Implementation of Multivariate Analysis of Variance (MANOVA) in experiments factorial two factors (Study: Growth and development of soybean germination)

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Abstract. Soybean is a type of leguminous plant that contains many essential substances for the health of the body, high protein, vitamins and many spread in Indonesia. The economical part of soybean plants is the seeds, which are widely used as raw materials for tofu and tempeh. Variant Analysis with Multiple Variables (Manova) is a multivariate statistical method used to analyze data from more than one variable with an interval or ratio scale, while the independent variable consists of two or more groups, where all of these variables are analyzed simultaneously or together. The purpose of this study was to obtain a linear model based on the source of diversity derived from the design used, the source of diversity and compile it into the variance table, and the main influence of the factors and the interaction effects of the combination treatment. This study is a repeat observation experiment with a two-factor factorial basic design. This kind of design is called factorial design in RAL time. The first factor is the light intensity consisting of 3 levels, namely bright, dim, and dark. The second factor of the planting medium consists of 3 levels, namely husk ash, soil, and cotton. The responses observed were growth and development of soybean germination. Observations carried out for 5 days. The number of combinations of treatments was 7. The experiment was repeated 2 times so that the experimental units were 14 units. Based on the results of the source of diversity, a linear model is formed:

\[ Y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \delta_{ijkl} + \omega_k + \alpha\omega_{ik} + \beta\omega_{jk} + \alpha\beta\omega_{ijk} + \epsilon_{ijkl}, \]

where \( i = 1,2,3; j = 1,2,3; k = 1,2; \) and \( l = 1,2,3,4,5. \) Linear models are formed from total diversity. The total diversity that is the source of diversity comes from the main effect of treatment, the interaction effect of the treatment combination and the effect of the error. From the variance table, it can be concluded that the sun’s rays intensity factor (A), planting media factor (B), time (C), factor A*B interaction, factor A*C interaction, factor B*C interaction, factor A*B*C interaction has a significant effect on the response observed which is indicated by the acquisition of \( F_{hitung} > F_{table} \) with a real level of 5%.

1. Introduction
Soybeans are a type of leguminous plant which contains many essential substances for the health of the body, high protein, vitamins and many in Indonesia. The commercial part of soybean plants is the seeds, which are widely used for raw materials of tofu and tempeh. Soybean seeds grown in certain media will grow and develop into sprouts. Germination is one of the stages included in the process of growth and development of grains into new plants. Internal and external factors influence germination of seed. Growth is a process that is characterised by an increase in the number of cells and an increase in cell volume that is not able to shrink again [1].

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In analysing the results of research, for example, variance analysis, sometimes forget to test the data to be examined, especially for tests involving real tests, because in analysing the assumptions underlying the analysis of variance must be fulfilled [2]. This needs to be considered because if one or more premises are not met can affect both the actual level and the F or t-test, there is a real deviation from the null hypothesis. For example in the case of an experimental error that does not meet the assumption of normality, the actual real level is more significant than stated. This results in the possibility of the null hypothesis being rejected the hypothesis actually is greater. So the non-fulfilment of assumptions will result in sensitivity in testing [3].

One factorial experiment to find out the existence of collaboration between interaction factors from a two-factor experiment or more is a multiple-location experiment. Multilocation experiments play an important role in plant breeding and agronomic studies [4]. The data obtained from this experiment have at least three main objectives in agriculture, namely the accuracy of estimation and forecasting results based on limited experimental data, determining yield stability and genotitive response patterns or agronomic treatment of the environment and genotyping or the best agronomic treatment to be developed in the future upcoming or new location.

Observation of the growth and development of soybean germination requires time. Experiments involving long enough time are called repeated observation experiments with two basic factorial design and use environmental design, namely a completely randomised design. This kind of design is a factorial design in a completely randomised design (CRD) [5].

According to Rohmah and Saputro [1] inundation stress affects plant growth. this is indicated by a decrease in some growth parameters. The most significant decrease occurred in the treatment of inundation stress with 200% inundation concentration. This shows that the planting media is very influential on the growth of soybeans. Meanwhile, according to Sinuraya et al. [6] the treatment of 40 ml POC concentrations tended to have increased soybean production in almost all observation variables. How to administer POC by watering tends to increase soybean production in all observation variables, which means that fertilizer application affects soybean growth.

In another study of the Manova test in Completely Randomized Design (CRD), Saleh [7] said that there were significant differences in the number of leaves and the weight of tobacco leaves which were influenced by the spacing. This is similar to what was conveyed by Wahyuningsih, Proklamasiningsih, and Dwianti [8] that the growing media with uptake of humic acid had an effect on the growth of soybean plants.

Based on this background, the authors intend to conduct scientific research with the title Implementation of Multiple Variant Variant Analysis in Factorial Two Factor Experiments (Case Study: Growth and Development of Soybean Germination) [9].

2. Method

Sources of data used in this study are experiment. The type of data used is quantitative data, that is, the data of the dependent variable is obtained from the growth of the length of the soybean germination rod, while the qualitative data is the independent variable data obtained from soybean development described descriptively through tables and graphs.

Research variables in this experimental design are:

- The independent variable is a variable made differently, in this case, the place is bright, dim and dark as a factor of light intensity. In husk ash, soil, and water with cotton as planting media. In the planting medium that has been planted with peanuts placed in a bright, dim and dark place.
- The dependent variable is the variable studied and occurred due to the influence of the independent variable. In this case is the speed of growth and the development of soybean germination by measuring the length of the stem formed in cm using the ruler and time. No other variables were controlled in this study. The watering treatment of soybean growth is assumed to be the same.
The technique carried out by the researcher in reviewing the data that has been obtained is by using factorial RAL, repeated observation with the help of the software program, Minitab 16. The analysis techniques used in this study are as follows:

- Describe the response data for each treatment combination by using graphs and tables.
- The design that will be used in this study there is 2 factors, namely light intensity (A) and planting media (B). The experimental unit used was relatively uniform, so the researchers used the repeated observation design method.
- Data processing and data analysis in this study are to use the SAS program and Minitab 16.
- The results of the factorial variance analysis in the time using the SOFTWARE will obtain the \( F_{\text{count}} \) value and the \( F_{\text{Table}} \) value for the interaction between light intensity and the planting medium comparing the \( F_{\text{count}} \) value with the \( F_{\text{Table}} \) value so that a decision based on the decision will be concluded.

3. Results and discussion
Soybeans are a type of leguminous plant which contains many essential substances for the health of the body, high protein, vitamins and many in Indonesia. People often process it into various foods, such as tofu and tempeh. In this experiment, before the soybean seeds are planted first choose soybean seeds so that the soybean seeds used are considered to have uniform quality.

In this experiment, the response is the growth and development of soybean germination. This experiment is a factorial experiment with repeated observations in which the treatment consists of a combination of levels of several factors.

The data used is the two-factor factorial experiment data with the environmental design is RAL. The two factors are the light intensity factor (A) which has three levels, namely bright, dim and dark and the media planting factor (B) which also has three levels, namely husk ash, soil and cotton. So that the number of treatment combinations is 7. Where each combination of treatments is repeated two times. Then the number of experimental units in this study is \( 7 \times 2 = 14 \) experimental units.

![Figure 1. Giving treatment for soybeans.](image)

| Combination of Treatment | Soybean Growth (cm) |
|--------------------------|---------------------|
| Growing media (B)        | Test 1              | Test 2              |
| Light intensity (A)      | H1      | H2      | H3      | H4      | H5      | H6      | H7      | H1      | H2      | H3      | H4      | H5      | H6      | H7      |
| Ash Husk                 | Bright   | 0       | 0       | 0,2     | 0       | 1,3     | 0       | 2,4     | 0       | 2,6     | 0       | 0       | 0,4     | 1       | 1,7     | 2,4     | 2,6     |
|                         | Dim      | 0,1     | 1,4     | 1,6     | 1,9     | 2,1     | 2,6     | 2,8     | 0,8     | 1,6     | 1,9     | 0       | 4,1     | 1,7     | 2,1     | 2,6     |
|                         | Dark     | 0,1     | 1,4     | 1,7     | 1,9     | 2,3     | 2,7     | 3       | 1,3     | 1,7     | 2       | 2,3     | 2,7     | 3       | 4,2     | 3,8     |
| Soil                    | Bright   | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
|                         | Dim      | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
|                         | Dark     | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Cotton                  | Bright   | 0,6     | 0,8     | 1,4     | 2,1     | 2,6     | 2,7     | 0,6     | 0,8     | 1,4     | 2,1     | 2,6     | 2,7     | 0       | 1       | 1,6     | 2,4     |
|                         | Dim      | 0,8     | 1,2     | 1,8     | 2,4     | 3       | 3,4     | 0       | 1       | 1,6     | 2,4     | 3       | 3,2     | 3,8     | 3       | 3,8     |
|                         | Dark     | 1,2     | 1,9     | 2,5     | 3       | 3,4     | 3,8     | 0       | 1,2     | 1,9     | 2,6     | 3       | 3,8     | 4,2     | 3       | 3,8     |

Table 1. The growth and development of soybean germination.
Before doing the analysis first test the assumptions in the research data. The assumptions made in this study are the test for normality and a similar test.

![Normal Probability Plot](image1)

**Figure 2.** Normality Test.

![Versus Fits Plot](image2)

**Figure 3.** Homogeneity Test

The design of the experiment with repeated observations is carried out by measuring the response of the experimental units repeatedly at different times. Experiments of repeated observations require an analysis model of the basic design model, the treatment attempted is expected to see the growth and development of the response during the study. The influence of time is very useful for the treatment given. Experiments like this are named according to the basic design used additional time as a basic design that is used factorially in time.

### 3.1. Soybean growth response

In the experiment, soybean growth was carried out by measuring the response of experimental units repeatedly at different times [10]. Based on the results of $F_{Calculate}$ in the table of analysis of variance, it is obtained the value of $F_{Calculate}$ the light intensity factor (A) of 9.7998, when compared with $F_{Table}$ of light intensity factor (A) with a 3.5545 value, the F value of the light intensity factor (A) is greater than
value of light intensity factor (A) which means that the null hypothesis is rejected, which means that the light intensity factor (A) affects the growth of soybeans with a level of 5%.

In the table analysis of variance obtained F value Calculate planting media factor (B) of 53.5650, when compared with F_table planting media factor (B) which is 3.5545 then the F value of Calculating the planting media factor (B) is greater than the F_table value of media factors planting (B) which means that the null hypothesis is rejected, which means that the planting media factor (B) affects the growth of soybean at a level of 5%.

In the table analysis of variance obtained the value of F_calculate the interaction of light intensity factor (A) and planting media factor (B) of 3.19236, when compared with F_table interaction of light intensity factor (A) and planting media factor (B) which is 2.9277 F value Calculates the interaction of light intensity factor (A) and planting media factor (B) greater than the value of F_table interaction of light intensity factor (A) and planting media factor (B) which means that the null hypothesis is rejected, which means the interaction of light intensity factor (A) and the planting media factor (B) has an effect on soybean growth with a level of 5%.

In the table of variance analysis obtained the value of F_count time (C) of 121.0152, when compared with F_table time (C) which is valued at 19.40932 then the value of F Time Count (C) is greater than the time value of F_table (C) which means that the hypothesis zero is rejected, which means time (C) affects the growth of soybeans at a level of 5%.

In the table of variance analysis obtained the value of F_calculate the interaction of light intensity factor (A) and time (C) of 35.2723, when compared with F_table interaction of light intensity factor (A) and time (C) which is 7.35844 then the value of F_calculate the interaction of factors light intensity (A) and time (C) is greater than the value of F_table interaction of light intensity factor (A) and time (C) which means that the null hypothesis is rejected, which means the interaction of light intensity factor (A) and time (C) influences on soybean growth with a level of 5%.

In the table of variance analysis obtained the value of F_calculate the interaction of planting media factors (B) and time (C) of 35.2723, when compared with F_table interaction of planting media factors (B) and time (C) which is 35.2723 then the value of F_calculate the interaction of factors planting medium (B) and time (C) is greater than the value of F_table interaction of planting media factors (B) and time (C) which means that the null hypothesis is rejected, which means the interaction of the planting media factor (B) and time (C) influences to the growth of soybeans with a level of 5%.

In the table of variance analysis obtained the value of F_calculate the interaction of light intensity factor (A), planting media factor (B) and time (C) of 2.22845, when compared with F_table interaction of light intensity factor (A), planting media factor (B) and time (C) which is 2.28245 then the value of F_calculate the interaction of factors light intensity (A), planting media factor (B) and time (C) which means that the null hypothesis is rejected, which means the interaction of light intensity factor (A), planting media factor (B) and time (C) affects the growth of soybean at a level of 5%.

Based on the results of the source diversity, a linear model is formed: $Y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \delta_{ijkl} + \omega_k + \alpha\omega_{ik} + \beta\omega_{jk} + \alpha\beta\omega_{ijk} + \epsilon_{ijkl}$ where $i = 1, 2, 3; j = 1, 2, 3; k = 1, 2; \text{and} \ l = 1, 2, 3, 4, 5$ which means $Y_{ijkl}$ is the value of soybean growth due to light intensity factor (A) level I, planting media factor (B) level j, test k and time of observation l, $\mu$ is a general effect, $\alpha_i$ is the main effect of light intensity factor (A) level i, $\beta_j$ is the general influence of the growing media factor (B) the level of j, $\alpha\beta_{ij}$ is the effect of the interaction of the light intensity factor (A) with planting media factor (B), $\delta_{ijkl}$ is a random treatment component, $\omega_k$ is the influence of the 1st observation time, $\alpha\omega_{ik}$ is the effect of the interaction of the light intensity factor (A) with time, $\beta\omega_{jk}$ is the effect of the interaction of the planting media factor (B) with time, $\alpha\beta\omega_{ijk}$ is the effect of the interaction of the light intensity factor (A), the growing media factor (B) with time, $\epsilon_{ijkl}$ is a random component of the interaction of time with treatment.

The source of diversity comes from the main effect of the treatment, the interaction effect of the treatment combination and the effect of the error. Analysis of variance obtained by the value of F
Calculate each factor of light intensity (A) is 9.7998, planting media factor (B) is 53.5650, interaction of light intensity factor (A) and planting media factor (B) is 3,19236, time is 19.40932, interaction of light intensity factor (A) and time is 7.35844, interaction of planting media factor (B) and time is 35.2723, and the interaction of light intensity factor (A), planting media factors (B) and the time is 2,28245 when compared with the F<sub>Table</sub> value of each light intensity factor (A) is 3,5545, the planting media factor (B) is 3,5545, the interaction of light intensity factor (A) and media factors planting (B) is 2,927744, time is 2,661305, interaction of light intensity factor (A) and time is 1,856621, and interaction of light intensity factor (A ), planting media factor (B) and time is 1,633713 that the results obtained from F<sub>Calculate</sub> > F<sub>Table</sub> art this has a significant effect on soybean growth or significant with a significant level of 5%.

From the experiment, repeated observations obtained the main influence, the effect of interaction of the light intensity factor (A) and the interaction of planting media factors (B), the interaction effect of light intensity factor (A) and time (C), the influence of the interaction of media planting factors (B) and time (C), the effect of the interaction of the light intensity factor (A), and the interaction of the media planting factor (B) with time (C), and error error.

3.2. Soybean development response

The development of soybeans in bright light or exposed to direct sunlight appears to be fast growing on cotton, and husk ash was growing media because in cotton and husk ash can store water content longer while in the growing media the soil is slow to grow because it does not store moisture.

Soybeans planted in the dim or not exposed to direct sunlight grow quickly but the roots and stems are not strong, the colour of the stems and leaves are pale to bend in the direction of unhealthy growing sunlight.

Soybeans are grown in a darker place to grow faster than they are planted in a bright and dim place, but the roots and stems are not strong, the colour of the stems and leaves are pale to bend in the direction of unhealthy sunlight.

4. Conclusion

Based on the results of the research that has been carried out with the analysis design of variants of the two RAL factors with the design of repeated observations, it can be concluded that the source of diversity comes from the main effect of the treatment, the interaction effect of the treatment combination and the effect of the error. Analysis of variance obtained by the value of F<sub>Calculate</sub> each factor of light intensity (A) is 9.7998, planting media factor (B) is 53.5650, interaction of light intensity factor (A) and planting media factor (B) is 3,19236, time is 19.40932, interaction of light intensity factor (A) and time is 7.35844, interaction of planting media factor (B) and time is 35.2723, and the interaction of light intensity factor (A), planting media factors (B) and the time is 2,28245 when compared with the F<sub>Table</sub> value of each light intensity factor (A) is 3,5545, the planting media factor (B) is 3,5545, the interaction of light intensity factor (A) and media factors planting (B) is 2,927744, time is 2,661305, interaction of light intensity factor (A) and time is 1,856621, and interaction of light intensity factor (A ), planting media factor (B) and time is 1,633713 that the results obtained from F<sub>Calculate</sub> > F<sub>Table</sub> art this has a significant effect on soybean growth or significant with a significant level of 5%.

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