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An Application of a Simple Method in Selection of Rice Varieties for Recommendation in Sri Lanka

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Abstract: Performance of a good crop variety should be consistent across locations and over different seasons. This is usually measured by the adaptability parameters and is normally being set as goals in all crop breeding programmes. Numerous methods / techniques have been proposed to evaluate adaptability of crop varieties. Most of them are very complex, difficult to understand by an average crop scientist / breeder and cannot be implemented through standard statistical packages. Therefore use of these methodologies is limited and conclusions are error bound. The Recently proposed method of relative superiority overcomes many of these shortcomings. The advantage of this method is that it uses only one parameter to select varieties for recommendation and analysis can be performed through standard statistical software packages. A paddy data set generated on 3, 3½ and 4½ month maturity group varieties tested over several locations and seasons were used to illustrate the value of this method. The method could easily detect adaptable varieties in the test so that method was simple and straightforward.

Key words: Breeding programmes % Environmental index % Interaction % Relative stability % Relative superiority % Varieties / genotype

INTRODUCTION

Stability parameters based on regression models are widely used. They were first proposed by Yates and Cochran [1]. Finlay and Wilkinson [2] later proposed the regression of observed genotypic response values on environmental index defined as the difference between the marginal mean of the environment and the overall mean. Eberhart and Russel [3] proposed a second parameter, basically the deviation mean squares from the regression model of Finlay and Wilkinson, which can be used in conjunction with the regression coefficient. They regarded a genotype to be stable if its regression coefficient was close to one and the deviation mean square was small. The assumption here is that the genotypes with coefficients significantly greater than one would be adapted to more favorable growing conditions whereas those with coefficients significantly less than one would be adapted to less favorable environments.

Some difficulties are realized in the use of regression parameters to identify stable high-yielding genotypes. Heterogeneous variances result in different precisions of the estimates of regression coefficients, b_i, thus complicating among-genotype comparisons. Furthermore, the environmental index used in corresponding regression models is strictly not an independent variable. Both dependent and regress variables in the model are therefore random variables, thus undermining the validity of confidence intervals and hypothesis tests of model parameters.

The stability variance parameter for each genotype estimated by Shukla [4] is not statistically independent and it can be negative as it is a difference of two sums of squares. As the distribution of this parameter is not clear, test of homogeneity of the estimates are approximate.

Recently, a few new approaches had also been proposed such as multivariate methods for analysis of genotype-by environment data. These include the biplot [5], spatial analysis [6], the additive main effects and multiplicative interaction (AMMI) models [7] and a few others. Eskridge [8] proposed the use of a safety first rule for selection of superior genotypes. His approach is

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subject to the choice of risk level " of obtaining disastrously low yields as well as choice of a stability measure. However, most of these techniques consist of fairly complicated analysis, difficult to understand by an agronomist and cannot be performed by standard software available.

Kamidi [9] proposed a simple technique for varietal selection. The uniqueness of this method is that the methodology can be used easily with the help of standard statistical software and is easy to understand. The objective of the present study was to illustrate the value of this method by applying it in evaluating adaptability of rice varieties in different maturity groups tested in multi–locational yield trials over two seasons in Sri Lanka.

MATERIALS AND METHODS

The method proposed by Kamidi [9] is based on the regression model of the form,

$$y_{ij} = m_i + b_i x_{ij} + d_{ij} \qquad (1)$$

Where:

y_{ij} = Yield of the i^{th} genotype at the j^{th} environment,

F_I = i^{th} genotype mean,

$\$_i$ = Regression coefficient,

d_{ij} = Deviation from regression,

x_{ij} = Environmental index for the i^{th} genotype at the j^{th} environment.

The environmental index,

$$x_{ij} = \frac{g\bar{y}_{\bullet j} - y_{ij}}{g-1} \qquad (2)$$

Where:

$\bar{y}_{\bullet j}$ = Marginal mean of the j^{th} environment

g = Number of genotypes

Based on model (1) the three parameters used for varital recommendation are specific stability, relative performance and relative superiority.

Specific Stability: The specific stability (henceforth refered to as stability) is defined as the correlation between genotype and environmental index. The correlation coefficient (D) significantly different from zero merely signifies the presence of some association between two variables. This association has to be sufficiently strong for a stable genotype. If D = 1 then it is regarded that the variety is stable. Thus in testing the stability it is necessary to determine whether the estimate of the correlation (r_{ge}) actually represents D = 1. The test is then H_o: D = 1 versus H_A: D < 1. Depending on the outcome, varieties are classified. If the D is not being significantly different from unity at " (i.e. $P > 0.05$) the genotype is regarded as very stable. Similarly, if $0.01 < P < 0.05$, the variety is considered as sufficiently stable, if $0.001 < P < 0.01$ the variety is considered as fairly stable and if $P < 0.001$, the variety is considered as unstable.

Table 1: The varieties tested in each maturity group in each season and location

Season	Maturity group	Varieties tested	Tested locations
Wet (2001/02)	3 month	Bg2845, Ld98–3, Bg300, Bg2834, At303 and Bg305	Ambalantota, Ampara, Arulaganwila, Batalagoda, Bombuwela and Vantharumollai
	3½ months	Bg2879, Bg2780, Bw328–1, Bg2835, Bg300, Bw99–1058, Bg99–1046, Bg357 and Bg359	Ambalantota, Ampara, Arulaganwila, Batalagoda, Bombuwela and Vantharumollai
	4 months	Bg2949–1, Bg379–2, Bg2937–2, Bg403, Bg2893 and Bg450	Ambalantota, Arulaganwila Batalagoda and Bombuwela
Dry (2002)	3 month	Bg2845, Ld98–3, Bg300, Bg2834, At303 and Bg305	Ambalantota, Batalagoda, Bombuwela, Labuduwa, Maha–Illupallama and Vantharumollai
	3½ months	Bg2880, Bw1059, Bw328–2, Bg2781, Bg358, Bg301, Bg2836, Bw1047 and Bg360	Ambalantota, Ampara, Arulaganwila, Batalagoda, Bombuwela, Labuduwa, Maha–Illupallama and Vantharumollai
	4 months	Bg2949–2, Bg379–2, Bg2937–2, Bg403, Bg2893 and Bg450	Ambalantota, Arulaganwila, Batalagoda and Labuduwa

Testing D with H_o: $D = 1$ versus H_A: $D < 1$ is fairly complicated. The test used in this circumstance is the test proposed by Gayen [10]. However, one can use the critical values published by Kamidi [9] and make inferences without actually performing the test.

Relative Performance: The relative performance (henceforth refered to as performance) of the i^{th} variety (p_i) is defined as $b_i - 1$, where b_i is the estimated regression coefficient (measure of response across environments) from model (1) i.e., by how much its response lies above or below the average ($b = 1$).

Relative Superiority: Relative superiority (henceforth refered to as superiority) of the i^{th} variety (s_i) is measured as a product of performance and stability i.e. ($S_i = p_i \times r_{ge}$). This parameter is taken as the measure for selecting stable high yielding varieties.

Yield (grain yield) data of three sets of rice varieties from three different maturity groups (3, 3½ and 4 month) tested over several locations in wet[1] (Maha) and dry (Yala) seasons were obtained from the Rice Research and Development Institute of Sri Lanka and used to illustrate the proposed methodology. The varieties used under each maturity group for each season and location are presented in Table 1. Note that each variety was replicated four times in respective locations.

The statistical analysis was carried out using SAS Version 8.2. A sample SAS program that can be used to carry out the analysis for three month maturity group for 2001/02 wet season is given in the appendix.

RESULTS AND DISCUSSION

Mean yield and corresponding adaptability parameters estimated by fitting model (1) for varieties in three maturity groups in the wet and dry seasons are presented in Tables 4 and 5 respectively. Fitting model (1) is in fact performing simple linear regression for each variety separately using yield of the i^{th} variety (y_{ij}) as the response variable and environmental index for the i^{th} variety (x_{ij}) as the explanatory variable. The x_{ij} were computed as defined in equation (2). For instance, the $\bar{y}_{.j}$, which are required to compute x_{ij} for the 3 month maturity group in wet 2001/02 season can be computed as shown in Table 2. Accordingly, for instance, environmental index for Bg2845 at Ambalantota, x_{11}, can be computed as, $x_{11} = [(6)(5.76)-(4.71)] /5 = 5.97$ (Table 3).

All regression models, except for 4 month maturity group, were significant ($P < 0.06$) with varying coefficient of determination (R^2) values. All the regression models related to 3 and 3½ month maturity group of wet season had R^2 above 65% while it was above 90% for 4 month maturity group of dry season. Among the regression

Table 2: Mean yield for 6 varieties at 6 locations (three month maturity group, wet 2001/ 02 season)

Location	Bg2845	Bg2834	At303	Bg305	Ld98–3	Bg300	mean ($\bar{y}_{.j}$)
Ambalantota	4.71	5.99	5.76	6.64	5.90	5.56	5.76
Ampara	5.88	6.95	6.84	6.62	6.26	6.48	6.51
Arulaganwila	3.76	4.47	3.60	4.14	4.03	3.85	3.97
Batalagoda	5.46	6.63	5.84	7.28	6.38	5.68	6.21
Bombuwela	4.02	4.51	3.67	3.97	3.60	3.62	3.90
Vantharumollai	6.73	7.17	5.53	6.59	5.37	5.67	6.18

Table 3: Environmental index for 6 varieties at 6 locations (three month maturity group, wet 2001/ 02 season)

Location	Bg2845	Bg2834	At303	Bg305	Ld98–3	Bg300
Ambalantota	5.97	5.71	5.76	5.59	5.73	5.80
Ampara	6.63	6.42	6.44	6.48	6.56	6.51
Arulaganwila	4.02	3.87	4.05	3.94	3.96	4.00
Batalagoda	6.36	6.13	6.29	6.00	6.18	6.32
Bombuwela	3.87	3.77	3.94	3.88	3.96	3.95
Vantharumollai	6.07	5.98	6.31	6.09	6.34	6.28

[1]Rainfall in Sri Lanka is distributed bimodally. The period from September to February in the following year during which North–East monsoon brings the rain is called wet (Maha) season. The period March to August during which South–West monsoon brings the rain is called dry (Yala) season. Rewrite the all references list according the red example according the journal format???

Table 4: Mean yield and corresponding adaptability parameters estimated by fitting model (1) for varieties in three maturity groups grown in 2001/02 wet season

Variety	Yield (*t/ha*)	Specific Stability (r_{ge})	Regression coefficient (b_i)	Relative performance ($p_i = b_i - 1$)	Relative superiority ($s_i = p_i * r_{ge}$)
3 month					
Bg305	5.87	0.95***	1.19	0.19	0.18
At303	5.21	0.95***	1.06	0.06	0.06
Bg2834	5.95	0.97***	0.99	–0.01	–0.01
Bg300	5.14	0.98***	0.94	–0.06	–0.06
Ld98–3	5.26	0.93**	0.92	–0.08	–0.07
Bg2845	5.09	0.82*	0.77	–0.23	–0.19
3½ months					
Bw328–1	5.85	0.96***	1.58	0.58	0.56
Bg2879	5.08	0.95***	1.17	0.17	0.16
Bg2780	5.09	0.99***	1.11	0.11	0.11
Bg357	5.65	0.94**	1.09	0.09	0.08
Bg99–1046	5.32	0.88*	0.93	–0.07	–0.06
Bg300	4.65	0.95***	0.92	–0.08	–0.08
Bw99–1058	5.19	0.91**	0.78	–0.22	–0.20
Bg2835	4.65	0.80*	0.70	–0.30	–0.24
Bg359	4.94	0.91**	0.63	–0.37	–0.34
4 months					
Bg403	4.44	0.99***	1.06	0.06	0.06
Bg450	4.56	0.98***	1.05	0.05	0.05
Bg2893	4.41	0.99***	1.02	0.02	0.02
Bg379–2	4.95	0.99***	0.96	–0.04	–0.04
Bg2949–1	4.55	0.98***	0.95	–0.05	–0.05
Bg2937–2	4.27	0.99***	0.95	–0.05	–0.05

*, **,*** r_{ge} not significantly different from one ($P > 0.001$, $P > 0.01$ and $P > 0.05$, respectively)

Table 5: Mean grain yield and corresponding adaptability parameters estimated by fitting model (1) for varieties in three maturity groups grown in dry 2002 season

Variety	Yield (t/ha)	Specific Stability (r_{ge})	Regression coefficient (b_i)	Relative performance ($p_i = b_i - 1$)	Relative superiority $s_i = r_{ge} * p_i$
3 month					
Bg2845	4.31	0.98***	1.15	0.15	0.15
Bg2834	4.52	0.93**	1.04	0.04	0.04
Bg300	4.48	0.97***	1.03	0.03	0.03
At303	4.24	0.93**	0.94	–0.07	–0.06
Ld98–3	4.52	0.96***	0.90	–0.11	–0.10
Bg305	4.64	0.99***	0.88	–0.12	–0.12
3½ months					
Bg2880	4.84	0.90*	1.26	0.26	0.23
Bg358	5.57	0.90*	1.19	0.19	0.17
Bw1059	4.65	0.90*	1.05	0.05	0.04
Bg2836	5.36	0.95**	1.04	0.03	0.03
Bg2781	5.42	0.94**	1.03	0.03	0.02
Bg301	5.05	0.87*	0.94	–0.06	–0.06
Bw328–2	5.47	0.91*	0.82	–0.18	–0.16
Bw1047	4.74	0.74[a]	0.77	–0.23	–0.17
Bg360	5.28	0.97***	0.72	–0.28	–0.27
4 months					
Bg379–2	5.59	0.97***	1.30	0.03	0.29
Bg403	5.66	0.93***	0.98	–0.02	–0.02
Bg2949–2	5.51	0.99***	0.98	–0.02	–0.02
Bg2893	5.82	0.98***	0.95	–0.05	–0.05
Bg450	5.11	0.96***	0.94	–0.06	–0.06
Bg2937–2	5.20	0.98***	0.80	–0.20	–0.19

*, **,*** r_{ge} not significantly different from one ($P > 0.001$, $P > 0.01$ and $P > 0.05$, respectively).

a – r_{ge} significantly different from one models fitted for dry season, 3 and 4 month maturity groups had the minimum R^2 value of 85% while 3½ month maturity group had 55% as its minimum value.

Among the varieties under 3 month maturity group tested in the wet season, Bg305, At303 and Bg2834 obtained the first three places, respectively based on superiority along with a high stability level (Table 4) while Bg2845, Bg2834 and Bg300 obtained the first three places in the dry season (Table 5). However, the variety Bg2834 was sufficiently stable while other two were highly stable. The varieties Bg305 and Ld98-3 gave highest yield in the dry season with a high stability but ranked at the bottom because of their poor performance.

In the case of 3½ month maturity group tested in the wet season, although varieties had varying levels of stability, the varieties that occupied the first three places were very stable. The varieties Bw328–1, Bg2879 and Bg2780 obtained first three places respectively based on superiority. Although the varieties Bw99–1058, Bg357and Bg99–1046 recorded high grain yields they were low in superiority (Table 4).

The variety Bw1047 of 3½ month maturity group cultivated in the dry season appeared unstable while only variety Bg360 was highly stable. The varieties Bg2880, Bg358 and Bw1059 of 3½ month maturity group obtained the first three places based on superiority along with the satisfactory stability levels in dry season (table 5). In general, stability level of 3½ month maturity group in the dry season appeared low so that it has to be improved in the future.

All the varieties in the 4 month maturity group were found to be highly stable regardless of the season. Bg403, Bg450 and Bg2893 received the first three places, respectively in the wet season (Table 4) while Bg379–2, Bg403 and Bg2949–2 received the first three places, respectively in the dry season (Table 5).

Among the maturity groups, 3 month maturity group varieties had the highest grain yield (5.42 t/ha) and 4 month maturity group had the lowest yield (4.53 t/ha) during the wet season while it was reversed in the dry season. This is a different issue which needs further studies.

Value of the method illustrated in this article is that it uses only one parameter to select varieties for recommendation. Half of the varieties which have been ranked within first three places under all three maturity groups in both seasons based on superiority are already recommended varieties owing to their superior performances consistently over locations and seasons. This shows the validity of this method. Furthermore, present example shows that the method is easy to use, practically highly feasible, technically sound and useful.

CONCLUSION

The uniqueness of this method is that only one parameter (relative superiority) is finally used to evaluate the varieties. The parameter is based on stability and performance and thus the approach used in the method is very informative. The main advantage of this method is that an average agronomist/ plant breeder can use this method using available standard statistical software packages. Although the method is simple and easy to implement it can effectively select varieties with high adaptability.

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Appendix

```
DATA vrec;
INPUT loc$                      Bg2845   Bg2839   At303   Bg305   Ld983   Bg300   lmean;
ei1=(6*lmean-bg2845) / 5;       /* loc is to define the variable location*/
ei2=(6*lmean-bg2839) / 5;       /*lmean is the location mean*/
ei3=(6*lmean-At303) / 5;        /* ei1 to ei6 are the environmental indices for 6 varieties*/
ei4=(6*lmean-Bg305) / 5;
ei5=(6*lmean-Ld983) / 5;
ei6=(6*lmean-Bg300) / 5;
CARDS;
Ambalantota                     4.71     5.99     5.76    6.64    5.90    5.56    5.76
Ampara                          5.88     6.95     6.84    6.62    6.26    6.48    6.51
Arulaganwila                    3.76     4.47     3.60    4.14    4.03    3.85    3.97
Batalagoda                      5.46     6.63     5.84    7.28    6.38    5.68    6.21
Bombuwela                       4.02     4.51     3.67    3.97    3.60    3.62    3.90
Vantharumollai                  6.73     7.17     5.53    6.59    5.37    5.67    6.18
RUN;
PROC REG;
MODEL Bg2845=ei1;
MODEL bg2839=ei2;
MODEL at303=ei3;
MODEL bg305=ei4;
MODEL Ld983=ei5;
MODEL bg300=ei6;
RUN;
PROC CORR; VAR Bg2845 ei1; RUN;
PROC CORR; VAR Bg2839 ei2; RUN;
PROC CORR; VAR At303 ei3; RUN;
PROC CORR; VAR Bg305 ei4; RUN;
PROC CORR; VAR Ld983 ei5; RUN;
PROC CORR; VAR Bg300 ei6; RUN;
```