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Implementation of Response Surface Methodology on a 4x4x2 Factorial Experiment with Completely Randomized Design of Weight Garlic Bulbs

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Abstract

The purpose of this study was to determine the variables that lead to optimum weights onion bulbs. Independent variables were observed temperature, GA3, and time. And the observed response is the weight of onion bulbs. ANOVA results of significant factorial experiment is temperature, GA3, and the interaction between temperature with GA3. The resulting response surface model $y = 2.45 + 0.04918\, x_1^3 + 0.18502\, x_2 - 0.05215\, x_2^3 - 0.09014\, x_1^3 x_2^2$, *with all the significant coefficient.* x_1^3 *the temperature effect on cubic,* x_2, x_2^3 *influence of* GA_3 *on linear and cubic, and* $x_1^3 x_2^2$ *interaction the temperature effect on cubic and quadratic* GA_3*. Variables that lead to optimum weight of onion bulbs are located in the code* GA_3 *1.5 and cubic level of* GA_3 *level code that is located at -1.5. Namely the provision of* GA_3 *at 30 ppm, and the maximum value of 2.90 for response.*

Keywords: *Response surface methodology, factorial experiments, completely randomized design.*

I. INTRODUCTION

The presence of onions for the community will become increasingly important seen from the way entrepreneurs at the level of smallholders and short-lived plant life. This makes the onion farming effort less seasonal, but onion planting is always done at all times. With the intensification of this effort, so many farmers lack of seeds, because the seeds provided are not directly used but must be stored first. This long storage time includes a disadvantage in terms of the farming system. Older storage aims to eliminate dormancy. The probable cause of dormancy is the unbalanced hormone balance, perhaps this can be overcome by the administration of temperature and concentration and the duration of GA_3 administration. So it is necessary to investigate whether these factors can break dormancy so as to accelerate growth.

The purpose of the experiment is to obtain information about how the response given by an object in certain circumstances to be noticed. Certain circumstances are usually something deliberately created or inflicted, either through treatment.

The experimental design discussed earlier is limited to factors or levels that have a significant or significant effect on the response. In fact, the double comparison test which is a further test of the experimental design that determines the difference between levels can only indicate a maximum or minimum response value that is confined to the levels tested only. In more recent studies, researchers sometimes are not sufficient simply by determining the maximum or minimum response rate of the tested levels only, since the maximum or minimum value may be present between the intervals of the tried levels. Therefore, it takes a method that can support those needs. One is the surface response method.

In each experiment, several combinations of treatments were conducted to find out which combination of treatments gave optimum results. To understand how far an optimum process is influenced by a number of variables is used Response Surface Methodology. This method is in principle a technique that includes regression analysis and experimental design to solve optimization problems. The basic idea of this method is to use experimental design with the help of statistics to find the optimal value of a response. This method is in principle a technique that includes regression analysis and experimental design to solve optimization problems (Box and Hunter, 1978).

Response surface Methodology is a set of mathematical and statistical techniques that are useful to analyze the problems which some independent variables affect the response variable and the ultimate objective is to optimize the response (Montgomery, 2001). Response surface Methodology was related with factorial experiment. The factorial experiment is an experiment whose treatment consists of all possible combinations of levels of several factors .

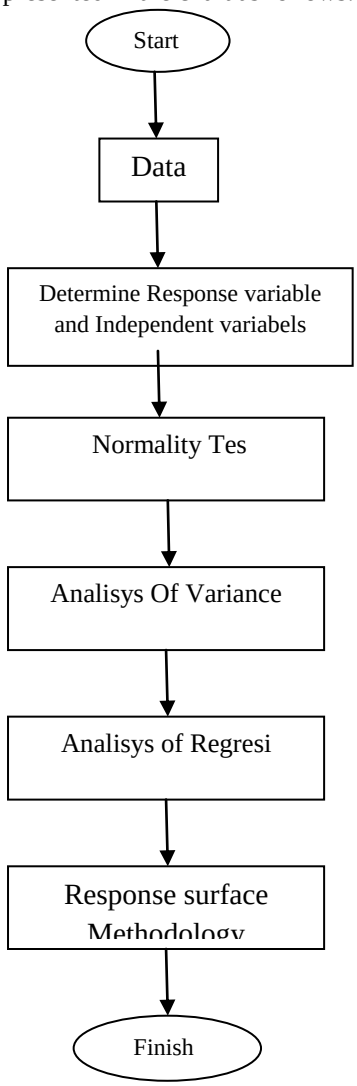
The purpose of this study is to understand the role of surface response method in determining the value of independent variables that cause the value of crystal growth response to be optimal. In this

experiment, the response variables of onion bulb growth (y) were influenced by three independent variables: temperature (x_1), GA3 (x_2) and time (x_3). Using the right model formulation, it can be obtained the value of independent variables (x_1, x_2, and x_3) causing the growth value of bulb weight of onion to be optimal.

II. RESEARCH METHOD

In this case, observations were made on field observations of tuber weight per plot. The data in this research is a secondary data data obtained in previous research in laboratory of seed of FP USU Sumatera Utara.

The population in this study is the experimental onion crop in Medan. The experimental unit in the field measuring 1 x 1.50m, with spacing of 20x15cm, so it consists of 50 plants per unit of experiment and the distance between plots 20cm. The experiment design used was factorial design. Factorial design with 3 factors and 3 replications, each factor consists of different levels. The stages of analysis can be briefly presented in the chart as follows:



III. RESULT OF THE RESEARCH

A. *Normality Test*

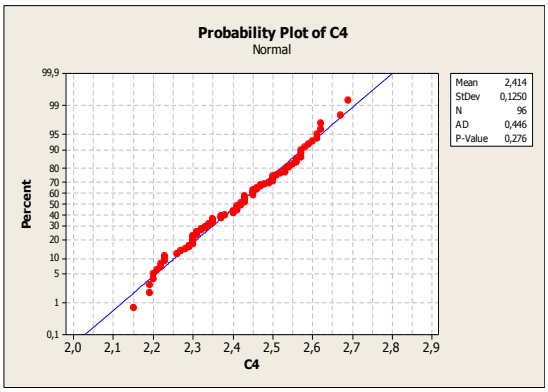


Figure 3.1 Normality Charts

In Figure 3.1 it can be seen that the results of normality test for weight response variables onion bulb has a significance value (P-value) of 0.276 where this value is greater than α = 0.05, which means that the distribution of data is normal distribution.

B. *Analysis of Variance*

Analysis of Variant

Table 3.1

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Temp	3	0.112	0.112	0.037	4.85	0.004
GA_3	3	0.254	0.254	0.085	10.99	0.000
Time	1	0.091	0.091	0.091	11.84	0.001
Time*GA_3	9	0.291	0.291	0.032	4.20	0.000
Temp*Time	3	0.017	0.017	0.006	0.73	0.538
GA_3*Temp	3	0.011	0.011	0.004	0.47	0.705
Temp*GA_3*Time	9	0.215	0.215	0.024	3.10	0.004
Error	64	0.493	0.493	0.008		
Total	95	1.485				

Based on Table 3.1 analysis of variance on temperature, GA3, and time variables showed the significance value (P-value) of 0.004 each; 0,000; 0.001. the analysis of variance on interaction between factors showed the value of significance (P-value) on the interaction Temperature with GA3 of 0.000 smaller than α = 0.05 then in the research the effect of treatment is very significant or reject H0. This means that there is at least one difference between treatments. This means that the interaction between the temperature with GA3 has a significant influence on the response. While for the analysis of variance on the interaction between factor Temperature with GA3 with time also has a value of significance (P-value) of 0.004 smaller than α = 0.05. So there is a significant influence on the response.

C. Analysis of Regression

Table 3.2

Predictor	Coef	SE Coef	T	P
Constant	2.45016	0.02727	89.83	0.000
X_1	-0.05865	0.03389	-1.73	0.087
X_2	0.18502	0.05425	3.41	0.001
X_1^2	-0.01021	0.01704	-0.60	0.551
X_1^3	0.04918	0.01682	2.92	0.004
X_2^2	-0.02083	0.01704	-1.22	0.225
X_2^3	-0.05215	0.02540	-2.05	0.043
$X_1 X_2$	0.03321	0.03031	1.10	0.277
$X_1^2 X_2$	-0.06535	0.03389	-1.93	0.057
$X_1^2 X_2^2$	0.00167	0.01064	0.16	0.876
$X_1^2 X_2^3$	0.01639	0.01587	1.03	0.305
$X_1^3 X_2$	0.00734	0.01967	0.37	0.710
$X_1^3 X_2^2$	-0.009014	0.004457	-2.02	0.046
$X_1^3 X_2^3$	-0.011793	0.006644	-1.77	0.080

Based on Table Regression 3.2 it is found that the factors that influence the response are GA3, cubic of temperature, cubic of GA3, and interaction between temperature and GA3 with equation as follows: $y = 2.45 + 0.04918x_1^3 + 0.18502x_2 - 0.05215x_2^3 - 0.009014x_1^3x_2^2$.

D. Response Surface Analysis

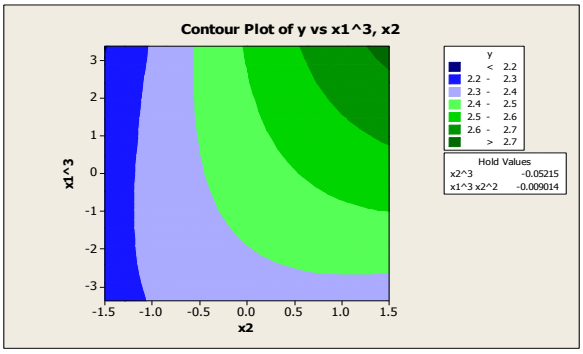


Figure 3.2

Based on Figure 3.2 shows that the higher the GA3 value and temperature increases, causing the tuber weight is also increasing. The highest GA3 bulb weight on the 1.5 level code, and the highest temperature at the 1.5-point code level of 2.89

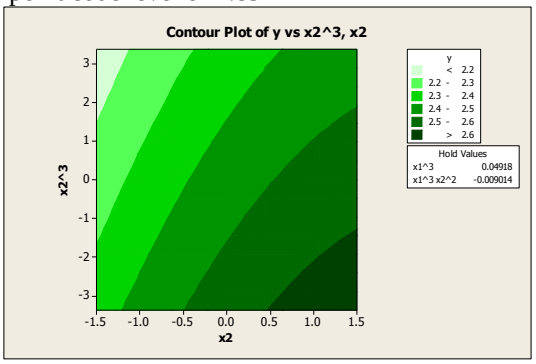


Figure 3.3

Figure 3.3 shows that tuber weight is higher if the GA3 value is at level 1.5 and the cubic value of low GA3 is at the level code -1.5. The value is 2.90.

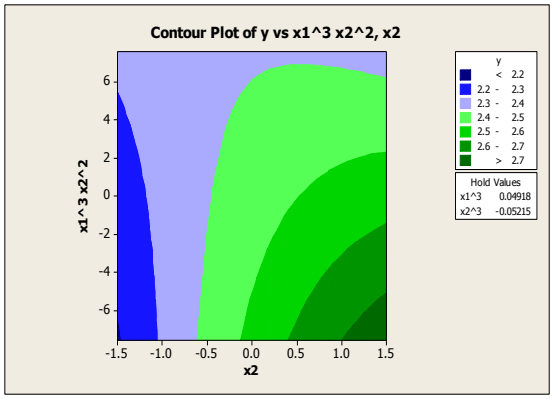


Figure 3.4

Figure 3.4 shows that the greater the GA3 value and the smaller the influence of GA3 interaction with temperature, the greater the weight of the onion bulbs generated. The high GA3 value is in the code level 1.5, while the temperature at the level code -1.5 is 2.79.

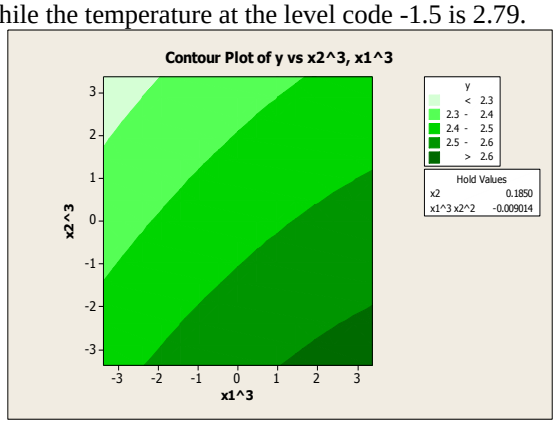


Figure 3.5

Figure 3.5 shows that the higher the cubic value of the temperature and the smaller the GA3 value, the greater the weight of the onion bulbs. The cubic value of the high temperature lies in the code level 1.5, while for GA3 is at the level code -1.5 that is equal to 2.79.

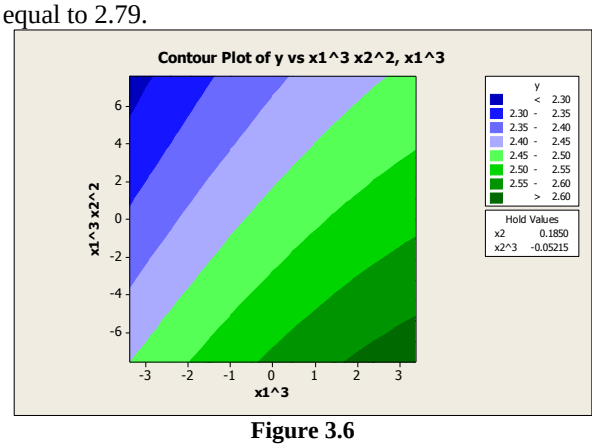


Figure 3.6

Figure 3.6 shows that the higher the cubic value of the temperature and the smaller the temperature and GA3 interaction values, the greater the weight of the onion bulbs. The cubic value of the high temperature lies in the code level 1.5, while for GA3 is in the code of level 0 of 2.61.

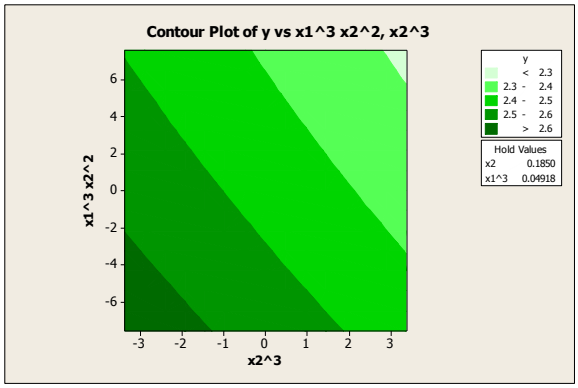


Figure 3.7

Figure 3.7 the smaller the cubic effect of GA3 and the smaller the interaction value between Temperature and GA3, the greater the weight of the bulbs produced. Highest GA3 value lies in the code level -1.5, while for the interaction is at the level code -1.5 that is equal to 2.69.

IV. CONCLUSION

Based on the analysis above discussion can be concluded that the most significant variables affect the growth of weight of onion bulbs is temperature, GA3, and the interaction between temperature and GA3. While the response surface model obtained is $y = 2.45 + 0.04918x_1^3 + 0.18502x_2 - 0.05215x_2^3 - 0.009014x_1^3x_2^2$.

While for the most optimal variable is GA3, located at the code level 1.5 that is on the GA3 of 30 ppm and the cubic of GA3 located at the code level -1.5. The maximum value of tuber weight is 2.90.

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