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AMMI, SREG and FREG Models for Stability Analysis in SPAR 2.0

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SUMMARY

Yield stability as a selection trait in plant breeding programmes and evaluation trials is constantly gaining importance over yielding ability. Some of the common techniques as an alternative to additive ANOVA model are Additive Main effects and Multiplicative Interaction (AMMI), Sites Regression (SREG) and Factorial Regression (FREG) etc. SPAR 2.0 (Ahuja *et al.* 2005) has a module on stability analysis, in which stability analysis can be performed using the three models, Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971) in a user friendly mode. However, it cannot perform stability analysis using AMMI, SREG and FREG models. This software package for stability analysis is developed for AMMI, SREG and FREG models and integrated with SPAR2.0. It has been developed using VC++ and VB, which are more flexible, user-friendly and economic. Data input can be from an ASCII or an Excel file. There is no restriction on the number of response variables and observations. It has been provided with an extensive Help document on statistical concepts involved, use of the software, example of data file, example of input files and output files. It has also the options like favorites and search through contents and index.

Key words : Stability analysis, AMMI, SREG, FREG, SPAR 2.0, Sensitivity coefficient matrix.

1. INTRODUCTION

The increase in agricultural output is due to the application of improved technology, increased use of inputs like hybrid seeds, fertilizers, irrigation and of course pesticides. To improve agricultural productivity and produce quality output optimizing available resources is the main concern of the research workers today. One of the most important resources that draw attention of the research workers is to develop a new plant type or a variety that will yield more than the existing one and will be stable across a range of environments, which may be locations or years or combinations of both. This is being achieved through taking yield stability as a selection trait in plant breeding programmes and evaluation trials. The term stability refers to the behavior of a crop in varying environments. The breeders' aim is to develop cultivars that are stable across a range of environments. The basic Analysis of Variance (ANOVA) model for two-way crossed classification with interaction serves to obtain some idea about the partition of variance over various terms. However, it identifies the interaction as a source but does not analyze it since the interaction here is modeled by a separate, additive parameter for each combination of genotype by environment coarsely and unparsimoniously. Joint regression analysis was suggested for identifying the stable cultivars. For details a reference may be made to Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971).

Whenever the information on external environmental characteristics such as weather parameters and soil characteristics is available, it may be accommodated in the basic ANOVA model mentioned above in an attempt to interpret the interaction using the technique called Factorial Regression (FREG) (Denis 1980, 1988, Snedecor and Cochran 1989). The Factorial Regression model is a linear model; hence classical estimation and testing procedures for regression can be used. Baril *et al*. (1995) had shown that Factorial Regression model provides a better basis for biological interpretation of interaction. This model serves as a means of finding the underlying physiological causes of observed sensitivities. The regression on the environmental mean or row regression model might be interpreted as a special type of Factorial Regression model with only one non-measurable, concomitant variable on the environmental factor.

When the component of deviation from linear regression is significant, the linear regression techniques (Factorial Regression and Joint Regression) fail to perceive important interaction effects since the linear regression in this case accounts for only a small portion of interaction sum of squares. In such cases Additive Main effects and Multiplicative Interaction (AMMI) and Sites Regression (SREG) models prove to be more realistic one in the sense that these digest the non-linear interactions too into a pattern rich model, discarding noise rich residual (see Gollob 1968, Gabriel 1971, 1978, Mandel 1971, Bradu and Gabriel 1978, Kempton 1984, Gauch 1985, Freeman 1985, Crossa 1990, Gower and Hand 1996, Parsad *et al*. 2006). AMMI and SREG models combine the features of factor analytic as well as analysis of variance techniques. The basic model is essentially a two way ANOVA model, which requires that the matrix of interaction parameters be decomposed by using factor analytic techniques (Yang 2001, William *et al.* 2002).

The use of most prevalent statistical packages require writing of syntax codes for stability analysis (Burgueno *et al*. 2002). Most of the users are not conversant with programing or writing syntax codes and as such may find it difficult to use these statistical packages. SPAR 2.0 (Ahuja *et al.* 2005) has a module on stability analysis, in which stability analysis can be performed using the three models, Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971). AMMI, SREG and FREG models however, are not available in this software. Therefore, in the present investigation, an attempt has been made to develop modules for performing AMMI, SREG and FREG analysis along with drawing bi-plots (Yan 2002) from the data generated through randomised complete block designs. Although we have used genotypes for treatments here but it can be used for studying any treatment × environment interactions and identification of stable treatment over environment. In the present article, we describe the Windows based Software for Stability Analysis using AMMI, SREG and FREG models.

2. SOFTWARE DESCRIPTION

Modules for Stability Analysis using AMMI, SREG and FREG models have been developed for windows platform and programing is done with the Visual C++ 6.0 and Visual Basic 6.0 of Microsoft Visual Studio 6.0 Enterprise Edition (see Papas and Murray 1998, Jerke 1999, Schildt 2004). The software has three modules namely Data Management module, Analysis module and HTML Help. These modules have been integrated with the SPAR 2.0.

2.1 Data Management

This module has been designed and developed to display the output of stability analysis. It supports following features to format the output generated:

- Saving the output in text, Excel and MS-Word file format.
- Printing the output with the facilities for displaying page setup and print setup.
- Editing facilities like Cut, Copy, Paste, Select, Clear Text, Undo and Redo.
- Searching and replacing any text in the Output Window.
- Formatting the output by changing background colour and text colour.

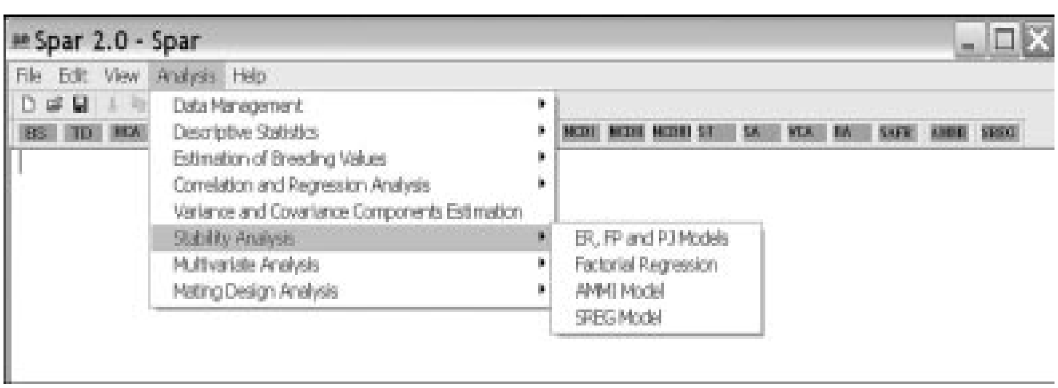

Fig. 1. GUI for Stability Analysis

2.2 Analysis

The various modules are available under Analysis Menu. This software for stability analysis using AMMI, SREG and FREG models has been integrated with existing SPAR 2.0 under stability analysis module as shown in Fig. 1.

The data used for testing the software for AMMI and SREG models were collected from the multi-year trials of released and pre-released varieties of groundnut conducted at research stations situated in different agro-climatic zones of Andhra Pradesh. These data were supplied by Regional Agriculture Research Station (RARS), Palem (Raju 2002). The data consist of 3 sites and 9 genotypes. The experiments were laid in Randomized Complete Block (RCB) design with 3 replications. The pod yields were expressed as kg/ha. The data used for testing the software for FREG model are from Aastveit and Martens (1986). The data set represents plant height of genotypes of barley. The experiment has been carried out at AS Norway, over a period of 9 years in an RCB design with 4 blocks. The sowing date was same for all 15 genotypes but differed from year to year. The data on different climatic variables corresponding to the years are also taken from the same source. The data shows sowing time in days after 1st April (ST); mean temperatures at six growth periods, (T1,...,T6); average rainfall in the six growth periods, (R1,…,R6); global circum radiation in the six growth periods, (Rad1, ..., Rad6).

2.2.1 Stability Analysis using AMMI and SREG Models

After clicking AMMI model a window appears as shown in Fig. 2. However, if the user selects SREG model, the screen for the same will appear. The analysis procedure will remain the same.

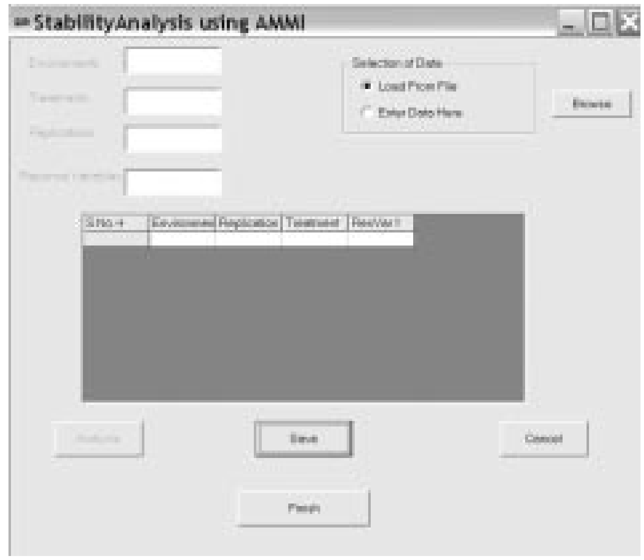

Fig. 2. Starting Window of AMMI Analysis

(a) ***Selection of Data*:** If user has already existing data file s/he can select the button "Load From File" (which is checked by default) and click the "Browse Data File" button for fetching the data. User need to select the type of the file from either of the two options ASCII and EXCEL. After selecting one of these say ASCII and clicking OK button, a dialog box will be opened. If user selects the option EXCEL then the worksheet of the selected EXCEL file also needs to be selected. The data will appear in the grid as shown in Fig 3. If user does not have an already created data file and wants to create it using the same software, then the option "Enter Data Here" is to be selected. In this case the user needs to first enter the number of "Environments", "Treatments", "Replications" and "Response Variables". Accordingly the data sheet will appear for the required number of observations. By default the data sheet will have the name of columns as Environment, Replication, Treatment and ResVar1, ResVar2 accordingly. The rows will have the name OBS 1, OBS 2 etc.

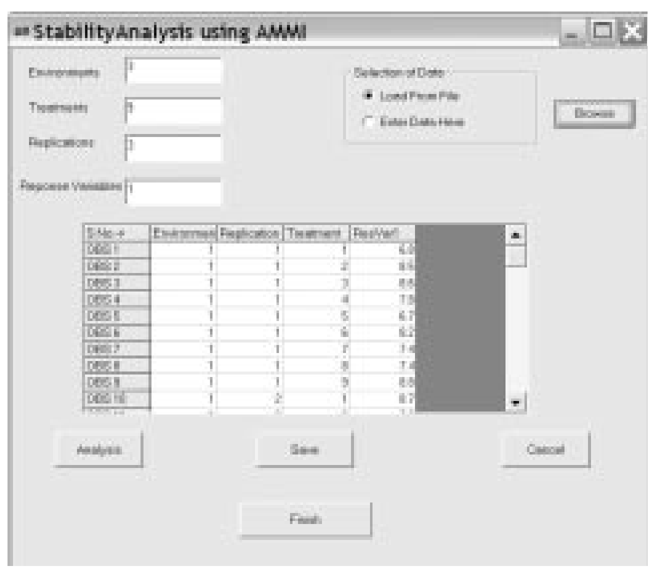

Fig. 3. Data Input through Existing Excel Worksheet

(b) ***Save:*** The data from the data sheet can be saved in any location of your machine by the option Save. After clicking the Save button a dialog box will appear where user can select the location to save input file by giving the appropriate name.

(c) ***Help:*** One can navigate through the help of the current module by clicking the help button any time. It will open the complete help regarding that module.

(d) ***Cancel and Finish:*** At any time user can select this option for canceling the operation and for termination of the particular operation.

(e) ***Analysis:*** This button performs the analysis and output appears in SPAR window and simultaneously graph is generated.

The output file contains several tables and results, which are helpful to depict the stability of different treatments with respect to different response variables. At the starting of the output file, ANOVA for each environment, and pooled ANOVA are given. In addition to above, percentage variation explained by each PCA's, their cumulative percentage and the corresponding biplots are displayed. It also gives AMMI ANOVA for interaction using Gollob test (Fig. 4).

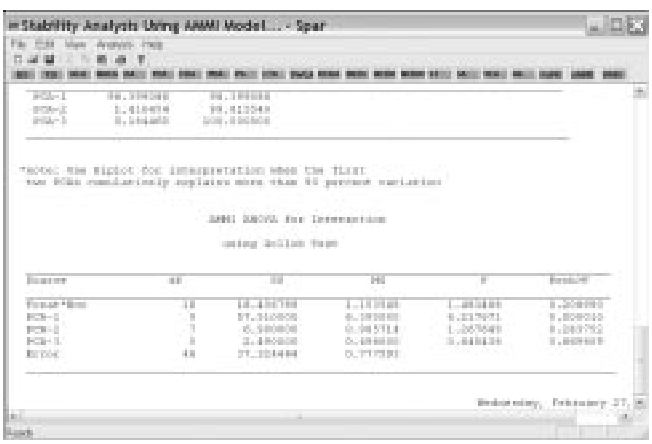

Fig. 4. Sample Output of AMMI Model

For SREG model the ANOVA for each environment, pooled ANOVA, percentage variation explained by each PCA's and their cumulative percentage are displayed. The biplots of mean versus First PCA and First PCA versus Second PCA are also displayed by clicking the two buttons provided (Fig. 5). There are four menu options in Graph menu bar for Copy, Print, Save and Exit.

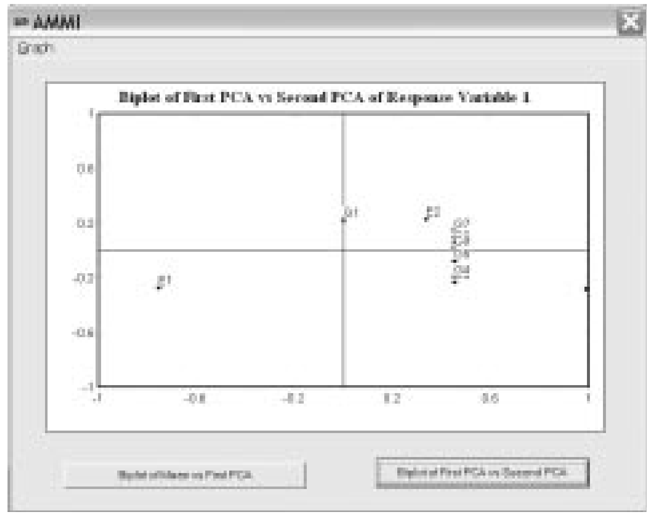

Fig. 5. Biplots

2.2.2 Stability Analysis using Factorial Regression (FREG)

On selecting Factorial Regression, a window appears as shown in Fig. 6.

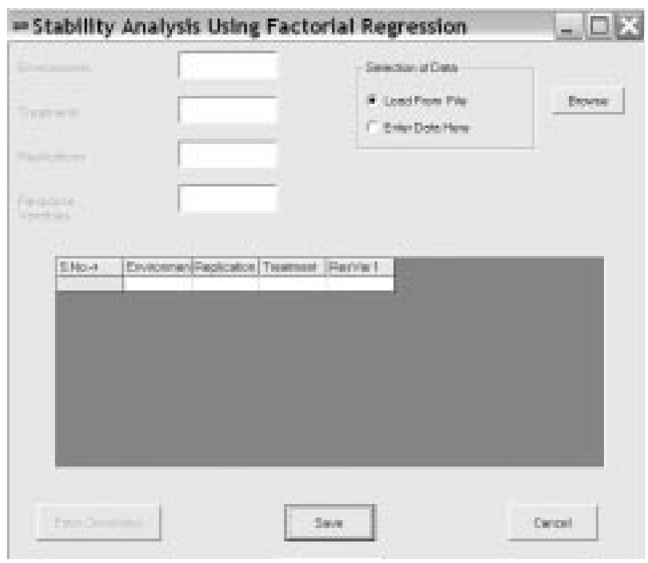

Fig. 6. User Interface of Factorial Regression

The procedure of input of the data is same as described in Section 2.2.1. The number of covariates, however, can either be specified through another data file containing data corresponding to Environments and Environmental Covariates by creating a spreadsheet. The number of Environmental Covariates should be less than the number of Environments to satisfy the conditions for true regression model. Here also the buttons like Cancel, Finish and Save are provided and some additional buttons like Back, for going back to the first step of the analysis process and for proceeding further the Analysis (Fig. 7) button.

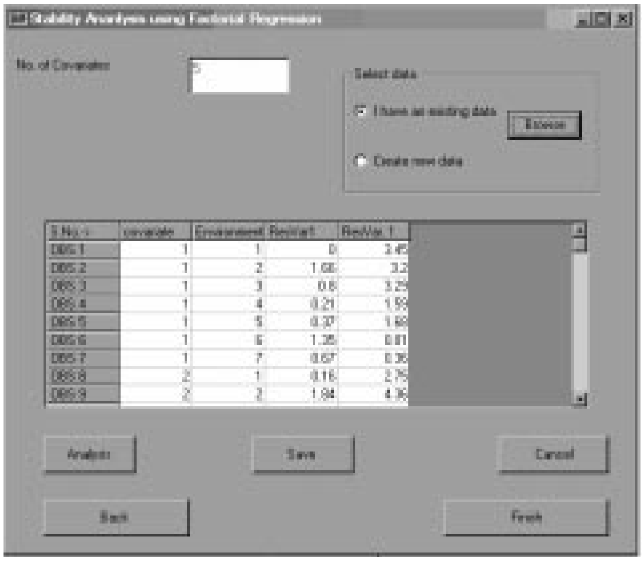

Fig. 7. Input Data Sheet for Environmental Covariates

On clicking the Analysis button, the output appears in SPAR window as shown in Fig. 8. The output file contains several tables and results, which are helpful to depict the stability of different treatments with respect to different response variables. At the beginning of the output file, ANOVA for each environment followed by pooled ANOVA are given. The data on different climatic variables corresponding to the years are then presented. The next portion of output file contains the ANOVA for Factorial Regression and Sensitivity Coefficient matrix.

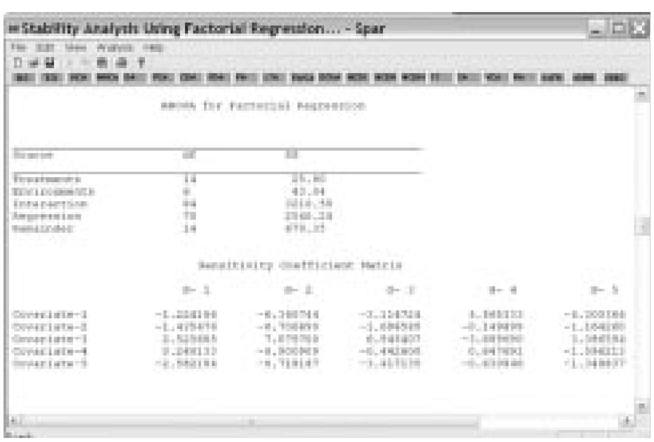

Fig. 8. Sample Output File for Factorial Regression

If one considers the covariate as sowing time, the genotypes, which have the sign of sensitivity coefficients as negative can take the advantage of early sowing. Similarly the genotypes, which possess positive sign for the sensitivity, will perform better if sowing is delayed.

2.3 HTML Help

The software contains Hyper Text Markup Language (HTML) based content, index search and favorites help as shown in Fig. 9 for AMMI. The help system has been developed using HTML workshop package. This can be used as reference for carrying out various software operations. It also provides the general introduction of the statistical procedure and the data files format that is to be provided for executing different analyses.

3. SYSTEM REQUIREMENTS

This software was developed using VC++6.0, VB6.0 and HTML workshop. It has been tested under Windows XP / Windows 2000. Minimum system requirements for its installation include P-II processor based personal computer system with 32 MB RAM, 4.0 GB hard drive, a CD-ROM drive or a USB port. The software has been integrated with SPAR 2.0 and details on its availability are given at www.iasri.res.in.

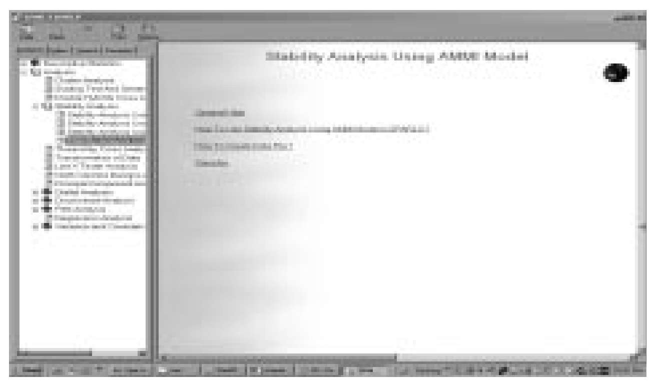

Fig. 9. Help of AMMI

4. CONCLUSION

The software for Stability Analysis using AMMI and SREG models provides a complete analysis using AMMI and SREG models and their corresponding biplots of Mean versus First PCA and First PCA versus Second PCA. It also provides environment-wise ANOVAs, pooled ANOVA, percentage variation explained by each Principal Component and Gollob test for AMMI analysis. In case of FREG analysis, ANOVA for each environment, pooled ANOVA, ANOVA for Factorial Regression and Sensitivity Coefficient Matrix are provided. It has been provided with an extensive Help document on statistical concepts involved, use of the software, example of data file, example of input files and output files. It has also the options like favorites and search through contents and index along with Shortcut menus in the toolbar. This software will be helpful to the biometricians and experimenters to perform the stability analysis using these three important models.

REFERENCES

Aastveit, H. and Martens, H.(1986). ANOVA interactions interpreted by partial least squares regression. *Biometrics*, **42**, 829-844.

Ahuja, Sangeeta, Malhotra, P.K., Bhatia, V.K., Parsad, Rajender and Gupta, V.H. (2005). Development of Statistical Package for Agricultural Research (Windows Version) - SPAR 2.0. Final Project Report, IASRI, 1-40.

Baril, C.P., Denis, J.B., Wustman, R. and Eeuijk, F.A. Van (1995). Analysing genotype by environment interaction in Dutch potato variety trials using Factorial Regression. *Euphytica*, **82,** 149-155.

Bradu, D. and Gabriel, K.R. (1978). The biplot as a diagnostic tool for models of two way tables. *Technometrics,* **20,** 47-68.

Burgueno, J., Crossa, J. and Vargas, M. (2002). SAS Programs for Graphing GE and GGE Biplots. CIMMYT, D.F.: CIMMYT. www.cimmyt.org/english/wps/biometrics.

Crossa, J. (1990). Statistical analysis of multi-locational trials. *Adv. Agronomy,* **44,** 55-85.

Denis, J.B. (1980). Analyse de regression factorielle. *Biom. Praxim*., **20**, 1-34.

Denis, J.B. (1988). Two way analysis using covariates. *Statistics,* **19,** 123-132.

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. *Crop Sci.*, **6,** 36-40.

Freeman, G.H. (1985). The analysis and interpretation of interaction. *J. Appl. Statist.,* **12,** 3-10.

Freeman, G.H. and Perkins, J.M. (1971). Environmental and genotype-environmental components of variability. VIII. Relations between genotypes grown in different environments and measure of these environments. *Heredity*, **26**, 15-23.

Gabriel, K.R. (1971). The biplot-graphical display of matrices with applications to principal component analysis. *Biometrika*, **58**, 453-467.

Gabriel, K.R. (1978). Least squares approximation of matrices by additive and multiplicative models. *J. Roy. Statist. Soc.*, **B40**,186-196.

Gauch, H.G. (1985). Integrating additive and multiplicative models for analysis of yield trials with assessment of predictive success. Cornell University, Department of Agronomy, Mimeo, 7-85.

Gollob, H.F. (1968). A statistical model which combines features of factor analytic and analysis of variance techniques, *Psychometrika*, **33**, 73-115.

Gower, J.C. and Hand, D.J. (1996). *Biplots*. Chapman and Hall, UK.

Jerke, Noel (1999). *Visual Basic 6*: *The Complete Reference.* Osborne, McGraw-Hill.

Kempton, R.A. (1984). The use of biplots in interpreting variety by environment interactions. *J. Agril. Sci.*, **103**,123-135.

Mandel, J. (1971). The partitioning of interaction in analysis of variance. *J. Research, NBSB*, **B73**, 309-328.

Pappas, Chris H. and Murray, William H. (1998). *Visual C++ 6: The Complete Reference*, McGraw-Hill.

Parsad, R., Crossa, J., Vargas, M., Bhatia, V.K. (2006). Biplot Graphic Display: Some Concepts. Design and Analysis of Farmers Participatory Research Trials Training, Sponsored by Rice Wheat Consortium Indo-Gangetic Plain, IASRI, New Delhi, August 11-13, 2006.

Perkins, J.M. and Jinks, J.L. (1968). Environmental and genotype-environmental components of variability. III, Multiple lines and crosses. *Heredity*, **23**, 339-356.

Raju, B. M. K. (2002). On Some Statistical Aspects of Assessing Sensitivity of Crop Varieties. Unpublished Ph.D. Thesis, IARI, New Delhi.

Snedecor, G.W. and Cochran, W.G. (1989). *Statistical Methods.* 8th edition, Iowa State University Press, Ames, Iowa.

Schildt, Herbert, (2004). *C++ - The Complete Reference*. 4th Edition, McGraw- Hill Professional.

William H. Press, Saul, A. Teukolsky, William T. Vetterling and Brian P. Flannery (2002). *Numerical recipes in C++: The Art of Scientific Computing.* Cambridge University Press, New York.

Yan, Weikai (2002). *GGE Biplot Analysis: A Graphical Tool for Breeders, Geneticists and Agronomists*. OPAMP Technical Books, California, USA.

Yang, Daoqi (2001). *C++ and Object-oriented Numeric Computing for Scientists and Engineers.* Springer Verlag, New York.