The response surface regressionmodel in the Yield and Yield Components of Sweet pepper with Fish-Molasses as Hydrofert in SNAP hydroponics system

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Abstract. In a world with a large number of statistical problems, optimization of the problem is the essential solution, especially in dealing with optimal decisions under uncertainty. This study aims to identify the response surface regression model in the volume and percentage of dilution of the fermented fish meal as hydrofert in the yield and yield components of growing sweet pepper in the Simple Nutrient Addition Production (SNAP) hydroponics system. This study uses a pure quantitative research design, particularly a 3 by 3 factorial with 30 samples per treatment. Results showed that the volume and percentage of dilution of the fermented fish molasses reach 42–47 for the number of days needed to reach marketable size with the surface regression model of=53.7535-0.0343*x-7.1907*y-0.0011*x*x+0.0601*x*y+0.785*y*y, , In terms of fruit length, it reaches 8.00 to 10.00 cm with a model of = 13.1967-0.1191*x-3.72*y+0.0005*x*x+0.0376*x*y+0.4422*y*y, Fruit diameter ranges from 3.50 to 4.00 cm with a model of 2.4771+0.0404*x+0.0559*y-0.0003*x*x+0.0018*x*y-0.0142*y*y and 0.5 to 0.6 g for the fruit weight of marketable fruits per plant = 0.8762-0.0022*x-0.175*y-1.0667E-5*x*x+0.0009*x*y+0.0249*y*y. Results showed a remarkable impact on how the data can be transformed to optimize the variables used in the study.

Keywords: *fermented fish-molasses, hydroponics,hydrofert, response surface model, sweetpepper*

Introduction

In the last decade, several studies have been conducted to identify the performance of vegetables using different field treatments. But none of which focuses on the performance of vegetables as to its specific response in the kind of methodology that is being introduced. One of the most recent advancements in the field of statistics is the introduction of response surface methodology, which is very timely in the study of growing sweet pepper using hydroponic fertilizers, which are fermented fish entrails, as a possible substitute for the very expensive hydroponic fertilizer that is currently on the market. To identify its development, one methodology is introduced with the use of a regression model. A regression model that will help to determine whether or not a particular method is likely to bring about the success that a certain researcher wants. The Response Surface Methodology (RSM) is one of the statistical methods particularly the regression that is very economical and friendly to use (Ahmad, N. &Janahiraman, T. V. 2014.It also shows descriptions of the first and second-order polynomial equations and this polynomial model was described as the regression model.

In this research, the main objective is to find the best response surface method to model two factors and four levels of parameters in the culture of sweet pepper. The study is anchored using the box-Behnken design, which develops a better regression model than the central composite design or full factorial design while the second regression model has shown to be more effective in predicting the performance of the given data set.

The Response Surface Methodology (RSM) is one of the statistical regression methods. This method is used to create a model and analyze the effect of each variable on the objective function(s). In the Box-Behnken design (BBD) that was introduced in 1990 by George E. P. Box and Donald Behnken, the data sets require three levels of each factor and the lowest total number of runs compared with the Central Composite Design (CCD)(Marchak, F. M., & Whitney, D.A, 1990). The response surface method used in research is face-centered by a central composite design. The advantage of the response surface method is that it can reduce the prediction error and advance the estimation using the polynomial equation. The polynomial equations that were developed using the response surface method are shown in the regression model containing the first and second orders. $y = \beta o + \beta ixi + \varepsilon ki$=1 (1) = $\beta o + \beta ixiki$=1 + $\beta iixi2ki$=1 + $\beta ijxixjj + \varepsilon i$ (2) y is the response function, and i, ii, and ij are the coefficients of the linear, quadratic, and interaction terms, respectively. xi and xj are the independent variables. The equation implies the identification of the optimum region where the value is close to the response region.

The sweet pepper is scientifically known as *Capsicum annum* L. and belongs to the family Solanaceae. The production of this crop is year-round and commands a variety of consumption methods (Obidiebube et al., 2012). Sweet pepper is an herbaceous perennial crop and will yield for several years in tropical climates, particularly in the Philippines. The crop is very rich in vitamins, including vitamin A and vitamin C, and in 100 grams of sweet peppers, there are 4.3 grams of carbohydrates, 1.3 grams of protein, and 24 kilocalories of energy. In the study of Ramzan, et al., (2015) the performance of sweet pepper were chronicled on number of fruits per plant, fruit weight per plant (kg), length of fruits (cm), diameter of fruits (cm), pericarp thickness(mm), number of locules per plant and yield (t /ha).

The nutritional component of the sweet pepper enticed the researcher to use approximation methods, particularly the response surface method, that have been widely used in engineering (Kayman and McMahon, 2005), in order to lessen the computational burden. This technique also has potential in other fields, particularly in agriculture, and is being used to approximate the performance function of each variable or parameter.

Objectives

This study aims to identify the response surface methods to model of two factors and four levels parametersin growing sweet pepperin SNAP hydroponics system.

Methodology

Method

To come up with a better measure of assessing the optimum level of the volume and percentage of dilution from the response surface regression of the fermented fish molasses as hydroponic fertilizer in the yield and yield components of growing sweet pepper in a simple nutrient addition production hydroponics system The first step of the study was to check the normality and suitability of the data, which belong to the 3x3 factorial. The factor A contains the percentage of water dilution and amount of water added per plant. The percentage of water contains 25, 50, and 75 percent of the total solution, while the amount of water added per plant contains 2, 3, and 4 liters per plant per 2 weeks.

Data preparation

The selection of data was based on the results from the experimental set-up, with 30 sample plants per treatment and replication three times. The following data was obtained through random sampling. The number of fruits per plant was gathered by counting the marketable fruits per harvest. Another data point is the fruit size of the marketable fruit, including the length and diameter; this was done by measuring using the vernier caliper from the treatments, and the days to reach marketable size were obtained by counting the number of days.

Results and Discussion

Data Screening

The data on the volume and percentage of dilution of the fermented fish meal as hydroponic fertilizer in the yield and yield components of growing sweet pepper (*Capsicum annum* in the SNAP hydroponics system were screened to ensure that the data was clean, usable, reliable, and valid for testing before further statistical analyses. Data screening was done to identify missing data, outliers, sampling adequacy, sphericity, and multicollinearity.

Presentation

The results were presented in tables and figures. Results have shown that in the first test for the multivariate test of significance, the interaction between the percent dilution and amount of water added to the plant is significant using Wilks with a p-value of 0.0036, which is above the 0.05 level of significance and has a 94.23% data confidence value.

In the presentation of the parameter estimates

The parameter estimates are shown in Table 1, which summarizes the effect of each predictor. Results have shown that the percentage of water was either 25 to 50 or 75 percent of the total solution with the amount of water added per plant containing 2, 3, or 4 liters per plant per 2 weeks, and it shows the average number of fruits, fruit size (L), and average number of fruits compared to the fruit size (w). Results support the hypothesis that parametric estimating, a statistics-based technique, is used to calculate the expected amount of time that is required to perform and complete an activity throughout the experimental set-up.

However, in the determination of an estimate that is based on a statistical correlation between a parameter and a cost or time value are important indicator to augment on what level of parameter is the degree of its relationships. Because the observed correlation is scaled to the size of the current scheme. This also requires statistical evidence of the correlation, and if the characteristics of both results are comparable, the observed correlation is then scaled to the size of the current results. Although parameters are descriptive measures of an entire population, their values are usually unknown because it is infeasible to measure an entire population. Thus, a random sample from the population is obtained using parameter estimates. The results also support the goal of statistical analyses, which is to obtain estimates of the population parameters along with the amount of error associated with these estimates. These estimates are also known as sample statistics.

Table 1. The Parameter estimates of the data on the percent water dilution to the amount of water consume per week.

Source of Variation		*Standard Error*	*t*	*p*	*Cnf. Lmt (-/+95.00%)*	
Average # of fruits	% of water dilution	0.157780	-0.21743	0.828041	-0.3450	0.27636
	Amount of water added per plant per 2 weeks	5.304385	-1.35561	0.176381	-17.6350	3.25359

	Interactions	0.024586	2.44452	0.015159	0.0117	0.10851
Fruit size (L)	% of water dilution	0.115876	-1.02763	0.305063	-0.3472	0.10908
	Amount of water added per plant per 2 weeks	3.895611	-0.95492	0.340491	-11.3904	3.95042
	Interactions	0.018057	2.08325	0.038191	0.0021	0.07317
Fruit size (W)	% of water dilution	0.007670	5.27142	0.000000	0.025329	0.055532
	Amount of water added per plant per 2 weeks	0.257849	0.21663	0.828661	-0.451844	0.563562
	Interactions	0.001195	1.51730	0.130388	-0.000540	0.004167
Ave wt of fruit per plants	% of water dilution	0.002570	-0.86890	0.385689	-0.007293	0.002827
	Amount of water added per plant per 2 weeks	0.086398	1.78488	0.043875	-0.345070	-0.004838
	Interactions	0.000400	2.14670	0.032728	0.000071	0.001648

Surface Plots

Figure 1 below depicts a high-level overview of data visualization techniques. Surface plots were used to identify how the percentage of water dilution and the amount of water added per plant fit its response. The results showed a three-dimensional relationships of the two variables, and the response was represented by a smooth surface with the volume and percentage of dilution of the fermented fish molasses reaches to 42–47 for the number of days needed to reach marketable size with the surface regression model of=53.7535-0.0343*x-7.1907*y-0.0011*x*x+0.0601*x*y+0.785*y*y, , for fruit length, it reaches 8.00 to 10.00 cm with a model of = 13.1967-0.1191*x-3.72*y+0.0005*x*x+0.0376*x*y+0.4422*y*y, fruit diameter ranges from 3.50 to 4.00 cm with the model of 2.4771+0.0404*x+0.0559*y-0.0003*x*x+0.0018*x*y-0.0142*y*y and 0.5 to 0.6 g for the fruit weight of marketable fruits per plant = 0.8762-0.0022*x-0.175*y-1.0667E-5*x*x+0.0009*x*y+0.0249*y*y. Knowing the surface regression provides awareness that there is a relationship between the response of the plant and the two variables used, which are the volume and percentage of dilution of the fermented fish molasses.

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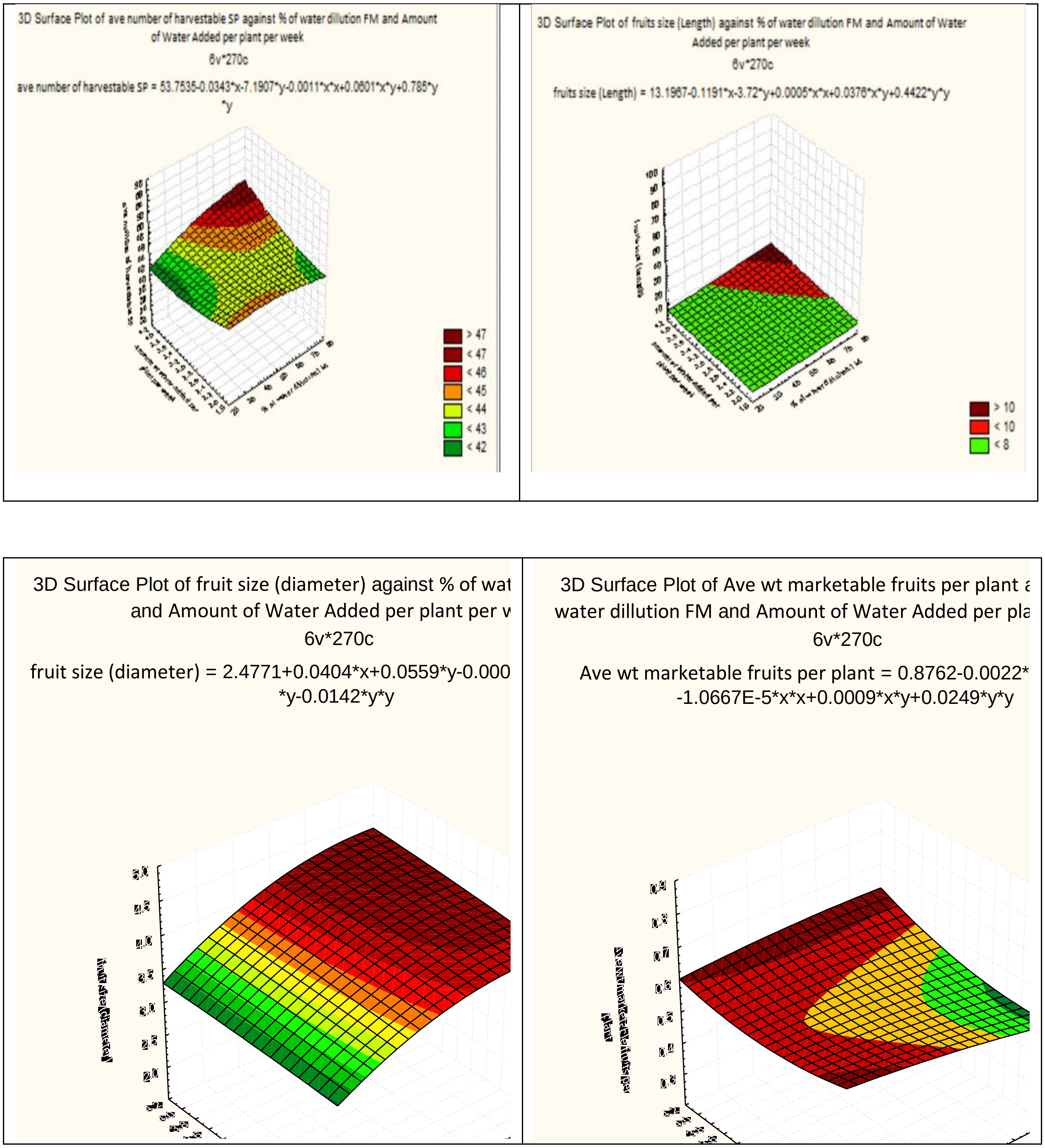

Figure 1. The 3D Surface Plot of Average Number of harvestable Sweet Pepper against % of water dilution of Fish Molasses and Amount of Water Added per plant per Week

Conclusion

The parameter estimates have a significant effect on the percentage of water, either from 25 to 50 or 75 percent of the total solution, with the amount of water added per plant containing 2, 3, or 4 liters per plant per 2 weeks. Date shows the average number of fruits, fruit size (L), and average number of fruits compared to the fruit size (w). There is a potential indicator that the dilution percentage affects the consumption of the plants.

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