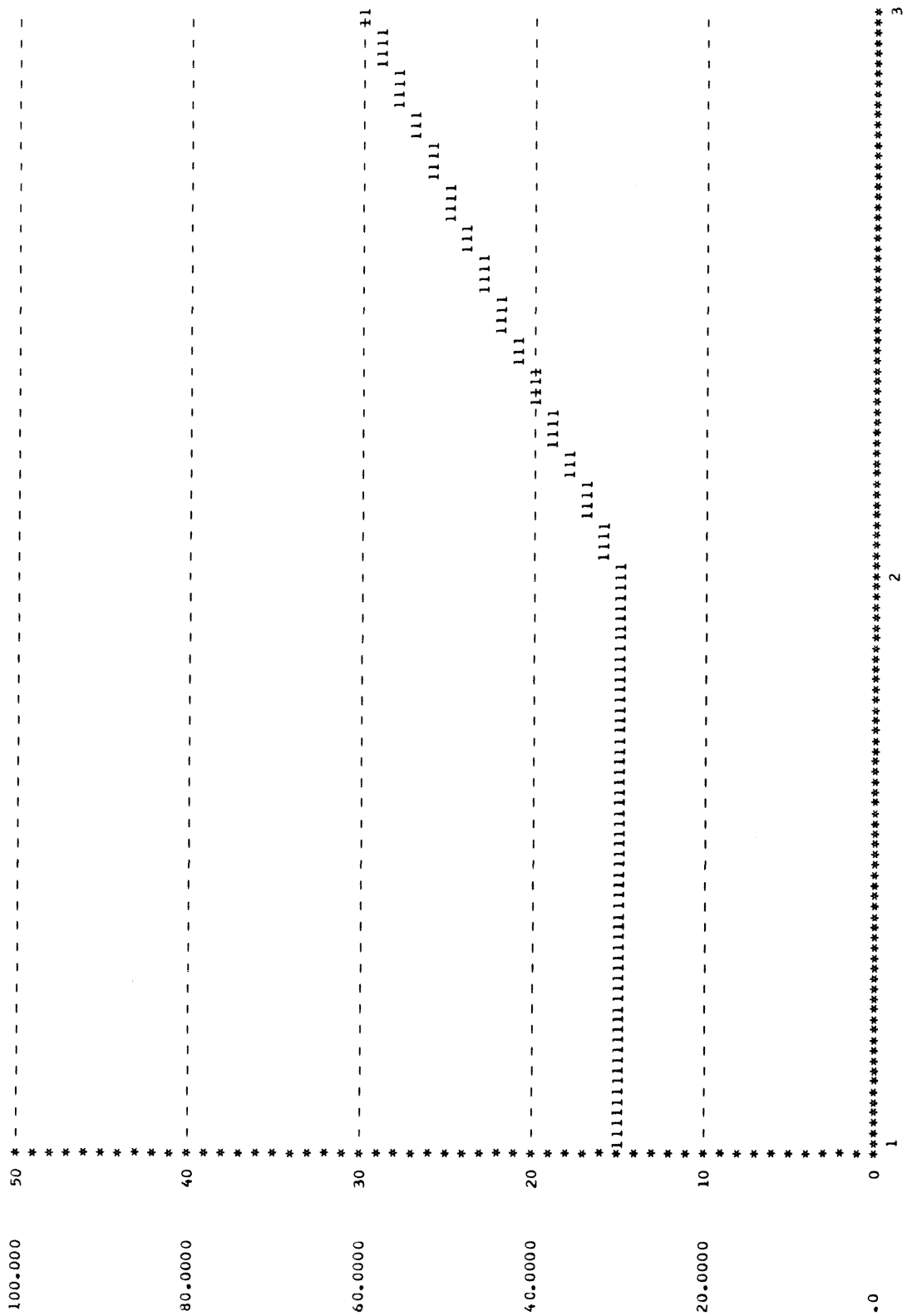
CONTROL VALUES FOR FACTOR SUBSCRIPTS

113 IMPLIES CELL MEANS ARE SUMMED OVER THIS SUBSCRIPT.
 114 LEVELS OF Y AXIS.
 115 LEVELS OF X AXIS.
 116 PRODUCE A SEPARATE PROFILE PLOT FOR EACH LEVEL OF THIS SUBSCRIPT
 1-111 THIS LEVEL OF LTH FACTOR IS TO BE PLOTTED.

FACTOR	R	1	2	3	4
CONTROL VALUES	1	114	113	113	115

PROFILE ANALYSIS, JOB= 1 PROFILE TEST DATA PHOSPHORUS MAIN EFFECT TIME 1 1

Y = DUMMY



LEVELS OF X = PHOSPHORUS

PROFILE ANALYSIS, MEANS OF PROFILE CELL PLOTS FOR JOB 2

FACTOR LEVELS 0 INDICATES THE LEVELS OF THIS FACTOR ARE TO BE THE LEVELS OF THE X AXIS
 * INDICATES THE FACTOR FOR WHICH A SEPARATE PROFILE PLOT IS PRODUCED FOR EACH OF ITS LEVELS.
 X INDICATES FACTOR FOR HORIZONTAL AXIS.
 Y INDICATES FACTOR FOR VERTICAL AXIS

LEVELS OF X AXIS

		LEVELS OF X AXIS		
		1	2	3
Y X	1 1 1 0 1 1 1 1 1			
	Y1 -Y12	MEAN	10.00	40.00
		NOBS	2	2
1 1 1 2 0 1 1 1 1	Y1 -Y12	MEAN	50.00	20.00
		NOBS	2	2

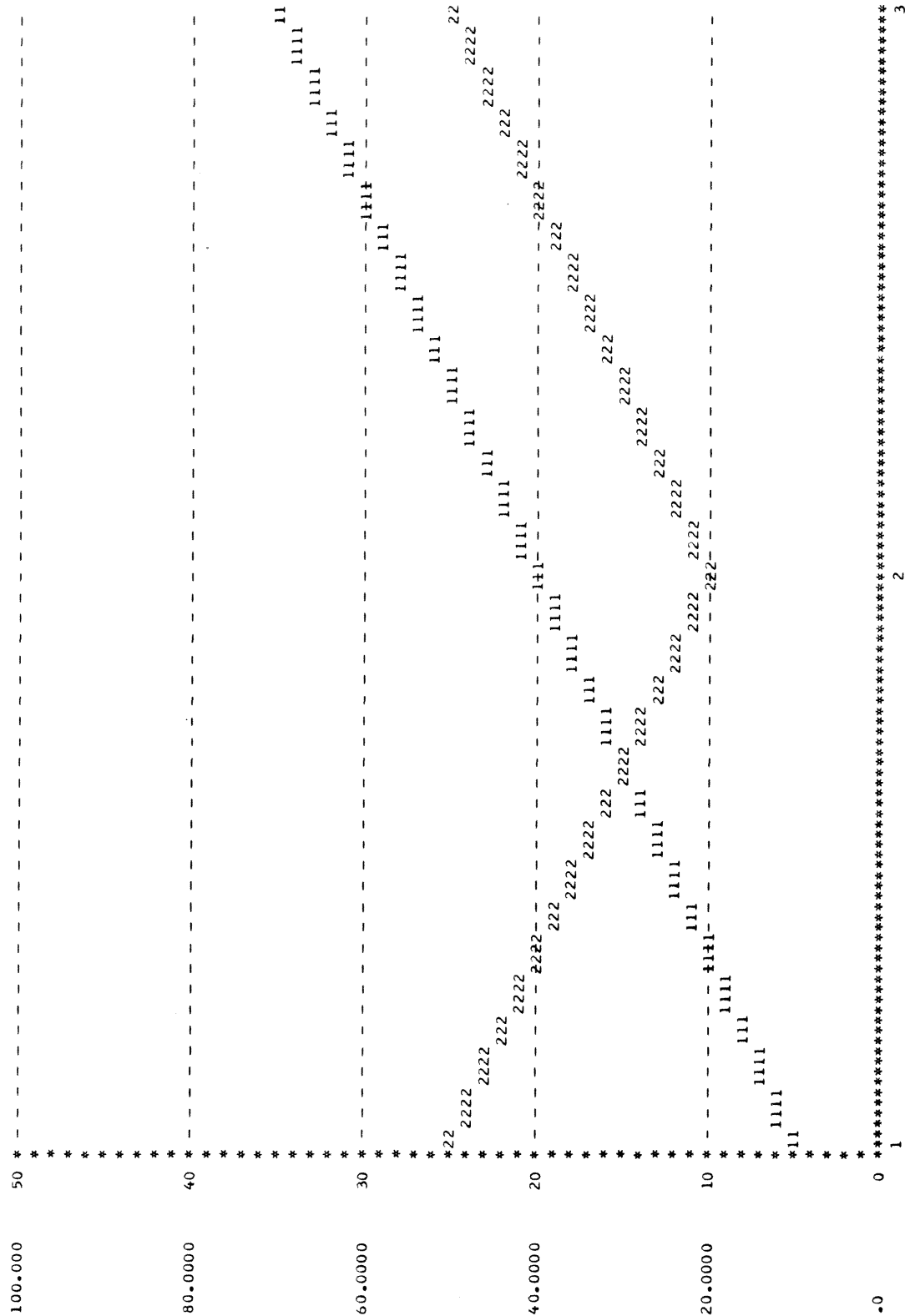
CONTROL VALUES FOR FACTOR SUBSCRIPTS

113 IMPLIES CELL MEANS ARE SUMMED OVER THIS SUBSCRIPT.
 114 LEVELS OF Y AXIS.
 115 LEVELS OF X AXIS.
 116 PRODUCE A SEPARATE PROFILE PLOT FOR EACH LEVEL OF THIS SUBSCRIPT
 1-111 THIS LEVEL OF LTH FACTOR IS TO BE PLOTTED.

FACTOR	R	1	2	3	4
CONTROL VALUES	1	1	113	114	115

PROFILE ANALYSIS, JJB= 2 NITROGEN X PHOSPHORUS COMBINED SPECIES TIME 1 1

Y = NITROGEN



LEVELS OF X = PHOSPHORUS

PROFILE ANALYSIS, MEANS OF PROFILE CELL PLOTS FOR JOB 3

FACTOR LEVELS 0 INDICATES THE LEVELS OF THIS FACTOR ARE TO BE THE LEVELS OF THE X AXIS
 * INDICATES THE FACTOR FOR WHICH A SEPARATE PROFILE PLOT IS PRODUCED FOR EACH OF ITS LEVELS.
 X INDICATES FACTOR FOR HORIZONTAL AXIS.
 Y INDICATES FACTOR FOR VERTICAL AXIS

LEVELS OF X AXIS

		1 2 3		
* Y X	1 1 1 0 1 1 1 1 1			
	Y1 -Y12	MEAN	0.0	30.00 60.00
		NOBS	1	1 1
	1 1 1 2 0 1 1 1 1			
	Y1 -Y12	MEAN	40.00	10.00 40.00
		NOBS	1	1 1

CONTROL VALUES FOR FACTOR SUBSCRIPTS
 113 IMPLIES CELL MEANS ARE SUMMED OVER THIS SUBSCRIPT.
 114 LEVELS OF Y AXIS.
 115 LEVELS OF X AXIS.
 116 PRODUCE A SEPARATE PROFILE PLOT FOR EACH LEVEL OF THIS SUBSCRIPT
 1-111 THIS LEVEL OF LTH FACTOR IS TO BE PLOTTED.

FACTOR	R	1	2	3	4
CONTROL VALUES	1	1	116	114	115

PROFILE ANALYSIS, MEANS OF PROFILE CELL PLOTS FOR JOB 3

FACTOR LEVELS 0 INDICATES THE LEVELS OF THIS FACTOR ARE TO BE THE LEVELS OF THE X AXIS
 * INDICATES THE FACTOR FOR WHICH A SEPARATE PROFILE PLOT IS PRODUCED FOR EACH OF ITS LEVELS.
 X INDICATES FACTOR FOR HORIZONTAL AXIS.
 Y INDICATES FACTOR FOR VERTICAL AXIS

LEVELS OF X AXIS

		LEVELS OF X AXIS		
		1	2	3
* Y X				
1 1 2 1 0 1 1 1 1 1 1	Y1 -Y12	MEAN	20.00	50.00
		NBS	1	1
1 1 2 2 0 1 1 1 1 1 1	Y1 -Y12	MEAN	60.00	30.00
		NBS	1	1

CONTROL VALUES FOR FACTOR SUBSCRIPTS

113 IMPLIES CELL MEANS ARE SUMMED OVER THIS SUBSCRIPT.
 114 LEVELS OF Y AXIS.
 115 LEVELS OF X AXIS.
 116 PRODUCE A SEPARATE PROFILE PLOT FOR EACH LEVEL OF THIS SUBSCRIPT
 1-111 THIS LEVEL OF LTH FACTOR IS TO BE PLOTTED.

FACTOR	R	1	2	3	4
CONTROL VALUES	1	1	116	114	115

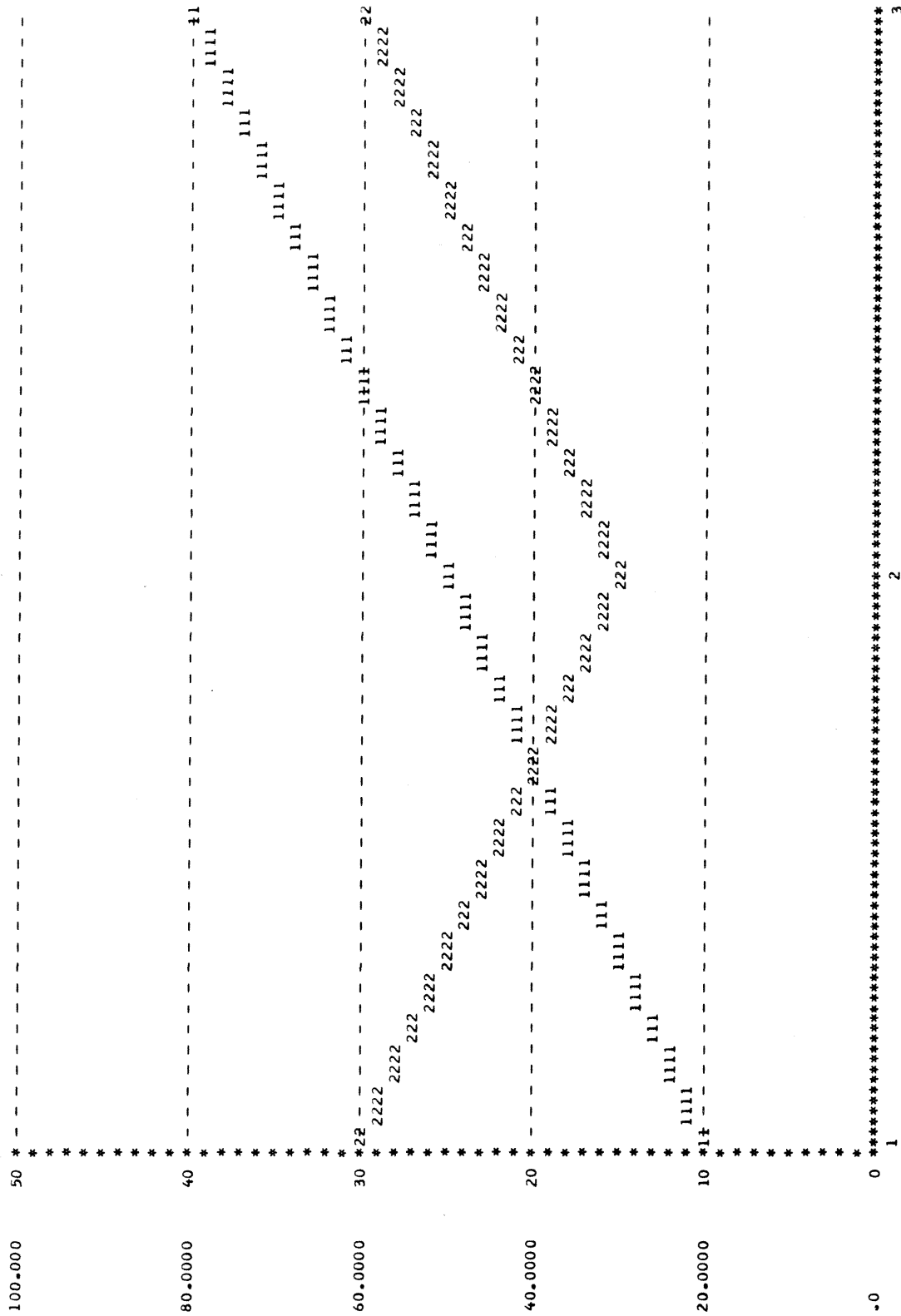
SPECIES 2

TIME 1

EACH SPECIES

PROFILE ANALYSIS, JOB= 3 NITROGEN X PHOSPHORUS

Y = NITROGEN



LEVELS OF X = PHOSPHORUS

FACTOR LEVELS

0	INDICATES THE LEVELS OF THIS FACTOR ARE TO BE THE LEVELS OF THE X AXIS
*	INDICATES THE FACTOR FOR WHICH A SEPARATE PROFILE PLOT IS PRODUCED FOR EACH OF ITS LEVELS.
X	INDICATES FACTOR FOR HORIZONTAL AXIS.
Y	INDICATES FACTOR FOR VERTICAL AXIS

X	Y			1	2	3	4
0	1	1	1	1	1	1	1
				Y ₁ -Y ₁₂			
				MEAN			
				NBS			
				30.00	35.00	40.00	50.00
				6	6	6	6
0	1	2	1	1	1	1	1
				Y ₁ -Y ₁₂			
				MEAN			
				NBS			
				50.00	55.00	60.00	70.00
				6	6	6	6

CONTROL FACTOR FOR SUBSCRIPTS

113 IMPLIES CELL MEANS ARE SUMMED OVER THIS SUBSCRIPT.

114 LEVELS OF Y AXIS.

115 LEVELS OF X AXIS.

116 PRODUCE A SEPARATE PROFILE PLOT FOR EACH LEVEL OF THIS SUBSCRIPT

I-111 THIS LEVEL OF LTH FACTOR IS TO BE PLOTTED.

20

Y = SPECIES

