Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP2: 38-41

M Mishra
Department of Statistics, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India

D Mazumdar
Department of Agricultural Statistics, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India

Correspondence
M Mishra
Department of Statistics, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India

National Conference on Conservation Agriculture
(ITM University, Gwalior on 22-23 February, 2018)

Association between the set of macro and micro climatic parameters with the set of wheat crop growth parameters: Redundancy analysis with Monte Carlo permutation tests

M Mishra and D Mazumdar

Abstract
Plants are affected by the environment during all phases of growth and development. Based on the measured data of wheat crop during 2009-12, the redundancy analysis (RDA) were used to analyze the variations of wheat crop growth parameters response, identify the key environmental factors (macro and micro climatic parameters) and their patterns influencing the variation of the growth parameters of wheat crop. Monte Carlo tests for the first and all canonical axes were highly significant as low inflation factors (<5), indicating that selected X set (macro-micro climatic) parameters in which micro parameters were important in explaining the Y set (LAI and plant height including yield) responses of wheat crop through RDA using CANOCO 4.5 Windows software. All selected environmental factors explained 79.5% of the variation of growth responses of wheat crop.

Keywords: Redundancy analysis, Environmental factors, growth parameters responses, wheat, CANOCO 4.5

Introduction

Wheat (*Triticum* spp.) is a cereal grain, originally from the Levant region of the Near East but now cultivated worldwide (Belderok, *et al.*, 2000 and Shewry, 2009) [2, 7]. India is the second-largest wheat producing nation, followed by the Russian Federation, United States of America, and France (Source: Foreign Agricultural service, United States Development of Agriculture, Office of Global Analysis) and its production and area has increased in last 10 years at compound annual growth rate of 3.07 percent and 0.94 percent (Source: Directorate of Economics & Statistics).

Planners, economists and researchers have always been interested in finding out ways and means to estimate crop yields in advance to the extent possible. With this objective, several regression models have been developed by many workers to predict the relationship with agricultural productivity and its components. In addition to the environmental factors, there are macro and micro climatic factors which were associated with the crop growth parameters that influence crop growth and productivity.

The principal effects of weather on crop growth and development are well understood and are predictable. Crop simulation models can predict responses to large variations in weather. At every point of application weather data are the most important input. The main goal of most applications of crop models is to predict commercial out-put (Grain yield, fruits, root, biomass for fodder etc.).

In this study, RDA using Monte - Carlo simulation technique was used for showing the association between the sets of macro and micro climatic parameters with the set of wheat crop growth parameters. The inclusive forward selection procedure was employed for sorting out the environmental factors explaining the most variance in the crop growth parameters data and then, Monte Carlo test with 499 permutations was carried out for significance testing of the selected environmental factors. All multivariate analyses were performed by using the software CANOCO, Version 4.5 for Windows (Ter Braak, 1989) [9]. Significance tests of the canonical axes involve either unrestricted permutation of the residuals of the reduced model, a method proposed by Freedman and Lane (1983) [4], or permutation of the residuals of the full model, a method proposed by Ter Braak (1990, 1992) [10, 8]. These methods are described in Anderson & Legendre (1999) [1] for multiple regression and in Legendre & Legendre (1998, section 11.3) [6] for RDA.

Applications and uses of crop growth models in agricultural meteorology:

1. When scientists and research managers need tools that can assist them in taking an integrated approach to finding solutions in the complex problem of weather, soil and crop management.
2. When policy makers and administrators need simple tools that can assist them in policy management in agricultural meteorology.

Materials and Methods

Data Source and period of data

Data from 2009 to 2012 on macro and micro climatic parameters with growth processes of wheat crop have been taken from the PhD dissertation work carried out in the Department of Agronomy, B.C.K.V., Mohanpur, Nadia (W.B.).

Experimental details

Treatments: Date of sowing – 2 (25th November and 20th December) – Main plot
Irrigation levels – 3 (1 irri, 3 irri and 5 irri) – Sub plot
Variety – 3 (PBW 343, K307, RSP 561) – Sub – sub plot
Design: Strip-plot design
Years of Experiment – 2009-10, 2010 – 11 and 2011 – 12
Replication – 3

Macro-climatic parameters

Maximum temperature (max. temp/ Tmax), Minimum temperature (min. temp/ Tmin), Relative humidity morning (RH-I), Relative humidity evening (RH-II) and Rainfall (Rf).

Micro- climatic parameters

Absorbed photosynthetic active radiation (APAR), Reflected photosynthetic active radiation (RPAR) and Transmitted photosynthetic active radiation (TPAR).

Growth processes parameters

Leaf area index (LAI), plant height (Plntht) and Yield (Y).

Simulation: an essential tool in Agricultural Sciences

Computer models, in general, are a mathematical representation of a real world system. One of the main goals of crop simulation models is to estimate agricultural production as a function of weather (macro and micro climatic parameters) and soil conditions as well as crop management. These models use one or more sets of differential equations, and calculate both rate and state variables over time, normally from planting until harvest maturity or final harvest. Crop Simulation Models (CSM) are computerized representations of crop growth, development and yield, simulated through mathematical equations as functions of soil conditions, weather and management practices (Hogenboom *et al*., 2004). CSM have played important roles in the interpretation of agronomic results, and their application as decision support systems for farmers is increasing.

Monte Carlo simulation is a useful technique to quantify uncertainty or spatial variation in input parameters on simulated output. In this technique, the model is run a large number of times using random values drawn from probability distribution for specific input parameters.

Redundancy analysis (RDA)

RDA is a multivariate analysis technique for two sets of variables. The most practical situation is the one in which these are sets of explanatory (x) and response (y) variables. Ter Braak (1990) [10] discussed the graphical interpretation of canonical analysis and RDA through biplots. RDA is a method to extract and summarise the variation in a set of response variables that can be explained by a set of explanatory variables. More accurately, RDA is a direct gradient analysis technique which summarises linear relationships between components of response variables that are "redundant" with (i.e. "explained" by) a set of explanatory variables.

The results of RDA were visualized in the form of ordination diagrams in the Canodraw for Windows program. Variables are represented as symbol such as lines with arrows pointing in the direction of maximal variation. Variables with lines close to each other and headed in the same (opposite) direction are highly positively (negatively) correlated. Two lines at a 90-degree angle indicate that the corresponding variables are uncorrelated.

Results and Discussion

The association between the set of macro and micro climatic parameters with the set of wheat growth parameters using RDA (Monte - Carlo simulation technique) with the constrained ordination (linear direct gradient analysis) method summarized in the first two RDA axes. Ter Braak and Smilauer (2002) [11] observed RDA was performed to derive the relation between the natural arrangements of species with the environmental variables using simple linear regression. Ter Braak and Smilauer (2002) [11] were also carried out Monte-Carlo permutation tests to determine the statistical significance of environmental variables and floristic variance to the ordination axes.

The inflation factor of selected meteorological parameters (macro and micro climatic), X-set was below 5 for wheat crop (Table 1). Association of meteorological parameters and growth parameters including yield of wheat crop were shown in biplot figure (Figure 2).

The first axis revealed that the LAI and Plant height of week 1 to week 8 along with APAR of week 1, week 3, and week 5, RPAR of week 3, week 6, week 7 and week 8, TPAR of week 8, maximum temperature and RH-II don’t contribute to yield but on the second axis, it was revealed that the LAI of week 1 to week 6 along with APAR of week 1, week 3, week 5 and week 8, RPAR of week 3, TPAR of week 8 and maximum temperature were important variables to promote yield (Figure 1).

Table 2 indicated that 62.1% of the total variance of growth parameters and 78.1% of the macro-micro meteorological parameters along with growth parameters were explained by the first two canonical associations represented by first two axes.

Same type of result reported by Deng *et al.*, (2013) [3] in which he studied the variations of eco-physiological responses of *Phragmites australis*, identify the key environmental factors and their patterns influencing the variation of the growth of *Phragmites australis* in Momoge wetland, China using RDA based on detrended correspondence analysis for eco-physiological responses of *Phragmites australis*.

Table 1: Forward selection of X set (micro and macro climatic) variables for wheat crop

Selected variables name	Mean	Standard Deviation	Inflation factor
APAR of Week 1	51.81	19.95	4.06
APAR of Week 3	63.99	15.91	4.77
APAR of Week 5	83.52	9.81	3.71
APAR of Week 8	88.68	3.91	1.59
RPAR of Week 1	5.07	1.16	2.56
RPAR of Week 3	4.63	0.61	1.48
RPAR of Week 5	4.19	0.68	2.94
RPAR of Week 6	3.57	0.45	1.66
RPAR of Week 7	3.66	0.46	4.12
RPAR of Week 8	3.96	0.57	2.55
TPAR of Week 1	43.11	19.22	0
TPAR of Week 3	31.39	15.87	0
TPAR of Week 5	12.29	9.49	0
TPAR of Week 8	7.36	3.71	0
Max. temp	28.06	3.71	1.71
RH-II	49.6	10.63	2.44

Table 2: The RDA results for wheat crop of X set (micro and macro parameters) and Y set (growth parameters) on axis 1-4

Axes	1	2	3	4
Eigen values	0.372	0.249	0.102	0.037
X - Y correlations	0.895	0.91	0.925	0.882
Cumulative percentage variance				
of Y data	37.2	62.1	72.3	76
of X - Y relation	46.8	78.1	90.9	95.6
Sum of all eigen values	1			
Sum of all canonical eigen values	0.795			

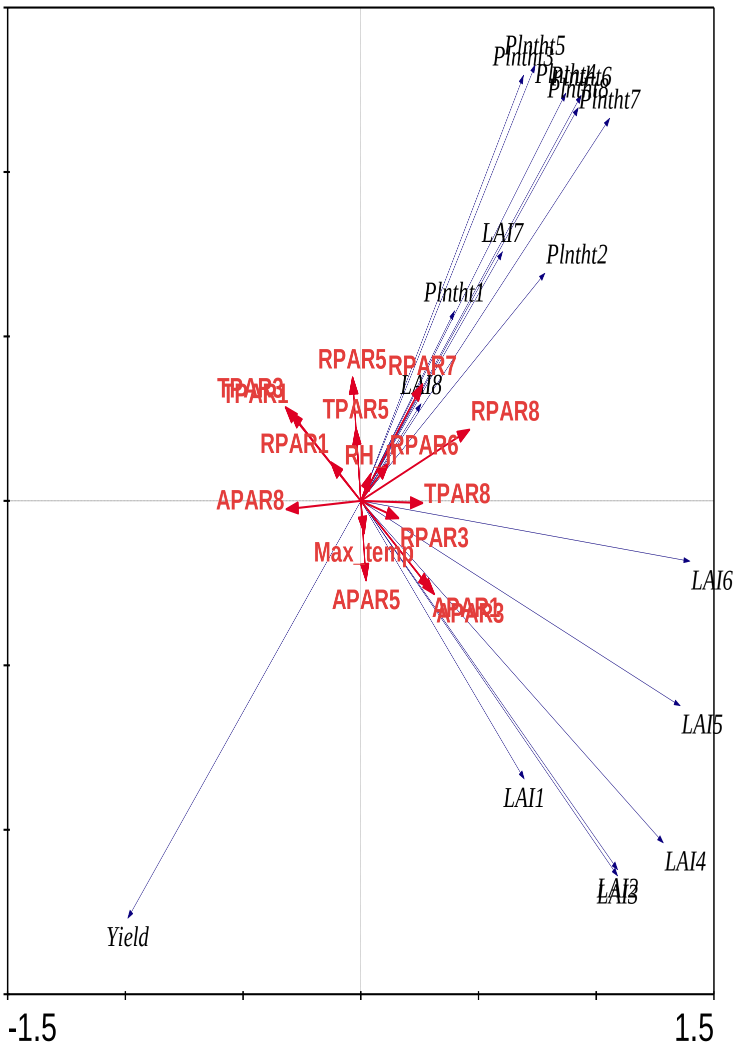

Fig 1: Bi-plot showing RDA results for association between the set of meteorological parameters (macro and micro climatic) with the growth parameters including yield of wheat crop (APAR1 to 8: APAR of week 1 to week 8, RPAR1 to 8: RPAR of week 1 to 8, TPAR1 to 8: TPAR of week 1 to 8, LAI1 to 8: LAI of week 1 to week 8, Plntht1 to 8: Plntht of week 1 to 8)

Conclusion

This investigation identified the key environmental factors influencing crop growth parameters of wheat crop. The results showed that the inflation factor of selected meteorological parameters (macro and micro climatic) was below 5. On second axis, the LAI of week 1 to week 6 along with APAR of week 1, week 3, week 5 and week 8, RPAR of week 3, TPAR of week 8 and maximum temperature if increase, the yield also increases. Monte Carlo tests for the first and all canonical axes were highly significant as low inflation factors (below 5), indicating that selected X set parameters in which micro (PAR) data are significantly important in explaining the Y set (growth- LAI & plant height including yield) responses of wheat crop using RDA.

Acknowledgement

The first author is thankful to the Department of Agricultural meteorology & Physics, Department of Agronomy and Department of Agricultural Statistics, Faculty of Agriculture, BCKV, Mohanpur, Nadia, West Bengal for their precious guidance and support for carrying out investigation. She also acknowledges the DST, Ministry of Science & Technology, New Delhi for the financial assistance in the form of INSPIRE Fellowship to carry out research.

References

1. Anderson MJ, Legendre P. An empirical comparison of permutation methods for tests of partial regression coefficients in a linear model. J Stat. Comput. Simul. 1999; 62:271-303.
2. Belderok RB, Mesdag H, Donner DA. Bread-Making Quality of Wheat. Kluwer Academic, Springer, 2000.
3. Deng CN, Pan XL, Chang FQ. Redundancy Analysis Revealing Relationship between Water-salinity and the eco-physiological Responses of Phragmites australis in Momoge Wetland, China. *Bulg.* J Agric. Sci. 2013; 19(2):274-281.
4. Freedman D, Lane D. A non-stochastic interpretation of reported significance levels. J Bus. Econ. Stat. 1983; 1:292-298.
5. Hoogenboom GJ, White JW, Messina CD. From genome to crop: integration through simulation modeling. *Field Crops Res.* 2004; 90:145-163.
6. Legendre P, Legendre L. Numerical Ecology. 2nd ed. Amsterdam: Elsevier, 1998.
7. Shewry PR. "Wheat". J Exp. Bot. 2009; 60(6):1537-1553.
8. Ter Braak CJF. Permutation versus bootstrap significance tests in multiple regression and ANOVA. Bootstrapping and Related Techniques, Springer- Verlag, Berlin, 1992, 79-86.
9. Ter Braak CJF. CANOCO- An extension of DECORANA to analyze species- environment relationships. *Hydrobiologia* 1989; 184(3):169-170.
10. Ter Braak CJF. Interpreting canonical correlation analysis through biplots of structure correlations and weights. *Psychometrika* 1990; 55:519-531.
11. Ter Braak CJF, Smilauer P. CANOCO reference manual and Cano Draw for window’s user’s guide: Software for canonical community ordination (version 4.5). Ithaca, Newyork, USA, Microcomputer Power, 2002.