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A Multiple Discriminant Function Approach to Study the Crop Response to Soil Characters (Bengalgram: Crop)*

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Abstract: Multiple group discriminant function approach is carried out to classify the yields of crops in terms of soil characteristics. Four groups in the form of cross-classification of two levels of Nitrogen (low-High) with two levels of Yield (Low-High) was carried out for the purpose, in revealing the relative importance of soil characteristics of practical utility. By using the determinental equation it was seen that λ_1 and λ_2 together account more than 95 per cent to the total variation. Further it is evident that the variables N,P,K are positively correlated with yield whereas pH of the soil and duration of crop are negatively correlated. Organic carbon and Electrical conductivity of the soil are moderately correlated with Nitrogen and Yield.

Introduction

Soil characters like pH, organic carbon (O.C), Electrical conductivity (E.C), Initial available N,P, K, and crop duration from sowing to maturity and date of sowing are known to influence the yield response of crops. The relative importance of pH, O.C, E.C, etc are often masked by the dominant influence of a major nutrient like Nitrogen (N),

Several methodological investigations having carried out to relate soil charateristics with crop yield of different crops. Multiple regression approach (Abraham 1973), factorial analysis (Abraham and Hoobakht 1974) and approach of linear function for two groups (Abraham *et al.*, 1975) were some of the methods employed to understand such relations.

A study is undertaken by employing multiple group discriminant function approach to four groups in the form of cross-classification of two levels of N (Low-High) with two levels of yield (Low-High). The multiple group discriminant function analysis applied to these four groups, has revealed the relative importances of the characters like pH, E.C., O.C, date of sowing, days to maturity, levels of K and P, in relation to crop yield.

Material and Methods

Experiments were conducted on cultivators fields in chickmagalur district of Karnataka state under All India Coordinated

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Agronomic Research Project (AICRP). The primary objective of these experiments was to determine the response of field crop viz., Bangalgram, to fertilizers. The soil samples from the experimental fields were collected before the lay out of the experiment. The soil samples were analysed for pH, E.C., O.C, and initial available N,P and K by following standard procedures. In order to findout the relative importance of the soil characteristics with the crop yield, the experimental plots were grouped in terms of dominant variable N and crop yield, as shown below.

Group I - Low Yield and low N level
Group II - Low Yield and high N level
Group III - High Yield and low N level
Group IV - High yield and high N level

In the above grouping total nitrogen level less than 3.04 q/ha was considered as low and more than 5.57 q/ha was considered as high. Similarly yield less than 7.28 q/ha was considered as low and more than 12.06 q/ha was considered as high.

The multiple group discriminant function,

$$Z = a_1 x_1 + a_2 x_2 + \ldots + a_9 x_9 \quad \text{------(1)}$$

was used for discriminating the groups in terms of soil characteristics and other variables, where in z is a linear function of the variables X_1, X_2, X3,.....X_9.

X_1 is plot yield in quintal per hectare

X_2 is pH of the soil from the plot

X_3 is organic Carbon (O.C) percentage of the soil from the plot

X_4 is available N q/ha in the soil of the plot

X_5 is available P in kg/ha in the soil of the plot

X_6 is available K in q/ha in the soil of the plot

X_7 is Electrical conductivity in mm Ohms/cm of the soil in the plot

X_8 is duration of crop in days from sowing to maturity

X_9 is period of sowing (X_9 = 0 if period of sowing is `normal' and X_9 =1 if period of sowing is delayed).

In the discriminant function sated above, the weights a_1, a_2, a_3... a_9 written in vector form as $a^1 = (a_1, a_2, a_3 \ldots a_9)$ were estimated by maximising the ratio

$$\lambda = \frac{a^1 B a}{a^1 W a} \quad \text{------(2)}$$

subject to the condition $a^1 W a = 1$,

where B and W

and are respectively, the "Between Group' and "within Group" variance covariance's matrices of the rector $X^1 = (X_1, X_2, X_2 \ldots\ldots X_9)$.

The estimated values of unknown weights were obtained as eigen vectors of the determinental equation.

$$B - \lambda W = 0$$

with values λ_1, λ_2..... as characteristic roots of the above equation with λ as a parameter of the equation (overall and Klett

1972). It is well known that the characteristic vectors are independent of the another for different characteristic roots. Accordingly the functions Z_1, Z_2.... obtained with the help of the estimated values of the weights a_1, a_2, a_3... a_9 corresponding to the characteristic roots λ_1, λ_2..... respectively are independent of one another. Moreover total variation in Z explainable in terms of the variable $X^1 = (X_1, X_2, X_2.....X_9)$. can be determined in terms of the characteristic roots λ_1, λ_2..... with the help of the group discriminant function Z_1, Z_2 ..... corresponding to the characteristic roots λ_1, λ_2..... respectively. It is possible to locate the variables $X^1=(X_1,X_2, X_2.....X_9)$. by taking Z_1, Z_2.....etc. as coordinated variables. For this purpose means of the variables for each of the groups were used. The finding are presented in Table 1.

Results and Discussion

With the help of the means of the variable $X^1 =(X_1, X_2, X_2.....X_9)$. and determinental equation.

$$B - \lambda W = 0 \quad \text{-------- (3)}$$

Vectors of weights $a^{(1)}$, $a^{(2)}$ corresponding to Z_1 and Z_2 were obtained with the help of the characteristics roots λ_1 and λ_2 respectively by solving the equation-(3). It was seen that these two characteristic roots λ_1 and λ_2 together account for more than 95 per cent of total variation with λ_1 accounting for more than 83 per cent and λ_2 for more than 12 percent of the total variation. This shows that the discriminant function Z_1 and Z_2 are sufficient to explain the total variation due to variables $X^1 =(X_1, X_2, X_2.....X_9)$. to the extent of 95 per cent. The descriminant space spanned by Z_1 and Z_2 was formed and the variables $X^1 =(X_1, X_2, X_2.....X_9)$. were located on the space as shown in Fig.1.

Based on group discriminant function analysis the correlations of the variables $X^1 =(X_1, X_2, X_2.....X_9)$. with the discriminant variables Z_1 and Z_2 were obtained (see Table 2a) . The following points have emerged as a result as a result of group discriminant analysis:

(I) The variable X_4 was of highest correlation coefficient (0.99) with Z_1 and of lowest correlation coefficient (-0.33) with Z_2 .
(ii) The variable X_1 was of highest correlation coefficient (0.92) with Z_2 and ofd lowest correlation coefficient (-0.03) with Z_1.

(Iii) From (I) and (ii) above it is evident that Z_1 forms dimension of nitrogen and Z_2 forms dimension of the yield.

With the help of coordinates Z_1 and Z_2 for the four groups (Table 2b) , the structural configuration of the groups and the nature of the nine variables, can be understood easily with the help of Table 2a. It is evident that the variables N,P and K are positively correlated. The variables pH and duration of crop were negatively correlated with nitrogen axis Z_1. Moreover yield and Electrical conductivity were positively correlated with the yield axis Z_2. Organic carbon (O.C) was correlated moderately with Z_1 and Z_2.

It can be inferred that the four groups formed on the basis of twin-criteria of yield and Nitrogen, are constant with the four groups being in the four different quadrants of the two-dimensional discriminated space Z_1 and Z_2 formed on

the basis of the nine variables $X^1 = (X_1, X_2, X_2 \ldots\ldots X_9)$.. The role of each of the variables in each of the groups can be understood with the help of the corresponding correlation coefficients presented in Table 2(a).

Table 1. Means of the different variables in different groups (Bengalgram).

Sl. No.	Variable	Xi	Group I	Group II	Group III	Group IV
1	Control yield (q/ha)	X_1	5.17	7.67	5.50	8.83
2	pH of the soil	X_2	8.36	8.27	8.10	8.02
3	Organic Carbon (%)	X_3	0.77	0.50	0.78	0.78
4	Available N (q/ha)	X_4	2.47	2.03	6.37	7.61
5	Available P (kg/ha)	X_5	7.53	6.00	7.04	8.23
6	Available K (q/ha)	X_6	4.42	6.06	7.14	7.47
7	Electrical conductivity (m.mhos/cm)	X_7	0.40	0.98	0.58	0.66
8	Crop duration (days)	X_8	98.53	101.65	97.41	94.56
9	Period of sowing	X_9	0.56	0.43	0.16	0.39

Table 2(b). The group means for the two discriminant functions $Z^{(1)}$ and $Z^{(2)}$ to plot the four groups in the discriminant space with origin at (0.0)

Discriminant functions (Means)	Group Means				
	Group I	Group II	Group III	Group IV	Group Centroid
$z^{-(1)}$	-0.6121	-1.1308	4.3942	5.8488	2.1250≅2.13
$z^{-(2)}$	-4.2705	-2.4981	-5.1142	-2.3381	-3.5561≅-3.56

Table 2(a). The discriminant weights, correlation coefficients (r_{i1}, r_{i2}) ANOVA `F' and the pairs of Co-ordinates $Z^{(1)}$ and $Z^{(2)}$ required for locating each of the 9 variables (Bengalgram).

Sl. No.	Variables	Weights		Correlation coefficients		ANOVA F (3,96 df)	Length of the Vector (r.)**	
		$a^{(1)}$ ~	$a^{(2)}$~	r_{i1}	r_{i2}		$Z^{(1)}$	$Z^{(2)}$
1.	Control yield (x1)	-0.0380	1.0802	-0.03	0.92	37.40**	12.7	34.4
2.	pH (x2)	-0.0362	-0.3860	-0.96	-0.17	4.00**	-3.9	-0.7
3.	Organic carbon (x3)	0.0451	-0.1817	0.63	-0.51	9.10**	5.7	-4.7
4.	Available N (x4)	1.0124	-0.1091	0.99	-0.03	265.10**	265.1	-6.7
5.	Available P (x5)	0.1486	0.3169	0.66	-0.01	4.20**	2.8	-0.02
6.	Available K (x6)	-0.0128	-0.3264	0.84	0.21	12.30**	10.3	2.6
7.	Electrical conductivity	0.2379	0.1376	-0.21	0.66	4.50**	-0.9	2.9
8.	Crop duration (x7)	-0.1999	0.0017	-0.89	0.02	4.80**	-4.3	0.1
9.	Period of sowing (x9)	-0.3233	0.4512	-0.64	0.40	3.20**	-2.1	1.3

Note: $Z^{(1)}$ and $Z^{(2)}$ serve as the pairs of Co-ordinates for locating the vectors with origin - not at (0,0) but at group centroid points (2.13, -3.56) in Table 2(b). (Fig. 1).

* Significant at 5% level
** Significant at 1% level.

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