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PROCEEDING

INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION AND EDUCATION OF MATHEMATICS AND SCIENCES 2014

ICRIEMS 2014

Yogyakarta, 18-20 May 2014

Global Trends and Issues on Mathematics and Sciences and the Education

PROCEEDING

Conference Proceedings

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Global Trends and Issues
on Mathematics and Science
and The Education

Faculty of Mathematics and Natural Sciences
Yogyakarta State University

ICRIEMS 2014 : Global Trends and Issues on Mathematics and Science and The Education

- Mathematics & Mathematics Education
- Physics & Physics Education
- Chemistry & Chemistry Education
- Biology & Biology Education
- Science Education

Preface

Bless upon God Almighty such that this proceeding on International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS) 2014 may be compiled according to the schedule provided by the organizing committee. All of the articles in this proceeding are obtained by selection process by the reviwer team and already ben presented in the Conference on 18 – 20 May 2014 in the Faculty of Mathematics and Natural Sciences, Yogyakarta State University. This proceeding consists of 344 parallel papers, and comprises 9 fields, that is mathematics, mathematics education, physics, physics education, chemistry, chemistry education, biology, biology education, and science education.

The theme of ICRIEMS 2014 is 'Global Trends and Issues of Mathematics and Science and the Education'. The main articles in this conference are given by five keynote speakers, which are Prof. Dean Zollman (Physics Department, Kansas State University), Prof. David F. Treagust (Center of Education, Curtin University), Prof. Dr. Amy Cutter-Mackenzie (School of Education, Southern Cross University, Australia), Prof. Tran Vui (Hue University, Vietnam), and Asst. Prof. Dr. Duangjai Nacapricha (Faculty of Science, Mahidol University). The conference is also supported by the LPTK (Lembaga Pendidikan Tenaga Kependidikan) Forum from Faculty of Mathematics and Sciences that consists of 12 universities all over Indonesia. Each member of the Forum contributed one invited speakers, such that there are an additional 10 invited speakers presenting in the forum. Besides the keynote and invited speakers, there are also 344 parallel articles that presented the latest research results in the field of mathematics and sciences, and the education. These parallel session speakers come from researchers from Indonesia and abroad, including Malaysia and Australia.

Hopefully, this proceeding may contribute in disseminating research results and studies in the field of Mathematics and Sciences and the Education such that they are accessible by many people and useful for the Nation Building.

Yogyakarta, June 2014

The Editor Team

Forewords from The Head of Committee

Assalamu'alaikum wa Rahmatullahi wa Barakatuh
May God bless upon us.

Your excellency The president of UNY Prof. Dr. Rochmat Wahab, M. Pd., M.A., ladies and gentlemen, good morning and welcome to State University Yogyakarta. This seminar entitled International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS): global trends and issues on mathematics and science and the education is organized by the Faculty of Mathematics and Science, State University of Yogyakarta working together with 12 members of the Association of the Faculty of Math and Sciences from Teacher Education Program (LPTK). This seminar is also dedicated to the golden aniversary of UNY; 1 among 90 academic activities dedicated to the aniversary.

Ladies and gentlemen, on behalf of the committee of this conference, I would like to express highest appreciation and gratitudes to the keynote speakers, including:

1. Prof. David F. Treagust (Center of Science Education Curtin University)
2. Prof. Dean Zollman (Physics Dept, Kansas University, US)
3. Dr. Amy Cutter-Mackenzie (School of Education, Southern Cross University, Australia)
4. Asst. Prof. Dr. Duangjai Nacapricha (Faculty of Science , Mahidol University)
5. Prof. Tran Vui (College of Education, Hue University, Hue City, Vietnam)

Secondly, I would like also to give sincere thanks and gratitudes to the speakers from 10 College of Educations, including:

1. Universitas Negeri Surabaya (UNESA): Prof. Dr. Muchlas Samani, and 33 speakers
2. Universitas Negeri Jakarta (UNJ): Prof. Dr. Gerardus Pola, and 7 speaker
3. Universitas Pendidikan Indonesia (UPI): Dr. Hary Firman, and
4. Universitas Negeri Malang (UM): Prof. Effendi, Ph.D
5. Universitas Negeri Padang (UNP): Prof. Tjeerd Plomp
6. Universitas Negeri Semarang (UNNES): Prof. Dr. Supriyadi Rustad

7. Universitas Pendidikan Singaraja (UNDIKSA): Prof. Dr. I Nengah Suparta, M.Si
8. Universitas Negeri Makasar (UNM): Oslan Junaidi, Ph.D
9. Universitas Negeri Gorontalo (UNG): Prof. Dr. Sarson Pomalto, M.Pd
10. Universitas Negeri Yogyakarta (UNY): Dr. Jaslin Ikhsan

Next, I also would like to thanks to our special guests and speakers from:
1. Universitas Pendidikan Sultan Indris (UPSI), Malaysia
2. University of Mahidol, Thailand
3. University of Malaysia in Trengganu

Next, I would like to thanks and welcome to 379 speakers from the entire Indonesia and all participants registered in this seminar.

Ladies and gentlemen, recently the number of research and publication on mathematics and science and the education is vulnarable. It is nescessary for us to organise, to share, and to publish the results of the research in this conference. I hope the conference will bear fruitful results and promote networking and future collaborations for all participants from diverse background of expertise, intitutions, and countries to promote science, mathematics, and the education.

Finally, I am delighted to thank the committee members who have been working very hard to ensure the succes of the conference.

Please enjoy the conference and enjoy Yogyakarta, the city of education, tourism, and culture. Thank you very much.

Assalamu'alaikum wa rahmatullahi wa barrakatuh

Dr. Slamet Suyanto, M. Ed.

Forewords from The Dean of Faculty of Mathematics and Natural Sciences, Yogyakarta State University

Assalamu'alaikum warahmatullahi wabarakatuh

May peace and God's blessings be upon us all.

On behalf of the Organizing Committee, first of all allow me to extend my warmest greeting and welcome to the International Conference on Research, Implementation, and Education of Mathematics and Sciences 2014, held in Yogyakarta State University, one of the qualified education universities in Indonesia.

To celebrate the 50th Commemoration of Yogyakarta State University, our faculty, in collaboration with Forum of MIPA LPTK, has the opportunity to conduct International Conference on Research, Implementation, and Education of Mathematics and Sciences 2014. This conference proudly presents five keynote speeches by five fabulous speakers: Prof. Dean Zollman, Prof. David F. Treagust, Prof. Dr. Amy Cutter-Mackenzie, Prof. Tran Vui, and Asst. Prof. Dr. Duangjai Nacapricha, around 380 parallel speakers with 344 orally presented articles.

Distinguished guest, ladies and gentlemen,

The independence of a country is impossible to gain if the education does not become the priority and it is not supported with the development of technology. We all know that the technology development could be achieved if it is supported by the improvement of firm fundamental knowledge. The empowerment of fundamental knowledge could not be separated from research which is related to the development of technology and the learning process in school and universities.

This conference is aimed to pull together researchers, educators, policy makers, and practitioners to share their critical thinking and research outcomes. Therefore, we are able to understand and examine the development of fundamental principle, knowledge, and technology. By perceiving the matters and condition in research and education field of mathematics and sciences, we could take a part in conducting qualified education to reach out the real independence of our nation.

Distinguished guest, ladies, and gentlemen

This conference will be far from success and we could not accomplish what we do without the support from various parties. So let me extend my deepest gratitude and highest appreciation to all committee members. I would also like to thank each of participants for

attending our conference and bringing your expertise to our gathering. Should you find any inconveniences and shortcomings, please accept my sincere apologies.

To conclude, let me wish you fruitful discussion and a very pleasant stay in Yogyakarta.

Wa'alaikumsalam warahmatullahi wabarakatuh

Dr. Hartono

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ADDITIVE MAIN EFFECT AND MULTIPLICATIVE INTERACTION ON FIXED MODEL OF TWO FACTORS DESIGN

Suwardi Annas and Selfi Dian Purtanti

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Abstract

Multilocation trials is usually conducted to study the factors effect of genotype and environment including their interaction in order to increase the yield of crops. The environment can be considered as giving different doses of fertilizers to each genotype. The present study was aimed to investigate both additive main and interaction effects on fixed model of two factors design. As the application, the study used a dataset of the yield of paddy in four varieties (IR8, IR5, C4-63, and PETA) given nitrogen fertilizer with six different doses (N_0, N_1, N_2, N_3, N_4, and N_5). The first step of analysis was estimating variance component using fixed model ANOVA (*Analysis of Variance*). Then, AMMI (*Additive Main Effects and Multiplicative Interaction*) model was applied which is the combination of additive main effect and the principal component analysis (PCA) of interaction effect. The result of study shows that the variance component has positive value for all factors of treatment. AMMI analysis produces AMMI-2 as the best model at the significant level of $\alpha = 0.05$. The biplot of AMMI-2 obtained that IR5 can adapt to nitrogen fertilizer in any level. Spesific interaction occurs in variety C4-63 in nitrogen N_4 level, variety IR8 in nitrogen N_5 level, and variety PETA in nitrogen N_0 level. Based on the result of study, it can be concluded that the use of AMMI fixed model in two factors design can effectively explain the effect and the pattern of interaction structure among treatment factor levels.

Keywords: AMMI, ANOVA, Genotype, Multilocation, PCA

Introduction

Factorial experimental design such as multi-location trials is often used in plant breeding research to examine the interaction of treatment factors. The factors are involved in multi-location trials, namely genotype and location. Location here can be interpreted as different doses fertilizers in a particular environment. Therefore, with this multi-location trials, stability of genotypes in a variety of different environments or adaptation of genotypes to specific environmental can be known.

In agriculture, grain yield which is not consistent with the environment changes is an indication of the interaction of genotype and environment. Carelessness in analysis of the genotype and environment interaction may lead to the removal of high yielding varieties in the selection process. Various methods have been used for the analysis and to assess the stability of a genotype result in a wide range of environments. The reliability of the analysis will be able to provide accurate conclusions in selecting high yielding genotypes and able to adapt to environmental conditions. The common statistical analysis applied to the multi-location trials is Additive Main Effects and Multiplicative Interaction (AMMI). AMMI method is a combination

of analysis of variance (ANOVA) for the main effect and principal component analysis (PCA) for interaction effects (Matjjik, 1996 and Widiastuti, 2010).

ANOVA in the AMMI method aims to determine whether there is any effect of varieties to different fertilizers doses. According to Steel & Torrie in Mattjik (1998), analysis of variance is an arithmetic process to decompose the total sum of squares into components associated with a known source of variation. Flexibility and the ability to decompose the diversity of interaction effects AMMI models using analysis based on principal component analysis which statistically has been able to sort out the effect of the interaction of the components that are orthogonal principal. In accordance with the definition of principal component analysis by Johnson and Wichern (1996) and Matjjik (2004), which attempts to reduce the *p* variable observation into *k* new variable which is orthogonal that each of the *k* new variables are linear combinations of the *p* old variables.

Furthermore, in presenting the pattern of genotyping scatter plots with the relative position to the various doses of fertilizer, the singular value decomposition were plotted between one genotypes component with fertilizer component simultaneously. A display in the form of plot is so-called biplots. AMMI analysis thus can improve the accuracy of the alleged response by genotype environment interaction and AMMI able to summarize the patterns and relationships between genotypes, environments, and the interaction both of genotype and environment.

Based on the problem described above, the objectives of this study were (1) to estimate the mean square of the expected value and variance components and (2) to apply AMMI models to the paddy crop yield.

Materials and Methods

As an illustration of the application, this study used the data in the form of paddy crop yield of 4 (four) varieties (IR8, IR5, C4-63, and PETA) were given nitrogen fertilizer with 6 (six) different doses (N_0, N_1, N_2, N_3, N_4, and N_5). This data was obtained from the book of Statistical Procedures for Agricultural Research, Second Edition by Kwanchai A. Gomez and Arturo A. Gomez, 1995.

In developing AMMI model, firstly, the mean square value estimation and variance components were made in the design of two-factor model of paddy crop yield. According to Suwardi *et al*., (2001), the method used to estimate the mean square of expected value and variance components in the design of the two-factor is the method of two-factor ANOVA with interaction. The design is as follows.

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}, (i=1,2,\ldots g; j=1,2,\ldots l; k=1,2,\ldots r) \qquad (1)$$

where:

Y_{ijk} : an observed value for factor A i-th level, factor B j-th level, and in k-th level
μ : overall mean
α_i : effect of factor A in i-th level
β_j : effect of factor B in j-th level
$(\alpha\beta)_{ij}$: effect of interaction AB in i-th level and j-th level
ε_{ijk} : trial errors

Model assumptions, namely; error (ε_{ijk}) is a random effect that spreads normally, to the fixed model: $\sum_{i=1}^{g} \alpha_i = 0, \sum_{j=1}^{l} \beta_j = 0\,, dan\ \sum_{k=1}^{r} (\alpha\beta)_{ij} = 0,$ (Sumantri, 1997).

Furthermore, ANOVA was also used to determine the effect of the main and interaction effects. In this stage, the effect of the interaction is decomposed into several principal components which are significant at the level of $\alpha = 0.05$, that resulting AMMI models.

Basically AMMI models incorporate additive analysis of variance for the main effect of treatment with multiple principal component analysis with bilinear modeling for the interaction effect (Zobel and Crossa in Sumertajaya, 2007) and (Matjjik, 2998). Therefore, the complete AMMI models can be written as follows:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \sum_{n=1}^{m} \sqrt{\lambda_n} \varphi_{in} \rho_{jn} + \delta_{ij} \qquad (2)$$

where: $\sqrt{\lambda_n}$ is the singular value for the n-th bilinear component ($\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_n$, φ_{in} is a ripple effect of factor A i-th level through the bilinear component n-th, ρ_{jn} is a double impact factor B through bilinear component n, δ_{ij} is the deviation from bilinear modeling.

In AMMI modeling, the additive effect of factor A and factor B and the sum of the squares and the mean square is generally calculated as the analysis of variance, but based on the average by a factor A to factor B. The results of the calculation of the sum of squares, mean squares and principal component interactions can arranged in a structure AMMI ANOVA. To interpret the results of the AMMI analysis, biplot method will be used by overlapping vectors in two-dimensional space. AMMI biplot will explain stable adapted varieties to different environments or adapt to a specific environment.

Results and Discussion

Estimating the expected value and the mean square of the variance component with ANOVA fixed models method to the data on grain yield of four rice varieties by giving six different nitrogen doses resulted in a positive variance components (Table 1). These results indicate that the method can be used to estimate for the variance component data used.

Table 1. Estimation of Mean Square Expected Values and Variance Component

Source of Variance	Mean Squares Expected Value	Variance Component
α	$18{\sigma_\alpha}^2 + {\sigma_\varepsilon}^2$	1647132,51
β	$12{\sigma_\beta}^2 + {\sigma_\varepsilon}^2$	480960,40
$\alpha\beta$	$3{\sigma_{(\alpha\beta)}}^2 + {\sigma_\varepsilon}^2$	1436194,65
ε	${\sigma_\varepsilon}^2$	314315,18

Furthermore, to apply AMMI method, the analysis of variance is done to determine the main factor effect of paddy varieties and the main factor effect of nitrogen fertilizer. The results of the analysis of variance in Table 2 shows that the main effect (varieties and fertilizers) and the interaction effect significantly at the level of $\alpha = 0.05$. These results indicate that the grain yield of paddy varieties influenced by the factors of nitrogen fertilizer. That is why AMMI analysis is needed to identify paddy varieties that interact positively with certain nitrogen doses.

Table 2. Two Factors ANOVA for both Varieties and Fertilizer

Source of Variance	Degree of Freedom	Sum of Square	Mean Square	*F*-value	*p*-value
Varieties (paddy)	3	89888101,15	29962700,38	95,32	0.0001

Fertilizer (nitrogen)	5	30429199,57	6085839,91	19,36	0.0001
Interaction	15	69343486,93	4622899,13	14,70	0.0001
Error	48	15087128,7	314315,18	-	-
Total	71	204747916,3	-	-	-

The process of singular value decomposition (SVD) of the interaction effect produced six singular values. The variance contributions of all principal components (PC) for the AMMI models are shown in Table 3.

Table 3. Contributions of Variance for the Principal Component of AMMI Model

PC	Singular Value	Eigen Value	Proportion	Cumulative
1	4647,92	21603189,14	0,94	0,94
2	1156,68	1337908,16	0,06	0,99
3	416,42	173401,24	0,01	1,00
4	1,247e-13	1,55e-26	0,00	1,00
5	0,00	0,00	0,00	1,00
6	0,00	0,00	0,00	1,00

The results of ANOVA for AMMI are obtained by the contribution of the diversity of the main components in Table 3 above can be presented in Table 4. Results of ANOVA are obtained two components with a *F*-value = 29.45 and *p*-value = 0.0001 at the significant level of $\alpha = 0.05$ on the first principal component. Similarly, the second principal component of the interaction is significant level at $\alpha = 0.05$ level with a *F*-value = 2.55 and *p*-value = 0.0001. These results show that the first two of PC are significant, so that the model AMMI-2 is applicable. This indicates that the data are four varieties of paddy grain yield of six nitrogen level can be explained by using a model AMMI-2 as the best model.

Table 4. ANOVA of AMMI-2 Modeling

Source of Variance	Degree of Freedom	Sum of Square	Mean Square	*F*-value	*p*-value
Varieties (paddy)	3	89888101,15	29962700,38	95,32	0.0001
Fertilizer (Nitrogen)	5	30429199,57	6085839,91	19,36	0.0001
Interaction	15	69343486,93	4622899,13	14,70	0.0001
PC-1	7	64809567,42	9258509,63	29,45	0.0001
PC-2	5	4013724,48	802744,90	2,55	0.0001
Deviation	3	520195,03	65024,38	-	-
Error	48	15087128,70	314315,18		
Total	71	204747916,30	-	-	-

Fig. 1 shows the biplot between PC-1 with PC-2. This biplot explained that the paddy varieties type C4-63, IR5, and IR8 have a major effect which is relatively the same because they are on the same vertical line. Furthermore, C4-63 and IR5 have the same relative effect of the interaction as it is located on a horizontal line. Similarly, IR8 and PETA also have a relatively similar interaction effect.

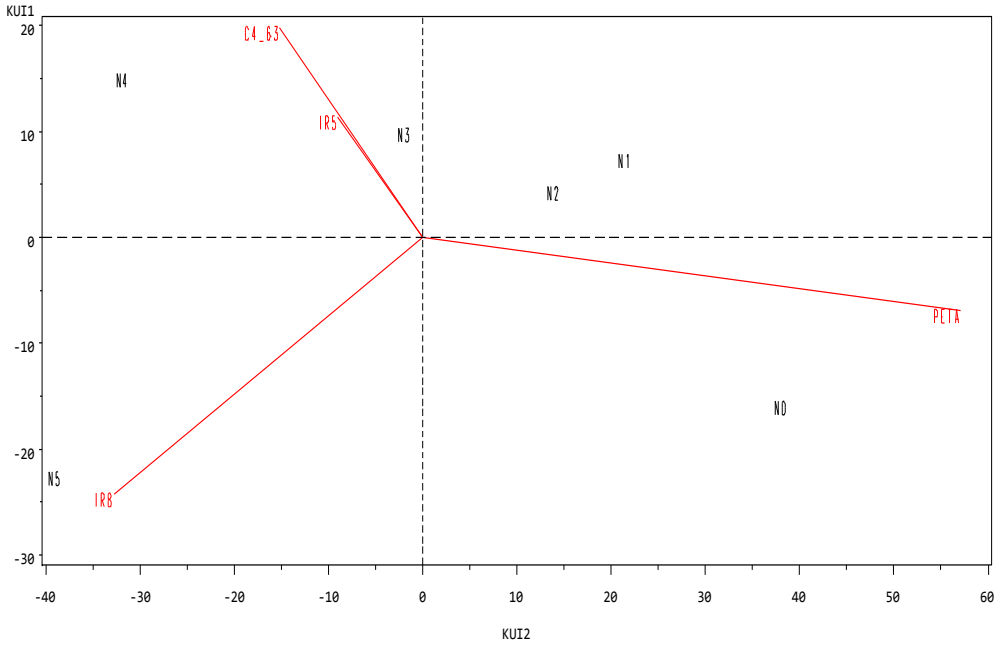

Figure 1. Biplot of AMMI-2 Model

Nitrogen doses $N_3, N_4,$ and N_5 have main effect which is relatively the same but have different interactions effect. In $N_0, N_1,$ and N_2 also have the same main effect, but N_0 has different effect interactions. PETA varieties are positively interact with $N_0, N_1,$ and N_2 because having the same direction. Similarly, varieties of C4-63, IR5 and IR8 are positively interact with $N_3, N_4,$ and N_5.

Biplot PC-1 with PC-2 also shows that IR5 is having a diversity at a relatively small so that all levels of nitrogen can be applied well on the rice varieties. In other words, IR5 was widely adaptable to all levels of nitrogen. While IR8 and PETA have specific adaptations to particular nitrogen level because it is at the furthest point of intersection of the zero point. Furthermore, C4-63 variety is specifically interacted at the level of nitrogen N_4, IR8 variety is specifically interacted at the level of nitrogen N_5, and the PETA variety is specifically interacted at the level of nitrogen N_0.

Conclusion

The results of the variance component estimators give a positive value on each factor effects of treatment. Therefore, ANOVA fixed models method can be used to assume variance components for data of grain yield of four paddy varieties to six nitrogen doses level. ANOVA resulted in a real effect on the significant level at $\alpha = 0.05$ for the main effects of varieties of fertilizers and nitrogen doses as well as their effect of interactions.

Based on the ANOVA for the AMMI models, it produces two main components interaction significant at the level 0.05 significance level in order to obtain a model AMMI-2 which is the best model. AMMI-2 biplot interpretation is concluded that IR5 has the diversity of a relatively small so that it can adapt to all levels of nitrogen wide. The specific interaction occurs in C4-63 varieties at the level of nitrogen N_4, IR8 varieties at the level of nitrogen N_5, and PETA varieties at the level of nitrogen N_0.

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