Application of Response Surface Methodology in Modelling and Optimization of the Yields of Maize (*Zea mays L.*) using Municipal Solid WasteComposts

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Abstract
In this study, the Author investigates the operating conditions required for optimal production of maize (Zea mays L.) in Uyo, South-South Nigeria. The maize production process was optimized by the application of factorial design 3^3 and response surface methodology. The combined effects of composts from Green manure, G(vegetable and fruit waste), sawdust (S), and municipal solid wastes (M) were investigated and optimized using response surface methodology. Morphological and yield data of maize were obtained and analyzed using the Design Expert Software. The experiment was laid down in a Randomized Complete Block Design. The treatments consisted of the three composted organic waste sources, each at three levels (0, 3, and 6 tonnes per plot). The study developed statistical models using the collected data, a first –order polynomial with 2-way interaction model was obtained using a least squares technique for prediction of grain yield and yield components of maize. The optimum conditions for the production of maize were shown using the graphical contour response surfaces. The average mean of the yield per plant was in the range of 36.78g to 104.13g. Treatment $G_0S_0M_0$ had the lowest mean of 36.78 while treatment $G_6S_6M_3$ had the highest mean of 104.13 followed by treatment $G_3S_6M_3$. Treatment G3S0M3 and $G_3S_0M_6$ had low yield per plant of 4 respectively. This shows that the highest level of green yard and sawdust and a higher level of municipal waste compost combination was the best treatment while treatment $G_0S_0M_0$ was an insignificant treatment in this study followed by $G_3S_0M_3$At the optimum condition, one can reach to a maize grain yield of 82.270kg/plot of 6 meters by 6meters. Obviously, increased productivity of maize can improve the livelihood and income per capita of smallholder maize farmers in Uyo and safe the farmers extra cost of input. Thus, it is believed that the approach employed in this study of maize can be useful for research on other commodities, and agro-climatic zones, leading to a better understanding of the overall production process.

***Keywords**: Compost, Response Surface Methodology, Factorial Design, Maize, Optimization, Green Manure, Municipal Solid Waste, Yield*

1.Introduction

Global population size is predicted to increase from 7.2 billion to over 9 billion by 2050 (according to the United Nations World Population prediction), which poses an unprecedented challenge for global crop production systems. Besides, global demands for major grains, such as maize (*Zea mays L.*), are projected to increase by 70%, forced by the human population requirements for food, fiber and fuel (Fedoroff*et al.*, 2010; Tilman*et al.*, 2010).Maize is becoming a cash crop, which contributes to the improvement of farmers' livelihood. Based on these statistics, supporting maize production will ensure successful food security and will improve the economic growth of West African countries (FAOSTAT, 2013).

Composting Municipal Solid Waste (MSW) is seen as a method of diverting organic waste materials from landfills while creating a product, at relatively low-cost, that is suitable for agricultural purposes (Eriksen*et al.*, 1999; Wolkowski, 2003). The trend may be accentuated by a combination of economic and environmental factors, aimed at reducing municipal landfill capacity; avert costs associated with land-filling and transportation of materials; adoption of legislation to protect the environment; minimizing the use of commercial fertilizers; increasing the capacity for the recycling of household waste, and so on(Kavitha and Subramanian, 2007).

Over the years, statistical methods have been used to examine the relationship between application of organic manure and crop productivity (Admas et al., 2015; Faisa et al., 2013; and Shafeek et al., 2017). However, most of these studies are focusing on the effects of application of organic manure on the yield and yield components of various crops(Ndukwu*et al.*,2016). They lack the ability to optimize levels of farm yard manure or the inorganic fertilizers using the treatment range applied for maximum production. Thus, the objective of design and analysis of experiments is to optimize a response (output variable) which is affected by numerous independent variables (input variables).

Optimization of levels of manures and fertilizers in soil management and crop production is essential since it enables the farmers to get the best production without an extra cost in input. When treatments are from a continuous range of values, then a Response Surface Methodology is needed for developing, improving, and optimizing the response variable. The main objective of Response Surface Methodology is to find the operating conditions for the system that are optimum or to find a section of the space factor in which operating requirements are satisfied (Montgomery, 2013). The first-order model is expected to be suitable when the experimenter is concerned in approximating the response surface that is true over a moderately small section of the variable space of independent variable in setting where there is almost no curvature in the response function (Montgomery, 2013). However, in most cases, the curvature in the true response surface is strong enough such that the first-order model (even with the interaction term included) is inadequate (Myers et al., 2016). A second-order model will likely be needed in such situations. Such a response surface could arise in approximating a response such as yield, where we would expect to be operating near a maximum point on the surface(Khuri and Mukhopadhyay, 2010). Thus, this study applied Response Surface Methodology to establish the best levels of the composts that optimized the yields of maize.

2. Materials and Methods

The study used Randomized Complete Block Design (RCBD), with 27 treatments (green manure compost, sawdust-riched compost, and municipal solid waste) each at three levels (0, 3, and 6 tonnes per hectare), and replicated three times. The selection of the sites was done based on a study tour.Compost samples were collected during the month of February, 2022. At each site of sampling, coordinates were taken with a hand held Garminetrex legend Hcx GPS (Global Positioning System) to reference the exact location (geographic coordinates) of the sampling points in the field. The municipal solid wastes obtained from composted landspread waste found within Uyo. The Green manure comprises decayed plant cuttings, leaves, stems, and other biodegradable materials obtained around the goat market (Nasarawa market) in Itam, Uyo. The sawdust compost was obtained from a very mountainous sawdust dumpsite located directly behind the Itam Timber market, Uyo. The mixed municipal solid waste compost was sourced from a dumpsite at NungAkpan and other dumpsites around Uyo. It consisted of organic wastes such as food waste, vegetable scraps, paper, food waste, etc. All laboratory analyses were conducted using standard procedures.This study used the traditional white maize variety of obtained from Itam market, Uyo.

Maize planting was done in the month of April, 2022 at 40 cm within rows and 80 cm between rows with 2 seeds per hole.The growth data collected during the field experiment were height, leaf area, leaf number and girth. Plants were selected at random from each plot and tagged for growth measurements.Data collection on yield includes number of cobs per plant, cob length (cm), cob diameter(cm), cob weight (cm), grain yield (tha^{-1}), and 1000 grain weight (g) were done monthly, using random sampling of six plants from each of the blocks (replicates). These were the important components which helped in the determination of growth attained during the growing period. Plant height was measured in centimeters from the ground level up to the tip of the topmost leaf. The measurement was later expressed as a mean of the selected plants. The stem diameters of the randomly selected six plants were taken using a pair of Vernier calipers. The measurement was taken 10cm from the ground level and converted to stem girth using the formular proposed by Ukonze*et al.* (2016) as shown below:

$$\text{Stem girth (SG)} = \text{stem diameter (D)} \times \pi \qquad \text{Equation 1}$$

where π (pi) = 22/7 (constant)

Data collected were later expressed as a mean of the six selected stands. The leaf area was measured with the use of a centimeter tape. This was obtained by measuring the widest part of each leaf per plant and the leaf length and multiplying by the factor of 0.75. That is, using the formular the formular by Ndubuaku*et al.* (2006) as follows:

$$\text{Leaf area} = \text{leaf length} \times \text{leaf breadth} \times 0.75 \qquad \text{Equation 2}$$

The leaf area per block (plot) was calculated simply by multiplying the leaf area per plant by the total number of maize stands per block. Numbers of leaves were counted fortnightly until the tasselling of the maize and the measurements were also expressed as means of the selected plants. All agronomic practices were kept uniform for all treatments. Yield data were collected.Average values of the measurements for the morphological parameters of the crop were recorded. The data collected were analyzed statistically by using Fisher's analysis of

Variance technique and least significantly difference test at 5% probability level was applied to compare the treatments means.

A field experiment was conducted in Experimental Farm, Dakadda Farm, under the license of the Department of Agricultural Engineering, Faculty of Engineering, University of Uyo. The soil of the experimental site was Loamy sand (LS) in texture. The initial soil physico-chemical properties of the experimental site are given in table 4.1. Municipal Solid waste composts (MSWC) were applied two weeks before sowing of the maize crop. The experiment consisted of nine treatments laid out in Randomized Complete Block Design (RCBD) consisting of three organic manure sources, namely composted Green manure, Sawdust-riched compost, and mixed municipal solid waste, each at three levels ($0tha^{-1}$, $3tha^{-1}$, and $6tha^{-1}$) and replicated three times, to produce a total of 27 treatments.

After the harvest of the maize crop, the maize grain samples were collected and subjected for analysis following standard procedures. The analysis done involved fitting first order polynomial models which were later used to obtain the polynomial settings of the input variables that would maximize the yield of maize. The visualization of the optimization was achieved through the use of Response Surface Contour Plots.

The equations for the fitted order models used for the fitted multiple regression is as represented below:

$$Y_i = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \cdots + \alpha_k X_k + \varepsilon_i \qquad \text{Equation 3}$$

where Y = Response variables, α_0 = intercept(constant value), α_i = 0,1,…k is the regression linear coefficients that measure the expected change in the response, y per unit change, X_k when other predictor variables are held constant, ε_i = error terms However, when the experimenter is relatively close to the optimum, a model that incorporates curvature is usually requires to approximate the response. In such a case a polynomial of higher degree must be used such as second-order model. The data obtained was subjected to Analysis of Variance (ANOVA) using Design Expert Software, in order to determine the effect of treatment. P-value of less than 5% (p less than 0.05) were regarded as statistically significant. Large value of the coefficient of multiple determinations (R^2) shows that the model adequately represents the experimental results. The parameters of the above model were estimated by means of Least Squares method.

3.Results and Discussion

3.1 Preliminary Analysis of the yield of maize

Table 1: Effect of green manure treatment on the grain yield of maize(weight in grammes per plant)

Variable	Green Manure	N	Mean	SE Mean	Std Dev	Minimum	Maximum	Range	Skewness	Kurtosis	Coefficient of Variation
Grain yield per plant	G0	36	76.59^{b}	3.02	18.14	34.70	105.40	70.70	-0.85	0.56	23.69
	G3	36	81.83^{ab}	2.31	13.84	53.50	105.40	51.90	0.07	-0.71	16.92
	G6	36	88.39^{a}	2.17	13.03	68.50	113.50	45.00	-0.20	-1.25	14.74

Means bearing different superscripts are significantly ($p<0.05$) different.

Source: Researcher.

Table 2: Effect of saw dust treatment on the grain yield of maize(weight in grammes per plant)

Variable	Saw dust	N	Mean	SE Mean	Std Dev	Minimum	Maximum	Range	Skewness	Kurtosis	Coefficient of Variation
Grain yield per plant	S0	36	73.04^{b}	3.01	18.05	34.70	103.20	68.50	-0.39	0.09	24.72
	S3	36	85.58^{a}	2.30	13.78	63.90	105.40	41.50	-0.11	-1.47	16.10
	S6	36	88.19^{a}	1.76	10.57	69.30	113.50	44.20	0.32	-0.35	11.98

Means bearing different superscripts are significantly ($p<0.05$) different.

Source: Researcher.

Table 3: Effect of municipal waste treatment on the grain yield of maize(weight in grammes per plant)

Variable	Municipal Waste	N	Mean	SE Mean	Std Dev	Minimum	Maximum	Range	Skewness	Kurtosis	Coefficient of Variation
Grain yield per plant	M0	36	78.54^{b}	2.99	17.95	34.70	105.40	70.70	-1.21	1.18	22.85
	M3	36	89.46^{a}	2.79	16.76	53.50	113.50	60.00	-0.75	-1.00	18.73
	M6	36	78.81^{b}	1.49	8.93	59.40	97.50	38.10	0.31	0.17	11.33

Means bearing different superscripts are significantly ($p<0.05$) different.

Source: Researcher.

The average yield grouped by factors for green yard compost at level 0 was 76.59g; at level 3, the average yield was 81.83 g and at level 6, the average yield was 88.39 g (Table 1). For sawdust treatment, the average yield at level 0 was 73.04 g, at level 3, it was 85.58 g and at level 6, it was 88.19 g (Table 2). For municipal waste treatment at level 0, yield was 78.54 g, at level 3 and 6, yields were 89.46 g and 78.81 g respectively (Table 3). Again, the data was normally distributed since their skewness and kurtosis test values were falling within the range of $\pm$ 3 and $\pm$ 1 respectively. The Kurtosis value for all levels of green yard, sawdust and municipal waste were 0.56, -0.71, -1.25, 0.09, -1.47, -0.35, 1.18, -1.00 and 0.17 respectively, while the skewness values for all levels of green yard, sawdust, and municipal waste compost were -0.85, 0.07, -0.20, -0.39, -0.11, 0.32, -1.21, -0.75, and 0.31 respectively.

From the result, it could be inferred that there was an increasing trend of yield with increase in green yard and sawdustcomposts, as well as the municipal waste compost, meaning that green yard compost, sawdust compost and municipal waste compost have a positive effect on maize grain yield. Table 4 presents theeffect of municipal waste treatment combination on the grain yield of maize.

Table 4.: Effect of municipal waste treatment combination on the grain yield of maize

Variable	GSMTreatment	N	Mean	SE Mean	Std Dev	Minimum	Maximum	Range	Skewness	Kurtosis	Coefficient of Variation
Yield per plant	G0 S0 M0	4	36.78^{j}	0.69	1.384	34.700	37.500	2.800	-1.99	3.98	3.76
	G0 S0 M3	4	94.90^{bc}	0.158	0.316	94.600	95.300	0.700	0.63	-1.70	0.33
	G0 S0 M6	4	74.58^{fg}	1.07	2.13	71.50	76.40	4.90	-1.54	2.77	2.86
	G0 S3 M0	4	100.07^{ab}	2.78	5.56	92.40	105.40	13.00	-1.12	1.53	5.55
	G0 S3 M3	4	65.05^{hi}	0.491	0.981	63.900	66.200	2.300	0.00	-0.83	1.51
	G0 S3 M6	4	74.22^{fg}	2.69	5.39	69.80	81.50	11.70	1.05	-0.16	7.26
	G0 S6 M0	4	88.45^{d}	2.15	4.30	82.50	91.70	9.20	-1.24	0.69	4.86
	G0 S6 M3	4	74.88^{efg}	2.91	5.82	69.30	80.00	10.70	-0.03	-5.82	7.77
	G0 S6 M6	4	80.40^{e}	2.45	4.89	73.60	84.30	10.70	-1.27	0.91	6.08
	G3 S0 M0	4	75.72^{efg}	1.15	2.31	73.80	79.00	5.20	1.42	1.96	3.04
	G3 S0 M3	4	62.17^{i}	2.94	5.87	53.50	66.50	13.00	-1.82	3.49	9.44
	G3 S0 M6	4	65.10^{hi}	2.82	5.64	59.40	70.00	10.60	-0.08	-5.55	8.67
	G3 S3 M0	4	87.20^{d}	1.72	3.43	83.50	91.80	8.30	0.76	1.73	3.94
	G3 S3 M3	4	100.57^{a}	2.22	4.45	94.60	104.80	10.20	-0.95	0.35	4.42
	G3 S3 M6	4	77.950^{ef}	0.517	1.034	76.400	78.500	2.100	-1.99	3.96	1.33
	G3 S6 M0	4	88.28^{d}	0.782	1.565	86.400	90.200	3.800	0.09	1.00	1.77
	G3 S6 M3	4	102.53^{a}	0.996	1.99	100.80	105.40	4.60	1.54	2.88	1.94
	G3 S6 M6	4	76.925^{ef}	0.614	1.228	75.500	78.300	2.800	-0.09	-1.96	1.60
	G6 S0 M0	4	70.35^{gh}	0.659	1.318	68.500	71.600	3.100	-1.25	2.19	1.87
	G6 S0 M3	4	100.83^{a}	0.989	1.98	98.60	103.20	4.60	0.18	-1.07	1.96
	G6 S0 M6	4	76.90^{ef}	1.89	3.77	72.50	81.70	9.20	0.31	1.43	4.90
	G6 S3 M0	4	70.35^{gh}	0.815	1.630	68.500	72.000	3.500	-0.20	-3.65	2.32
	G6 S3 M3	4	100.08^{ab}	2.01	4.02	94.40	103.80	9.40	-1.30	2.20	4.02
	G6 S3 M6	4	94.72^{bc}	1.28	2.56	91.30	97.50	6.20	-0.75	1.80	2.70
	G6 S6 M0	4	89.70^{cd}	2.61	5.22	82.50	94.50	12.00	-1.15	1.18	5.82
	G6 S6 M3	4	104.13^{a}	3.55	7.11	96.90	113.50	16.60	0.77	0.27	6.83
	G6 S6 M6	4	88.45^{d}	3.12	6.25	79.60	94.30	14.70	-1.33	2.51	7.06

Means bearing different superscripts are significantly ($p<0.05$) different.

Source: Researcher.

The average mean of the yield per plant was in the range of 36.78 to 104.13. Treatment $G_0S_0M_0$ had the lowest mean of 36.78 while treatment $G_6S_6M_3$ had the highest mean of 104.13 followed by treatment $G_3S_6M_3$. Treatment G3S0M3 and $G_3S_0M_6$ had low yield per plant of 4 respectively. This shows that the highest level of green manure and sawdust and a higher level of municipal waste compost combination was the best treatment while treatment $G_0S_0M_0$ was an insignificant treatment in this study followed by $G_3S_0M_3$. Conventionally, the yield data of treatments per plants indicated that the data was normally distributed since their skewness and kurtosis test values fell within the acceptable (threshold) range of ±3 and ±1.

3.2 Model Fitting for the yield of maize

Experimental maize yields were analyzed to get a regression model. The estimated coefficients of the regression model are given in table 5. The largest value of the coefficient of multiple determination (R^2= 0.9741) reveals that the model adequately represents the experimental results. This section represents result of the regression model.

Table 5: Coefficients of factorial effects of green manure, saw dust and municipal waste on the grain yield of maize per plant.

Term	Coefficient	SE Coef	T-Value	P-Value	VIF
Constant	82.269	0.379	217.29	0.000	
Green manure					
0	-5.678	0.535	-10.60	0.000	1.33
3	-0.442	0.535	-0.82	0.412	1.33
Saw dust					
0	-9.233	0.535	-17.24	0.000	1.33
3	3.311	0.535	6.18	0.000	1.33
Municipal waste					
0	-3.725	0.535	-6.96	0.000	1.33
3	7.189	0.535	13.43	0.000	1.33
Green manure*Saw dust					
0 0	1.392	0.757	1.84	0.070	1.78
0 3	-0.119	0.757	-0.16	0.875	1.78
3 0	-4.928	0.757	-6.51	0.000	1.78
3 3	3.436	0.757	4.54	0.000	1.78
Green manure*Municipal waste					
0 0	2.233	0.757	2.95	0.004	1.78
0 3	-5.506	0.757	-7.27	0.000	1.78
3 0	5.631	0.757	7.44	0.000	1.78
3 3	-0.592	0.757	-0.78	0.437	1.78
Saw dust*Municipal waste					
0 0	-8.361	0.757	-11.04	0.000	1.78
0 3	5.742	0.757	7.58	0.000	1.78
3 0	4.019	0.757	5.31	0.000	1.78
3 3	-4.203	0.757	-5.55	0.000	1.78
Green manure*Saw dust*Municipal waste					
0 0 0	-22.12	1.07	-20.66	0.000	2.37
0 0 3	18.73	1.07	17.49	0.000	2.37
0 3 0	17.76	1.07	16.59	0.000	2.37
0 3 3	-12.21	1.07	-11.41	0.000	2.37
3 0 0	14.51	1.07	13.55	0.000	2.37
3 0 3	-17.83	1.07	-16.65	0.000	2.37

3 3 0	-7.30	1.07	-6.82	0.000	2.37
3 3 3	9.61	1.07	8.97	0.000	2.37

Source: Researcher.

A linear regression model with 3 factors as the predictors for weight of maize (yield) that is green waste, sawdust waste and municipal waste with their level interactions was carried out and results presented as in Table 5. The p-values for insignificant waste (manure) interaction levels for G3 and S3 M3 were 0.412 and 0.437 respectively, which were greater than the significant level (0.05) (Table 5). The model derived from Table 5 was simplistically presented as:

Y = 82.27 – 0.442G3 + 6.12G6 + 3.44 G3S3 – 3.32G6S3 +
… -2.80 S6M6 + 9.61G3S3M3 + … -1.14G6S6M6 Equation 4

The results showed that when level 3 of green manure was compared to level 0 the result was significant. Also when level 6 of green manure was compared to level 0, the result was significant. When all other factors were held content and sawdust manure level 3 is compared to sawdust level 6 the yield increased by 5.92 g. Then moving from level 0 to level 3 in municipal waste, maize yield increase by 7.19 cm average. Thus, from the result, it could be deduced that, a unit increase in treatment G3 S3 M3 leads to a corresponding increase in grain yield of maize by 9.61 grams hence the most effective treatment for the 3 – way interaction followed by G3S6M3 and G6 S3 M6 with values of 8.23 g and 7.86 g respectively. However, a unit increase in treatment G3M3 leads to a corresponding decrease in yields by 0.59 gram which showed that this treatment was not significant. Also, a unit increase in treatment S6 M6 leads to a corresponding decrease in yield by 2.80 g, which also shows that this treatment was not significant (Table 5).

3.3 Analysis of Variance of Factorial Effects of Green Manure, Sawdust and Municipal Waste on the Grain Yield of Maize

Factorial ANOVA on the three factors was carried out and the findings were presented in Table 6.

Table 6: Analysis of variance of factorial effects of green manure, saw dust and municipal waste on the grain yield of maize

Source	Df	Adj SS	Adj MS	F-Value	P-Value
Model	26	25432.2	978.16	63.18	0.000
Linear	6	10034.1	1672.35	108.02	0.000
Green manure	2	2515.7	1257.84	81.25	0.000
Saw dust	2	4726.5	2363.23	152.65	0.000
Municipal waste	2	2792.0	1395.98	90.17	0.000
2-Way Interactions	12	5324.3	443.69	28.66	0.000
Green manure*Saw dust	4	785.2	196.31	12.68	0.000
Green manure*Municipal waste	4	2467.1	616.76	39.84	0.000
Saw dust*Municipal waste	4	2072.0	517.99	33.46	0.000
3-Way Interactions	8	10073.8	1259.23	81.34	0.000
Green manure*Saw dust*Municipal waste	8	10073.8	1259.23	81.34	0.000
Error	81	1254.0	15.48		
Total	107	26686.1			

R-sq	R-sq(adj)	R-sq(pred)	S
95.30%	93.79%	91.65%	3.93464

Source: Researcher.

Values were obtained for green manure, sawdust compost and municipal waste, interaction of green manure and sawdust, green and municipal waste, and finally the interaction for green waste, sawdust and municipal waste were.

The results showed that factor green waste was significant $f(2, 107) = 81.25$, $p<0.001$. Also, from the factorial ANOVA, sawdust waste was significant, $f(2,107) = 152.65$, $p<0.001$, likewise municipal waste with $f(2,107) = 90.17$, p-value <0.001. The results also indicated that interaction between sawdust and green waste was significant and the interaction between sawdust and municipal wastes were significant for 2-way interactions. For the 3-way interactions, a combination of green waste, sawdust compost and municipal waste were all significant.

3.4 Optimization Result of Grain Yield of Maize from Municipal Waste Treatment Combination

Tables 7 and 8 present the optimization results for the grain yield of maize from green manure, sawdust and municipal waste.

Table 7: Constraints for the optimization of grain yield of maize from municipal waste treatment combination

Name	Goal	LowerLimit	UpperLimit	Lower Weight	UpperWeight	Importance
A:Green manure	Is in range	0	6	1	1	3
B:Saw dust	Is in range	0	6	1	1	3
C:Municipal waste	Maximize	0	6	1	1	5
Grain yield	Maximize	36.78	104.13	1	1	5

Source: Researcher.

Table 8: Results for the optimization of grain yield of maize from municipal waste treatment combination

Number	Green Manure	Sawdust	Municipal Waste	Grain Yield	Desirability	
1	**6.000**	**6.000**	**6.000**	**82.270**	**0.822**	**Selected**
2	5.985	6.000	6.000	82.240	0.822	
3	6.000	5.980	6.000	82.218	0.821	
4	5.965	6.000	6.000	82.202	0.821	
5	6.000	5.956	6.000	82.158	0.821	
6	6.000	5.988	5.994	82.238	0.821	
7	5.915	6.000	6.000	82.102	0.820	
8	6.000	5.932	6.000	82.098	0.820	
9	5.953	6.000	5.994	82.177	0.820	
10	5.903	6.000	6.000	82.079	0.820	

Source: Researcher.

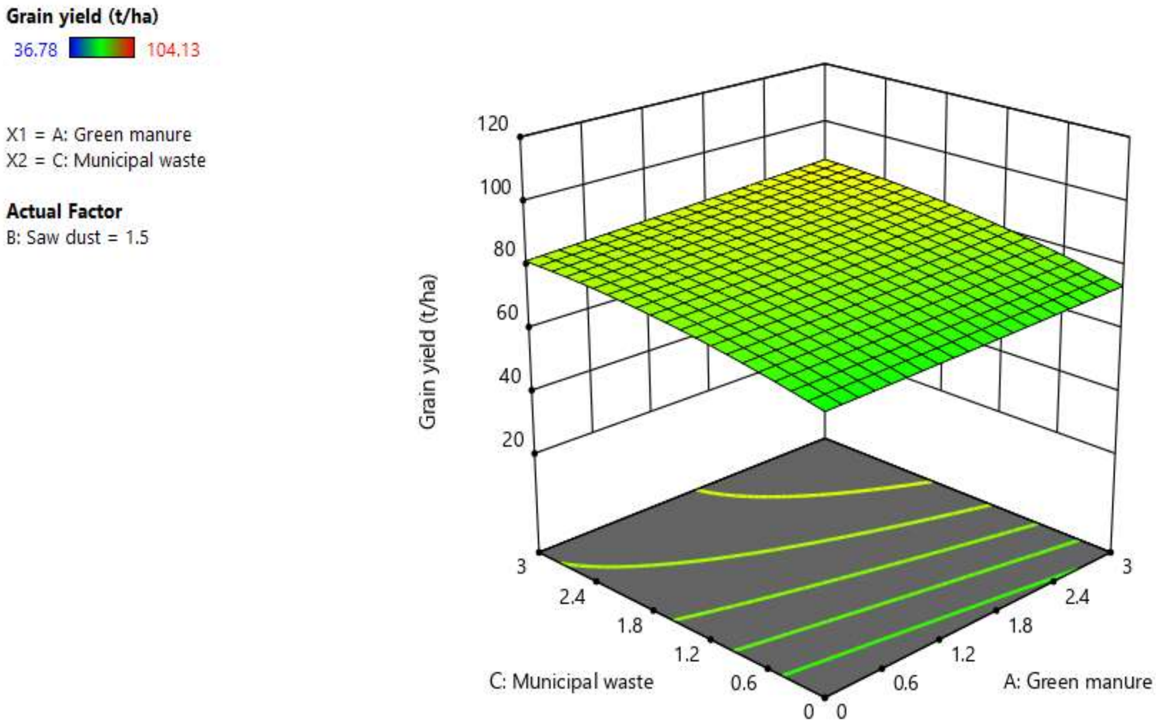

Figure 1: Response surface plot for for grain yield of maize from municipal waste and green manure.
Source: Researcher.

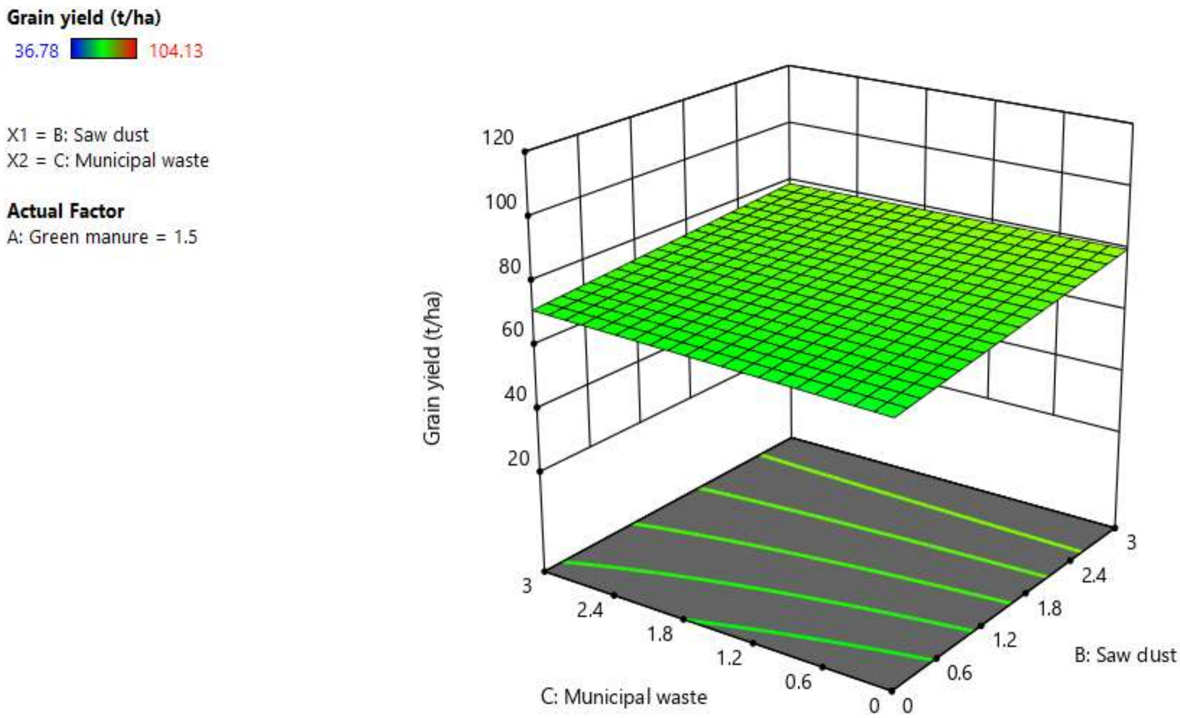

Figure 2: Response surface plot for for grain yield of maize from municipal waste and saw dust.
Source: Researcher.

The results showed that the values of green manure, sawdust and municipal waste were within the ranges of 5.903 to 6.00, 5.932 to 6.000 and 5.994 to 6.000 respectively. The range for grain yield was between 82.079 – 82.270 (Table 8). These results were in agreement with the acceptable values range reported by Kamtai (2019) for optimization of process parameters on organic manure for crop production.

The response surface plot indicated in Figure 1and figure 2 represent the grain yield of maize as a function of municipal waste and green manure and municipal waste and sawdust, respectively. From the figures, it was observed that grain yield increased gradually with increase in municipal waste and sawdust levels, respectively.

4. Conclusion

In this study, Response surface methodology (RSM) is found to be a relevant tool as far as the optimizations of the input variables(organic manures from composted municipal solid wastes) that maximizes the output variable (yields of maize) is concerned. The optimal conditions for the production of maize were obtained as stationary points from the fitted model and visualized graphically using contour response surface plot. From this study, it was concluded that composted green manure, sawdust, and municipal solid wastes had a positive impact on the yield and the yield components of maize.

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