TED ANKARA COLLEGE

FOUNDATION HIGH SCHOOL

INTERNATIONAL BACCALAUREATE

BIOLOGY EXTENDED ESSAY

THE EFFECT OF DIFFERENT TYPES OF ORGANIC FERTILIZERS ON THE GROWTH RATE OF *ZEA MAYS*

Candidate Name: Emre MENGİ

Candidate Number: 001129-0058

Supervisor: Hasan ALTINIŞIK

Word Count: 3736

Abstract

Among many types of fertilizers, most widely used ones are chemical and organic fertilizers. Chemical fertilizers are specialized fertilizers that their nutrient level is controlled by the production process. On the other hand, nutrient levels (nitrogen-potassium-phosphorus) of organic fertilizers are determined by their type such as vermicompost, poultry manure, farmyard manure, bat guano, and compost. These types differ from one another by nutrient levels. Although nutrient levels of those have literature values and researches about it, there is no data about application of organic fertilizers on a specified plant. The objective of this investigation is to find out how much a plant, in this case Zea mays (corn plant), can transfer the nutrients into its system via roots with respect to the fertilizer type. 5 types of organic fertilizers are used to grow Zea mays and NPK calculations are made by using different measurements, resulting in finding out the percentages of nutrients in the body of the plants.

It was revealed that poultry manure had the largest impact on plant growth, resulting in having a greater dry and fresh weight, higher potassium and phosphorus percentage. Vermicompost was the least effective among the organic fertilizers, at the same time, other fertilizers were moderately effective such as farmyard manure, compost, and bat guano. On the whole, the hypothesis is proved to be wrong, as vermicompost did not match the expectations of being the most effective. The reasoning can be made from the point that the nutrient release effect is slower as a result of worm activity, while other type of organic fertilizers have more nutrients available for the plant in the same time period.

Contents

Introduction

In agriculture, fertilizers are widely used among farmers. By containing the elements that a plant needs, fertilizers speed up the growth process by fully satisfying the needs of a plant. There are many types of fertilizers: organic fertilizers, chemical fertilizers, microbial fertilizers, and organomineral fertilizers. Each type has different substances to boost the growth process. Organic fertilizers are formed from animal and vegetable waste, for example: compost and manure. While most of the fertilizers are produced from minerals, organic fertilizers are formed from animal and vegetable matter. Another type of fertilizers, chemical fertilizers can be divided into 4 groups by what they contain: containing nitrogen, phosphorus, potassium and containing micronutrients. These are artificially made fertilizers which are used most commonly. Microbial fertilizers contain specified bacteria for each plant, increasing the production of nitrogen by getting it from air which cannot be directly used by plants. Containing compounds of different nutrients, organomineral fertilizers are also common in the sector of agriculture. But, it is known that the chemical fertilizers have the best effect on plants, which is because of the feeding way, these fertilizers supply the needed nutrients to the plant directly, while the nutrients that organic fertilizers contain have to be decomposed before being able to serve the plant.

When I was helping my father with the seasonal flower planting, as we were studying plants in biology lessons, I noticed that we were using an organic fertilizer. After inspecting the ingredients, I made some research about the other types of fertilizers that we can use to improve our garden. But the real question was about the rate of improvement. Then I decided to use this topic in my extended essay for a deep investigation. It is known that fertilizers quicken the growth of plants, however, which type of fertilizer has the biggest effect on plants in a calculated period of time? Because each fertilizer type except organic fertilizer contains a specified nutrient, organic fertilizers, with their variety of nutrients in each subtype, fit the purpose of the experiment best. For this experiment, corn, with the other name, maize (*Zea mays)* will be used. Corn is a large grain plant domesticated by indigenous people in prehistoric times. The leafy stalk produces ears which contain the grain, which are seeds called kernels. Maize kernels are often used in cooking as a starch. The six major types of maize are dent, flint, pod, popcorn, flour, and sweet[1]. 5 types of organic fertilizers: farmyard manure, poultry manure, bat guano, vermicompost, compost (fertilizer that is formed by the waste of the campus (Dışkapı Campus of Ankara University) will be used on 15(3 for each fertilizer type) corn plants. Throughout the integration of the experiment and the investigation, the question, "How do different types of organic fertilizers affect the growth rate of *Zea mays?"* will be answered.

[1] SMITH, Andrew F. (2013) The Oxford Encyclopedia of Food and Drink in America. 2nd ed. Oxford: Oxford U. Print

Hypothesis

As different organic fertilizers contain different minerals and nutrients, in agriculture, organic fertilizers are used with chemical fertilizers to fully supply the needed amount of nutrients to crops. Therefore, using only organic fertilizers is not sufficient for plant growth. Thus, in the experiment, an additional chemical fertilizer of nitrogen will be used in order to augment the growth of corn.

Among 5 types of fertilizers, compost has the least amount of nutrients as it is formed by the waste of a place, in this case, waste of a campus of a university. Bat guano, poultry manure, farmyard manure, vermicompost mostly consist of ammonium, phosphorus oxide, nitrogen and potassium, as main nutrients[2]. Depending on the solubility of nutrients in soil, vermicompost's use of worms during the formation of the fertilizer increases the nutrient available for plant's use. Therefore, it can be hypothesized that the corn seeds that use vermicompost as fertilizer will have the highest rate of growth, according to its final size, fresh and dry weight.

[2] http://w3.balikesir.edu.tr/~mucahitkivrak/index_dosyalar/tavuk%20gubresi.pdf

Method Development and Planning

The planned investigation has a main point of determining the best organic fertilizer for a seasonal plant. To reduce the differences between the plants that will be used, it was decided to use seeds instead of using already grown corn plants. It was estimated that the germination and growth time would significantly increase the duration of one of the phases of the experiment. The decision was made in the beginning of the second semester, in February, and a regular monitoring basis was only possible until July, because of an obligatory 3-week trip to Boston, which will interfere with the final measurement period. Therefore, a plant that would grow and be ready to be harvested in a short period of time was needed. After researching some papers on the internet and getting information from the experts in Ankara University, Faculty of Agriculture, the best possible plant to use in this investigation would be *Zea mays*, corn plant, which has a planting season like many other seasonal plants, in spring, after the frost in the soil is completely disappeared[3].

Another aspect of *Zea mays* is that it has high growth rate. The experiment had to be fit in a semester and an appropriate plant had to be chosen for such instance. To enhance growth, an addition had to be made to the fertilizers. Apart from each organic fertilizer, a chemical fertilizer containing nitrogen was used in every container, otherwise the nutrient amount in organic fertilizers would be insufficient to encourage growth in the planned duration. In less than two months, from 20.02.2015 to 07.04.2015, each of the 60 corn seeds successfully germinated and grew to nearly one meter, proving the accuracy of plant selection for the experiment.

Early planting of the corn seeds could create a problem, however, the location where the experiment is going to be performed was chosen to be at the greenhouse of Ankara University, Faculty of Agriculture, in Dışkapı, Ankara. In the greenhouse, 15 plant stands, 3

[3] http://corn.agronomy.wisc.edu/Management/L003.aspx

for each type of 5 organic fertilizers, were used to contain 4 corn seeds in each. By this way, all the nutrients that are available to the plants are controlled and measured, amount of soil for each plant is regulated, and the threat of frost in the soil is prevented via using plant stands at a greenhouse that has a stable temperature. Corn plant is durable to temperatures between 0°C-22.8°C, but cannot resist to cold under -2.2°C for a long time. Ankara has a dry climate where the temperature difference between day and night over 10°C and the temperature drops to minus degrees in winter, thus it creates a threatening environment for the corn plants. However, a greenhouse can sustain the need of corn plant's optimum temperature for growth, 20°C to 22.8°C[4]. Therefore, planting the corn seeds in February did not create any problem for the experiment.

Minimization of the effect of external factors was achieved by many ways using the greenhouse. An authorization was needed to enter the greenhouse, which was only granted to researchers of Ankara University, consequently decreasing the chance of disturbance of the set-up of the experiment. The greenhouse went under routine monitoring, fertilization, irrigation and temperature check.

Obtaining the organic fertilizers: farmyard manure, poultry manure, bat guano, vermicompost, compost, would obstruct the process of the experiment because especially bat guano and vermicompost are rare in market. Fortunately, needed organic fertilizers were present in the stock of A.U. Faculty of Agriculture, and people in charge eased the set-up of the experiment by providing the required amount of fertilizers and the right equipment for measurements.

During the harvest, there could be some loss of mass of corn plant via random mistakes. To minimize it, a special table was used package the plants stem and leaves. The stems were cut from the soil level and any dead leaf was also included in the containers. The

[4] http://www.clemson.edu/extension/rowcrops/corn/guide/environmental_conditions.html

same process was applied while granulating the stem and leaves, the dust left on the table after grinding is included in the packages.

For the measurement of nitrogen levels in corn plants, the organic bonds in corn plant must be broken down. To achieve this, the tubes were put into an oven that increases the temperature from 70°C (1 hr), 170°C (1 hr), 270°C (1 hr), 370°C (5 hr) respectively. After the end of this process, remains of the burning process were ready for nitrogen measurements.

Throughout the measurement process, there was some phases that contain hazardous and corrosive chemicals and materials. A prevention was taken to avoid any accidents that may occur; all these phases were guided and some of them were performed by a research assistant of A.U. Faculty of Agriculture, Mehmet Burak Taşkın.

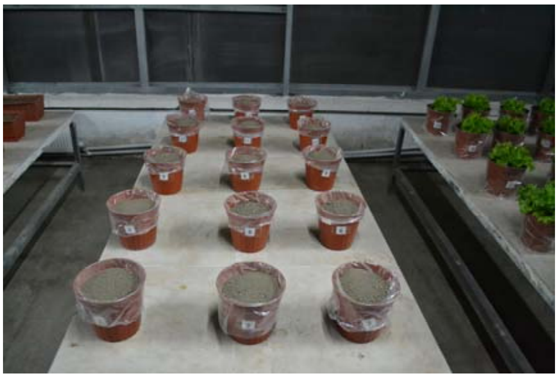


Figure 1. Seed Planting

Figure 2. Plants 1 month later after planting

Figure 3. 48 days after planting (harvest date)

Figure 4. Granuled plant leaves and stems

Method

Materials and Apparatus:

- 60 *Zea mays* seeds
- 15 plant stands
- 45 kg soil
- 12 L water (for irrigation)
- Secateurs
- 15 containers (to preserve the cut leaves and stem)
- Concave container (to homogenize soil and organic fertilizers)
- Scale
- 400 g of each type of organic fertilizers (farmyard manure, poultry manure, bat guano, vermicompost, compost)
- 600 g chemical fertilizer containing nitrogen
- Pure water (to cleanse the dust and external matter of the plant)
- Oven (specialized for drying the stems and leaves of the plant)
- 15 lockable plastic containers (to contain granules of the plant)
- Spoon
- *BOSCH* branded grinder
- 16 test tubes for nitrogen inspection
- *Gerhardt Kjeldaterm* branded oven (specialized for burning the granules)
- 32 mL Nitric acid solution
- 16 ceramic containers
- *Gerhardt Thermo HT* branded grill (specialized for heating up burned granules during addition of Nitric acid and water into the ceramic containers)
- 24 mL Barton solution

- 192 mL pure water (for phosphorus inspection)
- Funnel
- 16 volumetric flasks
- 16 paper filters
- 16 flasks with head pieces
- 24 test tubes (for phosphorus inspection)
- *SHIMADZU UV1201V* Spectrophotometer
- *Jenway PFP7* Flame Photometer
- Stirring device
- *Gerhardt Vapodest* Steam Distillator

Firstly, 15 plant stands are numerated from 1 to 15, 1-2-3 for farmyard manure, 4-5-6 for compost, 7-8-9 for vermicompost, 10-11-12 for poultry manure, and 13-14-15 for bat guano. 400 g of each type of fertilizers are measured on a scale and put into 15 containers, 3 containers for each type of organic fertilizers, farmyard manure, poultry manure, bat guano, vermicompost, and compost. For each plant stand, in total of 15, 3 kg of soil and 400 g of organic fertilizer is mixed in a concave container, in order to homogenize the mixture. Then, plants stands are filled with the mixture of fertilizer and soil and rested for one day to fully achieve the integration of the mixture and increase the effect of fertilizer on soil. 4 corn seeds, 60 in total, are planted into each of the plant stands and given 500 mL water.

Plants go under routine control of water levels, and temperature. 400 mL of water is given every two days. To increase the growth rate of all plants and decrease the time needed for the growth level for harvesting, 100 g nitrogen-containing chemical fertilizer is added every week. At the end of 48 days, plants are cut from the soil level. Stems and leaves are put into numerated 15 containers and gathered to the laboratory.

Each labeled plant is put on the scale without any remaining in the containers and fresh weight is measured. Then, plants are cleaned from dust and external matter by using pure water and they are put into 15 containers, being ready for drying in the oven. After drying, each plants' dry mass is measured.

Labeled plants are grinded with a grinder and the granules are put into numerated lockable plastic containers. 0.25 g of grinded plant matter is measured 32 separate times. 16 of them are put into ceramic containers and burned in an oven for phosphorus and potassium inspection. Other 16 of them are put into test tubes and placed into another oven (*Gerhardt Kjeldaterm*) for nitrogen inspection. Salicylic- sulfuric acid solution and catalyst salt solution is added to the test tubes. The temperature is increased from 70°C (1 hr), 170°C (1 hr), 270°C (1 hr), 370°C (5 hr) respectively, to completely break down the organic bonds of the plant.

The test tubes are brought to the nitrogen-level measurement device, *Gerhardt Vapodest* Steam Distillator and machine is started, values are recorded, and a formula to calculate nitrogen percentage is used for each.

On the other side, ceramic containers are put onto a grill, *Gerhardt Thermo HT,* and 2 mL of nitric acid is added to each solution while the contents of containers starts boiling. Pure water is added to containers to make them 50 mL each. 16 flasks are numerated and put paper filter on them. The solution in the containers are filtered and deposited in the flasks.

For phosphorus inspection, from each flask 1 mL of solution is put into numerated test tubes; 8 mL of pure water, and 1 mL of Barton solution are also added. To have a homogenized solution, each tube goes under a stirring process using a device. Phosphorus-level reader, *SHIMADZU UV1201V* Spectrophotometer, is started up, values are read from each tube, and phosphorus calculations are made based on formulas. For potassium inspection, *Jenway PFP7* Flame Photometer is used. Values are read and calculations are made again.

Results and Data Analysis

Measurement I

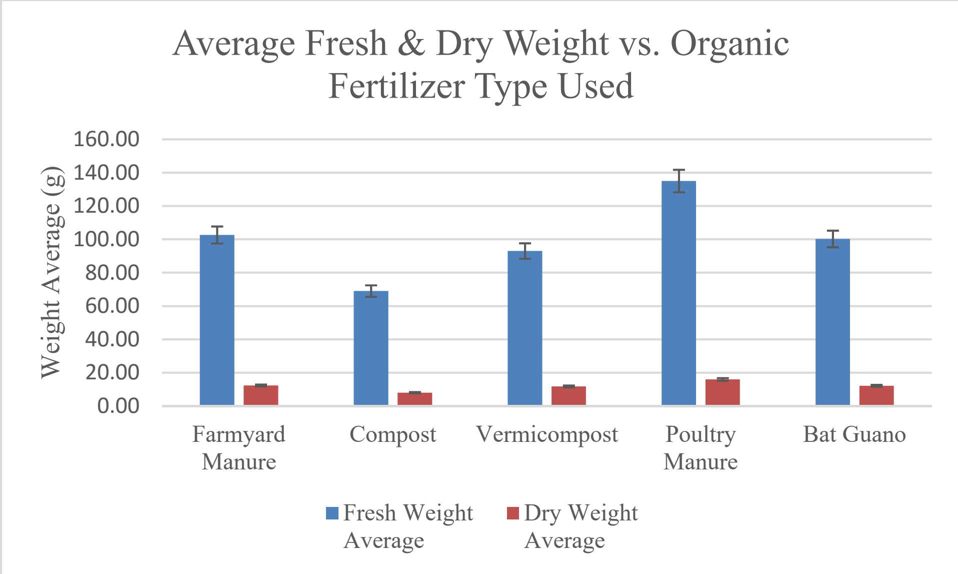
Fertilizer Type Used	Trial	Fresh Weight (g±0.001 g)	Dry Weight (g±0.001 g)
Farmyard Manure	1	105,64	12,87
	2	101,70	12,41
	3	100,45	11,70
Compost	4	58,64	6,55
	5	80,14	9,41
	6	68,07	7,98
Vermicompost	7	87,91	11,13
	8	101,60	12,52
	9	89,43	11,61
Poultry Manure	10	135,98	15,55
	11	146,91	16,73
	12	122,10	15,45
Bat Guano	13	98,86	11,71
	14	107,29	12,48
	15	94,52	12,05

Table 1. Set of results of dry and fresh weight after harvest of *Zea mays*

Fertilizer Type Used	Fresh Weight Average	Standard Deviation	Standard Error	95% CI
Farmyard Manure	102,60	2,71	1,56	6,73
Compost	68,95	10,78	6,22	26,77
Vermicompost	92,98	7,50	4,33	18,64
Poultry Manure	135,00	12,43	7,18	30,89
Bat Guano	100,22	6,49	3,75	16,13

Fertilizer Type Used	Dry Weight Average	Standard Deviation	Standard Error	95% CI
Farmyard Manure	12,33	0,59	0,34	1,46
Compost	7,98	1,43	0,83	3,55
Vermicompost	11,75	0,71	0,41	1,75
Poultry Manure	15,91	0,71	0,41	1,77
Bat Guano	12,08	0,39	0,22	0,96

Table 2 and 3. Overall data of average dry and fresh weight of *Zea mays.*



Graph 1. Graph of the average fresh & dry weight of *Zea mays* versus organic fertilizer type used.

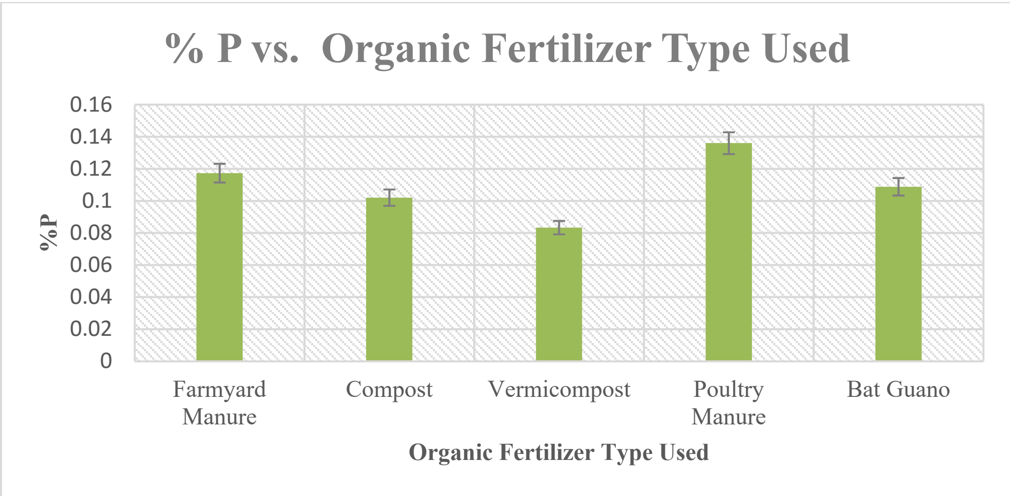
Measurement II

Fertilizer Type Used	Trial	Values Read from the Machine	Values minus Experiment Zero(x)	y = 25,528x - 0,1622	ppm P (y × 2000)	Average ppm P	**% P**
Experiment Zero		0					
Farmyard Manure	1	0,031	0,031	0,629168	1258,336	1173	0,12
	2	0,032	0,032	0,654696	1309,392		
	3	0,025	0,025	0,476	952		
Compost	4	0,027	0,027	0,527056	1054,112	1020	0,10
	5	0,026	0,026	0,501528	1003,056		
	6	0,026	0,026	0,501528	1003,056		
Vermicompost	7	0,017	0,017	0,271776	543,552	833	0,08
	8	0,026	0,026	0,501528	1003,056		
	9	0,025	0,025	0,476	952		
Poultry Manure	10	0,034	0,034	0,705752	1411,504	1360	0,14
	11	0,035	0,035	0,73128	1462,56		
	12	0,03	0,03	0,60364	1207,28		
Bat Guano	13	0,028	0,028	0,552584	1105,168	1088	0,11
	14	0,021	0,021	0,373888	747,776		
	15	0,034	0,034	0,705752	1411,504		

Table 4. Set of results of phosphorus measurement containing values read from the machine and the phases of phosphorus percentage calculation of *Zea mays*.

Fertilizer Type Used	Average ppm P	Standard Deviation	Standard Error	95% CI
Farmyard Manure	1173	193,29	111,60	480,17
Compost	1020	29,48	17,02	73,23
Vermicompost	833	251,85	145,41	625,64
Poultry Manure	1360	135,08	77,99	335,56
Bat Guano	1088	332,19	191,79	825,21

Table 5. Overall data of average phosphorus ppm of *Zea mays.*



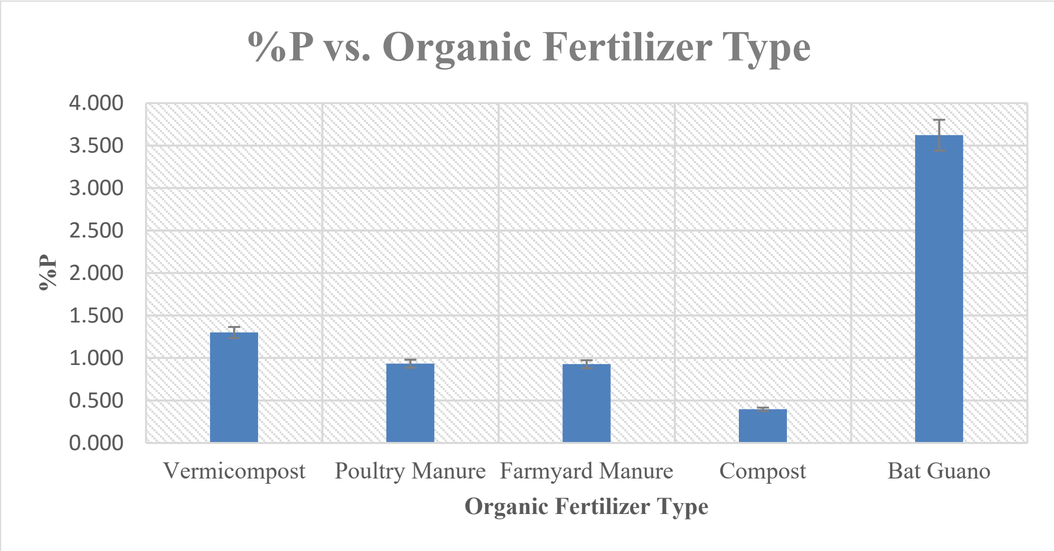
Graph 2. Graph of the average phosphorus percentage in *Zea mays* vs. type of organic fertilizer used.

Fertilizer Type	Values Read from the Machine	Values minus Experiment Zero(x)	y = 25,528x - 0,1622	ppm P	**% P**
E. Zero of Fertilizer	0,001				
Vermicompost	0,262	0,261	6,500608	13001,22	1,30
Poultry Manure	0,19	0,189	4,662592	9325,184	0,93
Farmyard Manure	0,189	0,188	4,637064	9274,128	0,93
Compost	0,085	0,084	1,982152	3964,304	0,40
Bat Guano	0,717	0,716	18,115848	36231,7	3,62

Table 6. Set of results of phosphorus measurement containing values read from the machine and the phases of phosphorus percentage calculation of organic fertilizers.

Fertilizer Type	Vermicompost	Poultry Manure	Farmyard Manure	Compost	Bat Guano
% P	1,30	0,93	0,93	0,40	3,62

Table 7. Overall data of average phosphorus percentage of organic fertilizers.



Graph 3. Graph of the average phosphorus percentage in organic fertilizers with respect to its type.

Calculations (Measurement II)

To find the percentage of phosphorus of *Zea mays*, values read from the machine have to be processed through a standard calculation including an equation.

An example of the calculation for the first trial is shown below:

1. Firstly, if experiment zero, the tube that is left empty, has a value different than 0, this value is subtracted from the trial value.

$0{,}031 - 0 = 0{,}031$

2. Using the equation ($y = 25{,}528x - 0{,}1622$), the trial value is used as x, and y is found.

$y = 25{,}528 \times 0{,}031 - 0{,}1622 = 0{,}629168$

3. Because water is added to the solution in the ratio of 2000, the value obtained at the end of the 2^{nd} step is multiplied by 2000.

$0{,}629168 \times 2000 = 1258{,}336$

4. To find the percentage of phosphorus in the solution, last obtained value is divided to 10000.

$1258{,}336 \div 10000 = 0{,}1258\ \%$

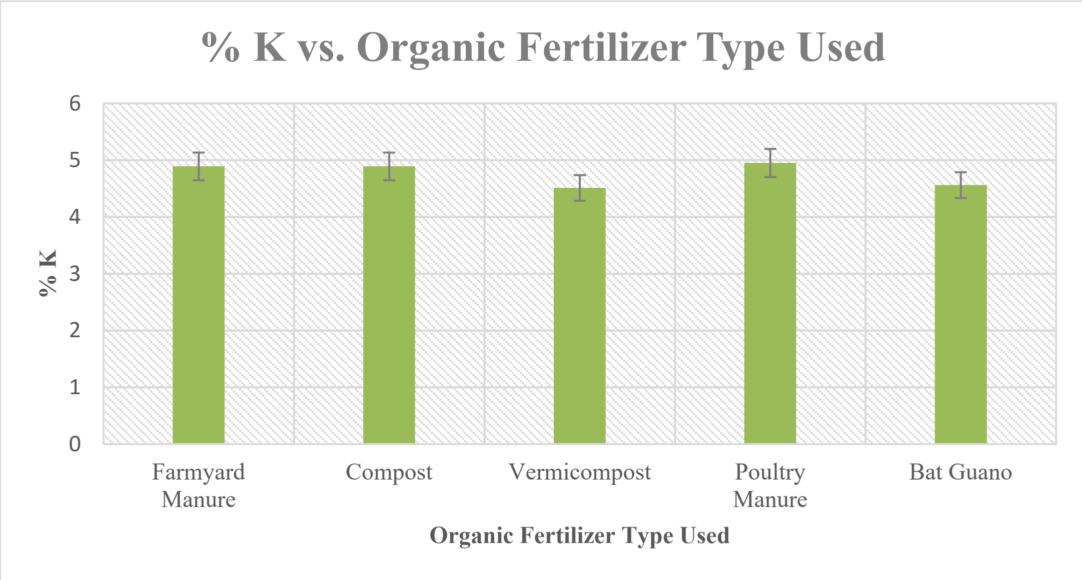
Measurement III

Fertilizer Type Used	Trial	Values Read from the Machine	Values minus Experiment Zero(x)	y = 0,0066x² + 0,3484x - 0,3237	ppm K (y × 1800)	% K	**Average % K**
Experiment Zero		1					
Farmyard Manure	1	45	44	27,7835	50010	5,00	4,89
	2	44	43	26,8609	48350	4,83	
	3	44	43	26,8609	48350	4,83	
Compost	4	45	44	27,7835	50010	5,00	4,89
	5	44	43	26,8609	48350	4,83	
	6	44	43	26,8609	48350	4,83	
Vermicompost	7	42	41	25,0553	45100	4,51	4,51
	8	42	41	25,0553	45100	4,51	
	9	42	41	25,0553	45100	4,51	
Poultry Manure	10	44	43	26,8609	48350	4,83	4,95
	11	46	45	28,7193	51695	5,17	
	12	44	43	26,8609	48350	4,83	
Bat Guano	13	43	42	25,9515	46713	4,67	4,56
	14	42	41	25,0553	45100	4,51	
	15	42	41	25,0553	45100	4,51	

Table 8. Set of results of potassium measurement containing values read from the machine and the phases of potassium percentage calculation of *Zea mays.*

Fertilizer Type Used	Average % K	Standard Deviation	Standard Error	95% CI
Farmyard Manure	4,89	0,10	0,06	0,24
Compost	4,89	0,10	0,06	0,24
Vermicompost	4,51	0,00	0,00	0,00
Poultry Manure	4,95	0,19	0,11	0,48
Bat Guano	4,56	0,09	0,05	0,23

Table 9. Overall data of average potassium percentage of *Zea mays.*



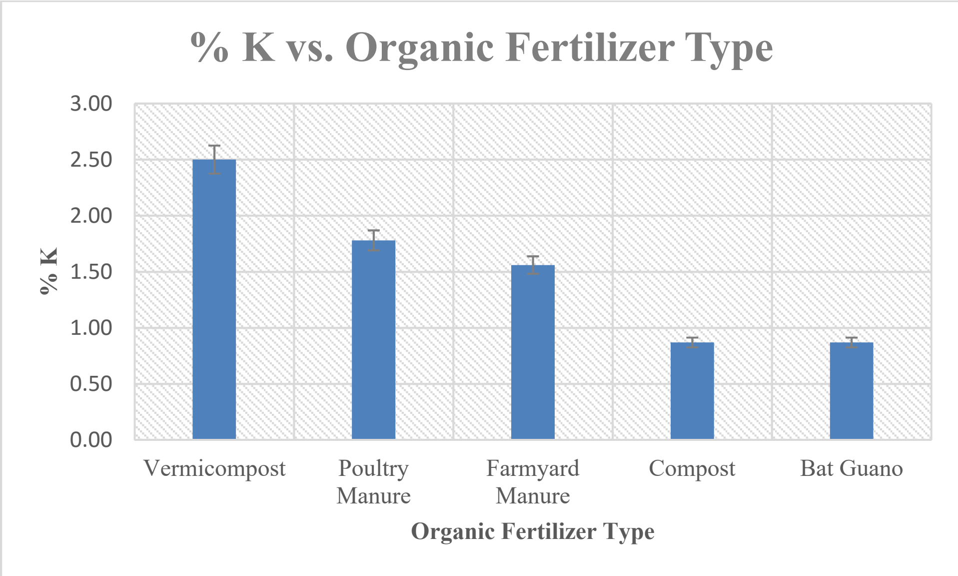
Graph 4. Graph of the average potassium percentage in *Zea mays* vs. type of organic fertilizer used.

Fertilizer Type	Values Read from the Machine	Values minus Experiment Zero(x)	$y = 0{,}0066x^2 + 0{,}3484x - 0{,}3237$	ppm K (y × 1800)	**% K**
E. Zero of Fertilizer	2				
Vermicompost	29	27	13,8945	25010	2,50
Poultry Manure	23	21	9,9033	17826	1,78
Farmyard Manure	21	19	8,6785	15621	1,56
Compost	14	12	4,8075	8654	0,87
Bat Guano	14	12	4,8075	8654	0,87

Table 10. Set of results of potassium measurement containing values read from the machine and the phases of potassium percentage calculation of organic fertilizers.

Fertilizer Type	Vermicompost	Poultry Manure	Farmyard Manure	Compost	Bat Guano
% K	2,50	1,78	1,56	0,87	0,87

Table 11. Overall data of average potassium percentage of organic fertilizers.



Graph 5. Graph of the average potassium percentage in organic fertilizers with respect to its type.

Calculations (Measurement III)

To find the percentage of potassium of *Zea mays*, values read from the machine have to be processed through a standard calculation including an equation.

An example of the calculation for the first trial is shown below:

1. Firstly, if experiment zero, the tube that is left empty, has a value different than 0, this value is subtracted from the trial value.

$45 - 1 = 44$

2. Using the equation ($y = 0{,}0066x^2 + 0{,}3484x - 0{,}3237$), the trial value is used as x, and y is found.

$y = 0{,}0066 \times (44)^2 + 0{,}3484 \times 44 - 0{,}3237 = 27{,}7835$

3. Because water is added to the solution in the ratio of 1800, the value obtained at the end of the 2nd step is multiplied by 1800.

$27{,}7835 \times 1800 = 50010$

4. To find the percentage of potassium in the solution, last obtained value is divided to 10000.

$50010 \div 10000 = 5{,}00\ \%$

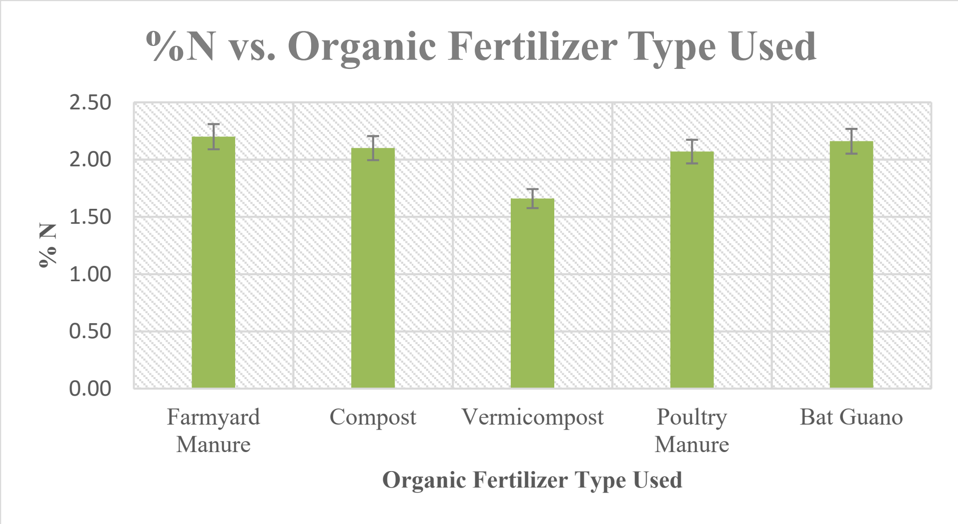
Measurement IV

Fertilizer Type Used	Trial	Values Read from the Machine	Values minus Experiment Zero(x)	% N = (T - E_0) × 0,1929 × 1,4 ÷ 0,25	**Average % N**
Experiment Zero		0,14			
Farmyard Manure	1	2,20	2,06	2,225	2,20
	2	2,06	1,92	2,074	
	3	2,28	2,14	2,312	
Compost	4	2,22	2,08	2,247	2,10
	5	1,74	1,60	1,728	
	6	2,30	2,16	2,333	
Vermicompost	7	1,72	1,58	1,707	1,66
	8	1,52	1,38	1,491	
	9	1,78	1,64	1,772	
Poultry Manure	10	2,02	1,88	2,031	2,07
	11	2,06	1,92	2,074	
	12	2,10	1,96	2,117	
Bat Guano	13	2,08	1,94	2,096	2,16
	14	2,14	2,00	2,160	
	15	2,20	2,06	2,225	

Table 12. Set of results of nitrogen measurement containing values read from the machine and the phases of nitrogen percentage calculation of *Zea mays*.

Fertilizer Type Used	Average % N	Standard Deviation	Standard Error	95% CI
Farmyard Manure	2,20	0,12	0,07	0,30
Compost	2,10	0,33	0,19	0,81
Vermicompost	1,66	0,15	0,08	0,37
Poultry Manure	2,07	0,04	0,02	0,11
Bat Guano	2,16	0,06	0,04	0,16

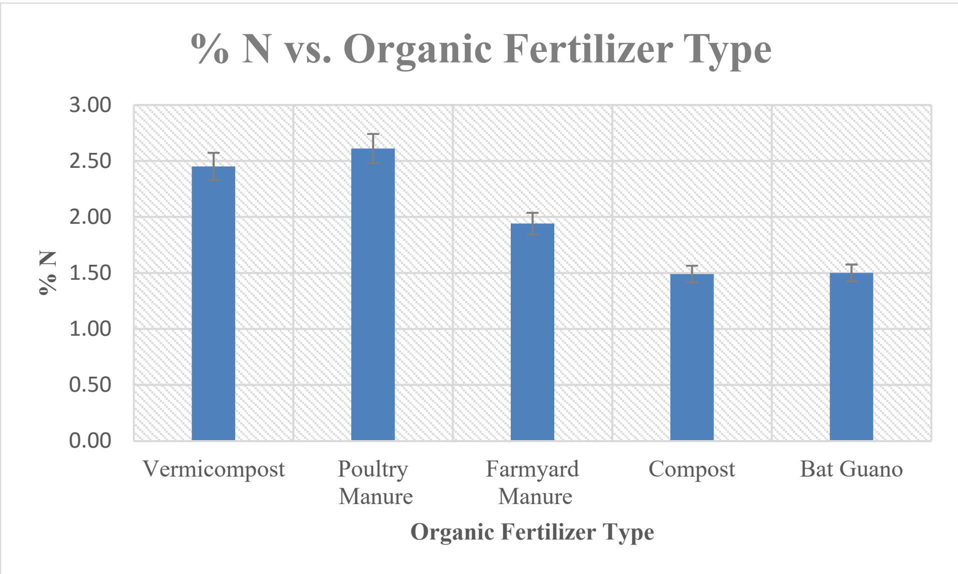
Table 13. Overall data of average nitrogen percentage of *Zea mays*.



Graph 6. Graph of the average nitrogen percentage in *Zea mays* vs. type of organic fertilizer used.

Fertilizer Type	Vermicompost	Poultry Manure	Farmyard Manure	Compost	Bat Guano
% N	2,45	2,61	1,94	1,49	1,50

Table 14. Overall data of average nitrogen percentage of organic fertilizers.



Graph 7. Graph of the average nitrogen percentage in organic fertilizers with respect to its type.

Calculations (Measurement IV)

To find the percentage of nitrogen of *Zea mays*, values read from the machine have to be processed through a standard calculation including an equation.

An example of the calculation for the first trial is shown below:

1. Firstly, if experiment zero, the tube that is left empty, has a value different than 0, this value is subtracted from the trial value.

$2,20 - 0,14 = 2,06$

2. Using the equation ($\%N = 0,1929x \times 1,4 \div 0,25$), the trial value is used as x, and % N is found.

$\% N = 0,1929 \times 2,06 \times 1,4 \div 0,25 = 2,225 \%$

ANOVA Test

To fully evaluate and conclude the investigation, an ANOVA test is required to be sure about the validity of the outcome of the experiment. Among different measurements, dry weight of plants with respect to their soil contents, the type of organic fertilizer that was used, is chosen. After processing the data with data analysis tools, the results of ANOVA test is shown below:

ANOVA

Source of Variance	*SS*	*df*	*MS*	*F*	*P-value*	*F criterion*
Inter-Groups	94,86587	4	23,71647	33,43675	9,20918E-06	3,47805
In-Groups	7,092933	10	0,709293			
Sum	101,9588	14				

Evaluation

The experiment was done under guidance and monitoring of a research assistant in Ankara University, Faculty of Agriculture, therefore minimizing both random and systematic errors. The latest technology and equipment were used to maximize the accuracy and precision, including flame photometer, spectrophotometer, and steam distillator, which are used to determine the NPK (nitrogen-phosphorus-potassium) levels in the plants that grew by using different types of organic fertilizers. Although there is not any errors to mention that caused a change in the experimental process, there are still parts that can be improved to reach to the actual value and fully answer the research question with all aspects.

During the process of harvesting, plants were cut from soil level, leaving the roots in the soil and excluding them from the measurements that took place in the laboratory. As a part of the plants' biomass, roots could also be included in the measurements as they can contain nitrogen, potassium, and phosphorus. There is a chance that some segment of the nutrients did stay in the roots. Not considering these parts might have had an effect on the nutrient percentage. However, because the same process is applied in all trials, comparison of the effect of different type of organic fertilizers on *Zea mays* do not conflict with the issue mentioned.

Another matter is the use of chemical fertilizers during 20.02.2015 – 07.04.2015, when the plant germination and growth occurred. Because there was a time restriction that was born from external factors that includes travels of the writer of the thesis in summer, a fast-growing plant was selected. Other than the selection, the process was speeded up by using nitrogen-containing chemical fertilizer. This addition enabled the experiment to be done in less than two months, while most probably having an effect on nitrogen levels of the plants that was read during the measurement. If the time limitation did not exist, the plant growth could be observed without the inclusion of chemicals in a longer time period.

Nevertheless, the results of ANOVA test shows that the measurement values are valid and can be used to prove or disprove the hypothesis. The p value, 9,20918E-06, is lower than 0,05, which means that the data are conclusive and credible.

Other than the improvisations that could be made on the experiment done, there are other additions that could be made to broaden the spectrum of the investigation. The plant used in the investigation was *Zea mays*, corn plant. The effect of different types of organic fertilizers on this plant is shown thoroughly the investigation. Including other plants to the experiment might have a different outcome or the same results. By using increasing the independent variables, in this case organic fertilizer type and plant type, comparison between two plants may have given a better idea on how type of organic fertilizer affect the nutrient level in plants. On the other hand, this investigation is based on the question, “How do different types of organic fertilizers affect the growth rate of *Zea mays*?”, and this question is answered with definitive details.

Conclusion

The hypothesis before starting to the experiment, the hypothesis was, among the different types of organic fertilizers, vermicompost would have been the most effective to increase NPK level of the plants. This hypothesis was formed by expanding the idea that worms are the natural decomposers, which will enrich the fertilizer by composing more nutrients and making them available to the plants. At this point, this hypothesis is proven wrong. Despite the development of the hypothesis was based on reasoning, the results proved that vermicompost was the least effective. The only highest value was received during the measurement of potassium level in the fertilizer, vermicompost. When compared to a research in Oregon State University[5], it is stated that the nutrient release speed is one of the slowest among organic fertilizers, which explains one of the flaws of the hypothesis.

When the NPK level of bat guano is compared between the investigation and the research that is mentioned, bat guano did not come as first in the rankings of nutrient levels. This situation cannot be justified by the release speed, because the research states that its speed is between medium and fast. Most probable answer is the origin of bat guano as it can differ by region, in this case U.S.A. and Turkey.

Comparing the NPK percentages of fertilizers and those of plants, there was a significant detail. The percentage of phosphorus was lower in the plants than in the fertilizers, which means either most of the phosphorus could not be transferred to the plant or it was used for daily processes of the plant. For the other two nutrients, potassium and nitrogen, the nutrient level was lower in fertilizers than it was in plants, meaning production of nitrogen and potassium did occur in the plants.

[5] http://extension.oregonstate.edu/lane/sites/default/files/documents/lc437organicfertilizersvaluesrev.pdf

Data shows that poultry manure had the biggest impact on plants' nutrient levels at overall. As it is both farmyard manure and poultry manure are easily obtainable by people working in the field of agriculture, use of such organic fertilizers will decrease amount of chemicals used in cultivation. Reduction of chemicals in agriculture will both cut down the harm caused by feeding from food containing hormones and chemicals and the pollution of environment at the process of specialized chemical production.

Another detail is that NPK levels of 3 plants which were fed by compost did perform well, despite the common belief of futility of using compost as fertilizer when compared to other available sources. Therefore, the collection of organic waste of each living quarter should be encouraged. By this way, not only organic wastes can be recycled by using them as natural fertilizers, but also use of chemicals can be decreased in agriculture, providing a more organic and less chemical future for humans.

Bibliography

ANONYMOUS. (02/2006) "Corn Agronomy-Planting Season" University of Wisconsin. Available under http://corn.agronomy.wisc.edu/Management/L003.aspx

CARD, Adrian et. al. (10/2014) "Organic Fertilizers" Colorado State University Extension. Available under http://www.ext.colostate.edu/mg/gardennotes/234.html

ELLIOT, A.L. et. al. (10/2014) "Phosphorus Fertilizers for Organic Farming Systems" Colorado State University Extension. Available under http://www.ext.colostate.edu/pubs/crops/00569.html

İNAL, Ali, SÖZÜDOĞRU, Sonay, ERDEN, Dilara. (06/1996) "Tavuk Gübresinin İçeriği ve Gübre Değeri" Ankara Üniversitesi Tarım Bilimleri Dergisi. p.45-50

KIVRAK, Mücahit. (No date) "Tavuk Gübresi" Balıkesir Üniversitesi. Available under http://w3.balikesir.edu.tr/~mucahitkivrak/index_dosyalar/tavuk%20gubresi.pdf

PENHALLEGON, Ross. (2003) "Nitrogen-Phosphorus-Potassium Values of Organic Fertilizers" Oregon State University Extension Service. Available under http://extension.oregonstate.edu/lane/sites/default/files/documents/lc437organicfertilizersvaluesrev.pdf

SHARPLEY, Andrew et. al. (No date) "Nutrient Analysis of Poultry Litter" University of Arkansas Cooperative Extension Service. Available under https://www.uaex.edu/publications/PDF/FSA-9529.pdf

SMITH, Andrew F. (2013) The Oxford Encyclopedia of Food and Drink in America. 2nd ed. Oxford: Oxford U. Print

TABAN, Süleyman, TURAN, Murat Ali, KATKAT, A. Vahap. (No date) "Tarımda Organik Madde ve Tavuk Gübresi" Available under http://arastirma.tarim.gov.tr/tavukculuk/Belgeler/web%20English%20Doc/journal%20(Dergimiz)/Dergimiz%20Cilt%2010%20Ozel%20sayi/Cilt%2010%20Ozel%20Sayi%201%20Makale%201%20Tar%C4%B1mda%20Organik%20Madde%20ve%20Tavuk%20G%C3%BCbresi.pdf

WIATRAK, Pavel. (No date) “Environmental Conditions Affecting Corn Growth” Clemson University Cooperative Extension. Available under http://www.clemson.edu/extension/rowcrops/corn/guide/environmental_conditions.html