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The Study on Humanure as an Alternative to Commercial Fertilizer and its Decay Rate with Various Additives

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Abstract: ***Agricultural pollution is major environmental pollutants and is caused by excessive use of chemicals, which ultimately deteriorate the soil health when applied continuously for better yield, also it pollute surface and ground water quality and it account for emission of tons of green house gases. Hence the study was taken with a view to evaluate opportunities and possibilities of usage of recycled human waste in the agricultural production, highlighting the general sanitation crisis, fertilizer scenarios and its limits, constraints and cost. The aim of the study was to promote the use of humanure onto the agricultural crops/lands, which addresses the consequences of changes in agricultural production with respect to ecology, environment and economy. From the study it is found that initially it produce lower yield but for long run yield is projected to be high. A study was also carried out on Kinetics of the decay of Humanure with various additives and it is found that the macronutrients content of Humanure can be enhanced by using the combination of Saw Dust, Rice Husk and Wood Ash as additives.***

Keywords: Humanare, Saw Dust, Rice Husk, Wood Ash

1. Introduction

Faeces contain nitrogen, phosphorus, potassium and also organic carbon as well as most of the pathogens. Stored excreta are transformed from a harmful product into a productive asset. Human faeces are the main source of diarrheal pathogens and all other common endemic gastro-enteric infections and some respiratory infections.

Ecological sanitation not only seeks to sanitize feaces, but also to provide nutrient for plants [15]. It play a major role on closing nutrient loops and improving soil fertility and structure, yield will be higher per unit space, plants will be healthier and more nutritious and lower levels of external inputs and less water will be required [1] & [2]. Human excreta, on average, sufficient plant nutrient [15] in the forms of nitrogen, phosphorus and potassium to grow the 230 kg of crops they need each year, with approximately 65 to 90% of the nutrient being found in urine. Furthermore, these nutrients are in chemical compounds easily accessible to plants.

Humanure is dark brown, crumbly and is earthy smelling like any other organic fertilizers [13]. It serves primarily as a soil conditioner; whether it's spread in a layer on the soil surface or is dug in. soil regularly mended with compost is better able to hold air and water, drain more efficiently and contains a nutrient reserve the plants can draw on.

Treated faeces are worked well into the soil, and should not be left on the soil surface [13]. It should not be used for growing vegetables, fruits or root crops that will be consumed raw. A period of at least one month between application and harvest is recommended for treated feaces.

2. Material and Methodology

The studies were carried out by making ten plots each of equal dimensions i.e. 250 sq-ft of each plot size. To cross check the results and to assess humanure is better alternative, two types of crops are grown namely Soya bean and Green Gram in each of five plots with different application options for each plots. The crops grown and the quantity of seeds sown on the plots with the spacing are as per standard Agricultural practices. Sowing of seed was done during month of February and crops were harvested by mid of May. The physico-chemical properties of soil were studied in four interval of time namely before sowing, at 45th day after sowing, before harvesting and after harvesting, physical growth and crop yield was also compared.

2.1 Soil Sampling

Soil sample are took randomly from many places in the field, Quadrate method is used in preparing sample. For analyzing physical parameters like Bulk Density, Particle Density, Moisture content and chemical parameters like pH, Electrical conductivity, Organic carbon, Soil Nitrate, Phosphates, and Potassium was determined as per the procedure mentioned in [6] & [11].

2.2 Plant Analysis

It is done by noting average leaf length, width, average height is noted for top third leaf dimensions of the 25 plants

in each plot at 65th day, and average dry weight of plant is noted by taking initial and final reading on electronic balance and dried for two days and re-weighted, also average percent of organic matter present is determined and yield of the crop is measured by harvesting the crop and was dried in sunlight for two days in the respective plots and the cereals from the crop were separated after ensuring complete dryness, then cereals were weighed in an electronic balance to note the yield [5] & [11]. The obtained yield from 250 sq-ft is then computed for hectare.

2.3 Decay Rate Coefficient of Humanure with Various Additives to Find the Optimal NPK

Set of experiments and data analysis were carried out to model the optimal NPK values in Humanure. Equal quantities of Humanure and various additives like sawdust, rice husk and wood ash were collected, mixed proportionately and was continuously monitored at two different namely at 55^0c in hot air oven and at room temperature for a period of 22 days. The initial and final weight, volume and density of the mixtures, the nitrates, phosphates and potassium values of the compost were analyzed in the laboratory.The experiment was carried out for 22 days consecutively and the mixtures were analyzed for NPK values each day.

2.4 Multiple Regression Equation:

It is general used to learn about the relationship between several independent and dependent variable. These procedures are widely used in research, which allows answering general question "what is the best predictor of…" In general, multiple regression procedures will estimates a linear equation of the form

$$Y= a + b1X1 + b2X2+…. bnXn \quad (1)$$

Where y = dependent variable, a = intercept and b1, b2...bn = regression coefficients and X1, X2…Xn = independent variable. Correlation coefficient is done in interpreting the degree to which 2 or more predictors are related to the dependent variables in the correlation coefficient R, which is the square root of R-square. R can assume values between 0 and 1. In interpreting relation between variables signs of the regressions or "b" coefficient are important.

Descriptive statistics were used in describing the basic features of the data in a study, which provides simple summaries about the sample and the measures. It is used to present quantitative descriptions in a manageable form. The distribution of values over a range of values is described using MEAN, MEDIAN, MODE AND STANDARD DEVIATION.

3. Results and Discussions

3.1 Initial Soil Properties

Initial soil properties before sowing were carried out, and the type of soil is red and the texture is fine in nature, the other properties like moisture content (%) is 0.35, specific gravity.55, Bulk density is 1.11g/cc and water holding capacity (%) was 139.83 and the chemical properties like pH was 7.39, EC (Electrical conductivity) was 0.321, organic carbon % was 0.449, Organic Matter (%) was 0.774, nitrate was 70.3 (kg/ac), Phosphorus as P_2O_5 was 16.10 (kg/ac) and Potassium as K_2O was 107 (Kg/ac).

3.2 soil properties of plots before and after harvesting the crop

3.2.1 NPK values of soil

From the figure 3.1 and 3.2 it can be noted that the NPK has been well utilized in the plot 3, 4 and 5 where farm yard, Humanure, Humanure and Urine was applied respectively as against to control and fertilizers applied plots.

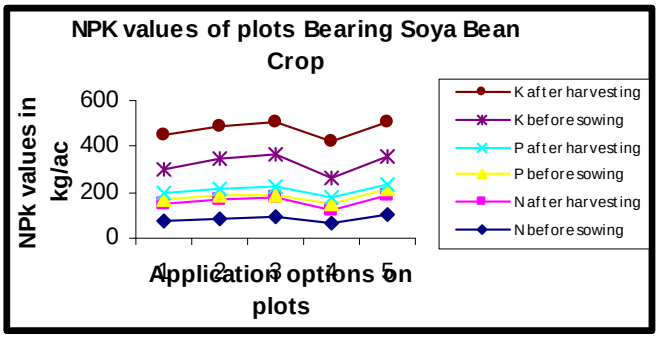

Figure 3.1: NPK values of the plots bearing Soya bean crop

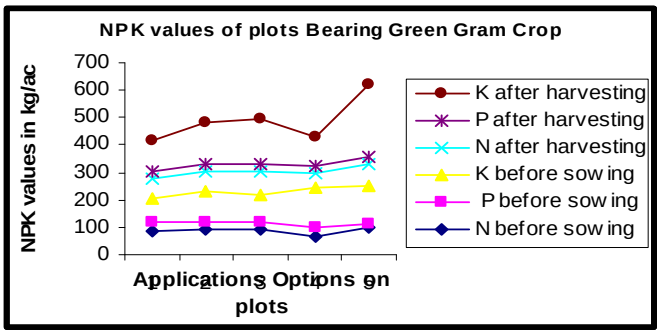

Figure 3.2: NPK values of the plots bearing Green gram crop

3.2.2 Percentage of organic carbon in soil

From the figure 3.3 and 3.4 we can note that % of organic carbon content left out in soil was found to be high in the plot where organic fertilizer and eco-fertilizer were applied. Organic matter thus improve the carbon content in soil hence the fertility and yield of the crop.

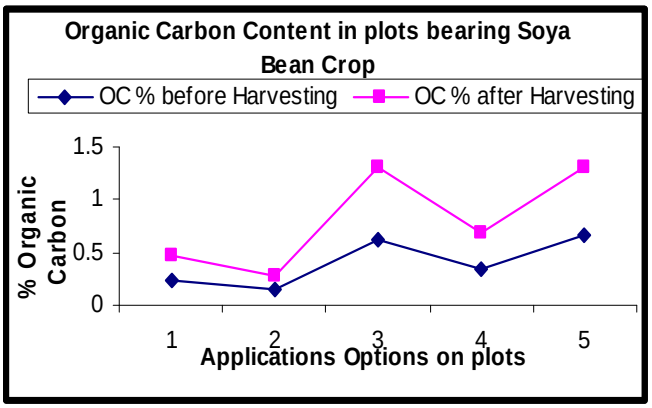

Figure 3.3: Organic Carbon content in plots bearing Soya bean crop

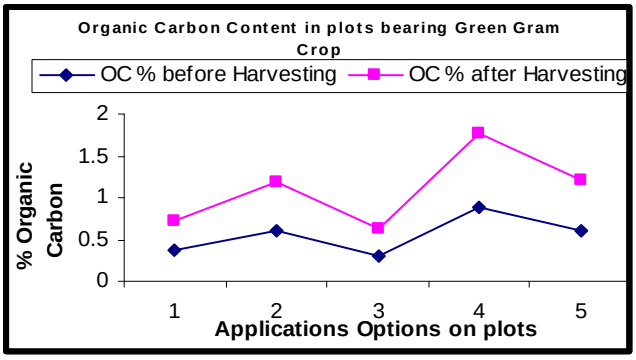

Figure 3.4: Organic Carbon content in plots bearing Green gram crop

3.2.3 Percentage of organic matter in soil

From the figure 3.5 and 3.6 the organic matter is found to be high in plots where organic fertilizers was applied and organic carbon, organic matter and NPK was well utilized in plots 3, 4, and 5 plots as against control and commercial fertilizer. We can observe that plot with Humanure and Humanure with urine increase the nutrient values in the soil and thus enhancing the fertility of soil.

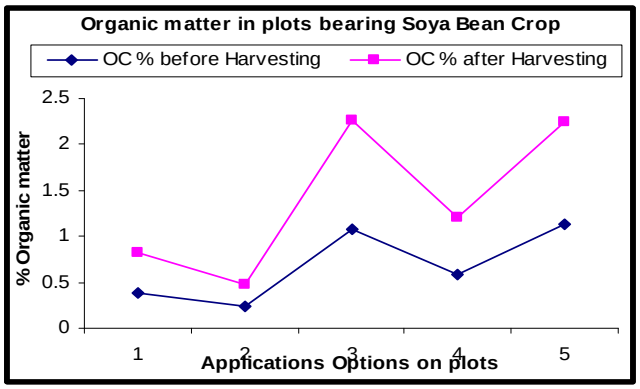

Figure 3.5: Organic matters in plots bearing Soya bean crop

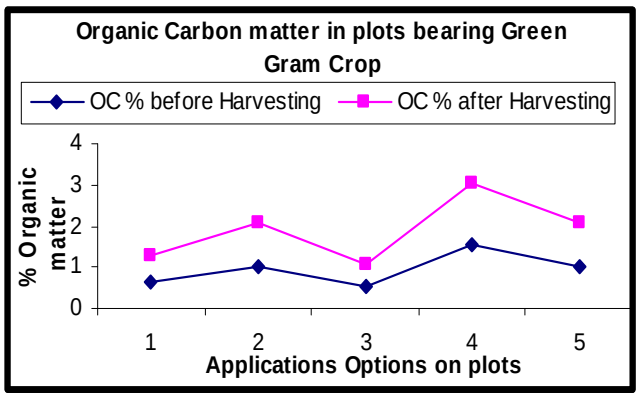

Figure 3.6: Organic matters in plots bearing Green gram

3.3 Physical Growth of the Crops

From the figure 3.7 and 3.8 we can observe that the average leaf length, width, height are high in the 5th plot where eco-fertilizer is applied. Although in the 4th plot average values are almost near to the ones grown in plot 3 and 2. Being plot 1 is control, it have lesser values than all the others.

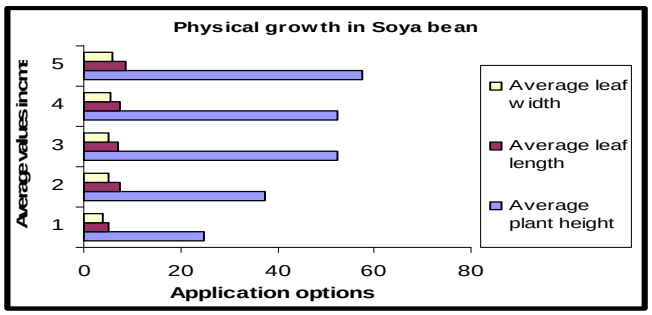

Figure 3.7: Physical growths in Soya bean

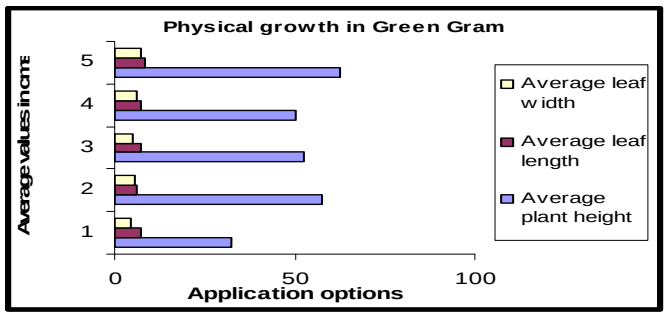

Figure 3.8 Physical growths in Green Gram

3.4 Dry Weight of the Crops

From the figure 3.9 we can observe that the average dry mass is highest in the 5th plot and 2nd plot has the second highest dry mass because of the commercial fertilizers. The organic manure (Humanure and farm yard manure) however hold the almost similar mass.

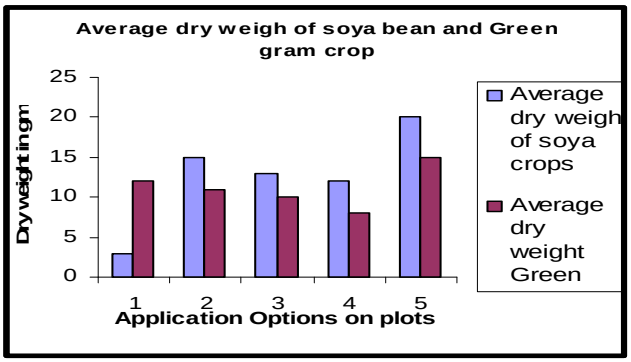

Figure 3.9: Average dry weights of soya bean and Green gram crop

3.5 Organic matter in crops

In the figure 3.10 we can observe that the organic matter is high in 5th plot, plot 1 being control hold higher organicmatter than plot 2. This show that commercial fertilizers are not good supporters to organic matters in the soil, in turn the soil fertility. Eco-fertilizers can contribute to good percent of organic matter in plants and in turn in yield, thus enhancing quality of the crop.

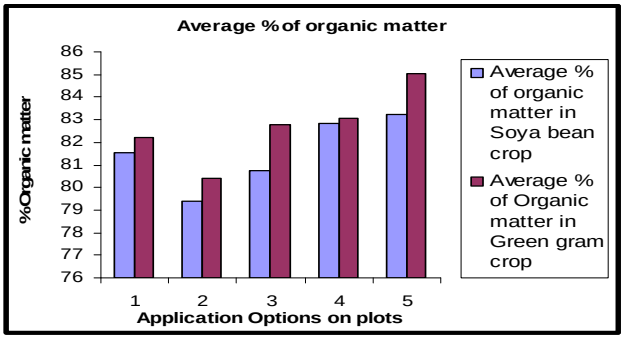

Figure 3.10: Average % of Organic Matter

3.6 Obtained and Estimated Yield of Crops

In the figure 3.11 we can observe that the obtained yield is higher in 5th plot, whereas plot 3 and 4 has produced almost the same quantity. 2nd Plot though ranks the second highest yield. It can be learned that over a period of time, the organic manure will be able to give a much higher yield than commercial fertilizers, preserving the nutrient in the soil and thus in turn the crop. Figure 3.12 indicate the estimated yield from the crops.

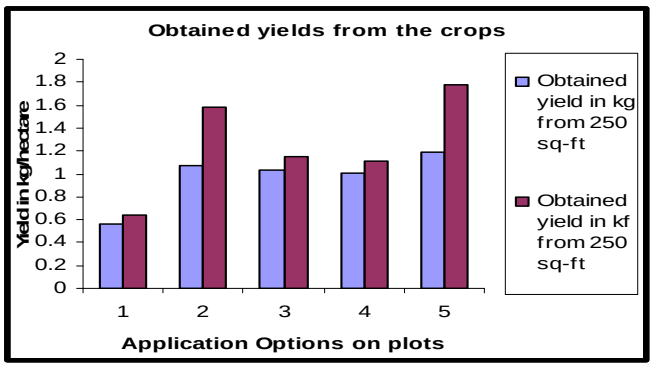

Figure 3.11: Obtained yield from the crops

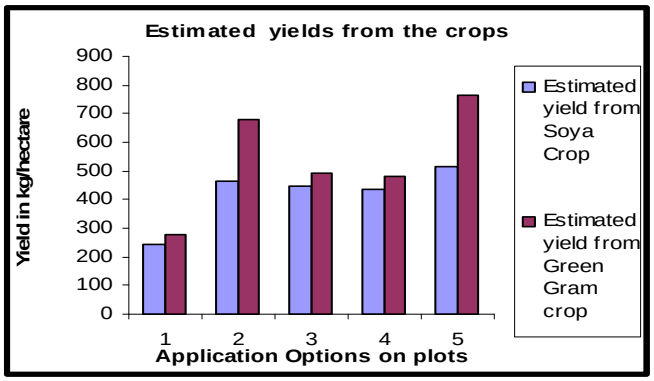

Figure 3.12: Estimated yields from the crops

3.7 Percentage increase in the yield

From the figure 3.13 we can observe that % increase is high in plot where eco-fertilizer was applied followed by the plotwhere commercial fertilizer was applied. The farm yard manure and humanure shows consistent increase in the yield.

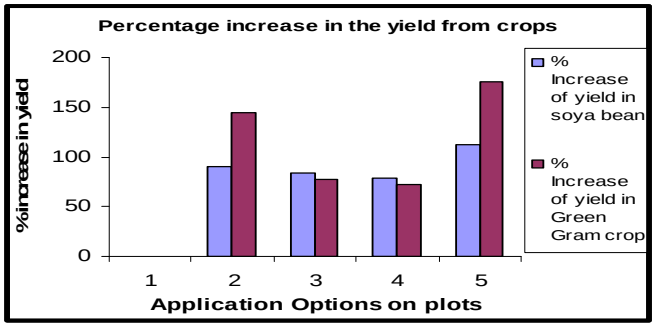

Figure 3.13:% increase in the yield

3.8 Cost benefits analysis of Humanure versus other fertilizers

From the figure 3.14 we can see that humanure costs much less than any other inorganic fertilizer available in the market. Thus it can be a better alternative to all commercial fertilizers available in market, forming the economical and eco-friendly loop.

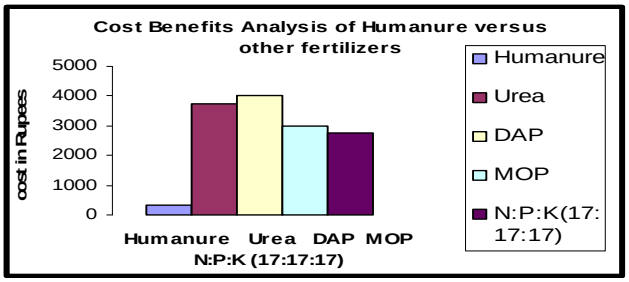

Figure 3.14: Cost benefit analysis.

Soya bean and Green gram in the area having 30mm and above monsoon rainfall like in Mysore requires 1.19 million liters per hectare. It is also known that compost uses 30% as less water as the commercial fertilizers. So the amount of water required and that could be saved using humanure as fertilizers are shown in figure 3.15 and 3.16.

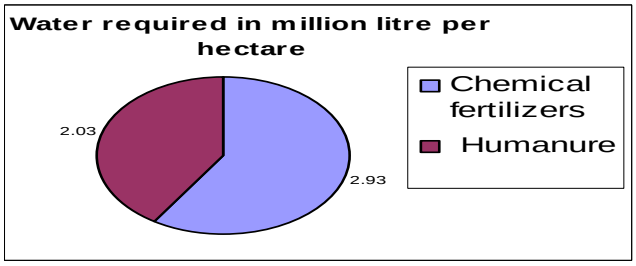

Figure 3.15: water required in million litre per hectare

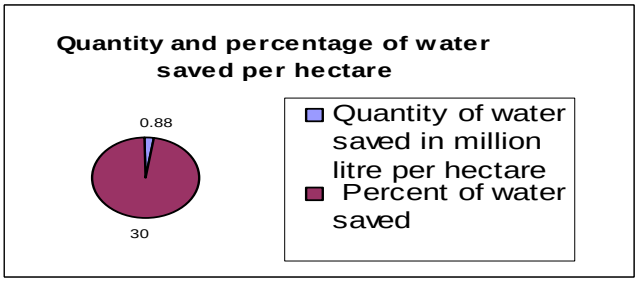

Figure 3.16: Quantity and percentage of water saved per hectare

3.9 Decay Rate of Humanure

The decay rate indicates the excreta decay over passage of time. The optimum NPK values of the compost were incubated and were monitored at two different temperatures for 22 consecutive days. The Initial Weight (Table-1), Volume (Table-2), Densities (Table-3), Initial NPK values are shown in Table- 4. Then the decay rate of the mixtures was monitored.

Table 1: Weights of the additives and composts

Material	*Initial Wt (gm)*	*Final weight (gms)*		
		At 55 ^{o} C	*Room temp*	*Under sunlight*
Humanure (H)	10	4.66	5.57	6.38
Saw Dust (SD)	10	8.32	8.91	9.02
Rise Husk (RH)	10	8.33	8.64	9.53
Wood Ash (WA)	10	8.92	9.35	9.47
H + SD	10	6.97	7.56	8.95
H + RH	10	7.26	7.80	8.64
H + WA	10	6.20	6.55	7.89

Table 2: Volume of the additives and composts

Material	*Initial Volume /cc For 10 g*	*Final weight (gms)*		
		At 55 ^{o}C	*Room temp*	*Under*
Humanure (H)	12.00	06.0	06.8	07.2
Saw Dust (SD)	28.00	14.0	16.0	17.4
Rise Husk (RH)	23.20	11.2	14.0	15.9
Wood Ash (WA)	25.00	17.8	18.4	19.1
H + SD	21.60	16.0	17.1	17.7
H + RH	19.20	15.2	15.8	16.3
H + WA	22.50	16.9	17.6	18.1

Table 3: Density of the additives and composts

Material	*Initial volume /cc For 10 g*	*Final weight (gms)*		
		At 55 ^{o}C	*RoomTemp*	*Under sunlight*
Humanure (H)	12.00	06.0	06.8	07.2
Saw Dust (SD)	28.00	14.0	16.0	17.4
Rise Husk (RH)	23.20	11.2	14.0	15.9
Wood Ash (WA)	25.00	17.8	18.4	19.1
H + SD	21.60	16.0	17.1	17.7
H + RH	19.20	15.2	15.8	16.3
H + WA	22.50	16.9	17.6	18.1

Table 4: Initial NPK Values Additives

Material	*N*	*P*	*K*
H	05.77	07.59	00.50
SD	15.40	53.27	04.10
RH	13.51	03.39	01.60
WA	00.89	01.50	04.50

The experiments for the estimation of NPK values from the compost along with different additives were carried out for consecutive 22 days and showed in the following tables.

Table 5: Nitrates, phosphates, potassium values of Humanure + Saw Dust

Days	*Humanure + Saw Dust*					
	Nitrates		*Phosphates*		*Potassium*	
	55 ^{o} C	RM	55 ^{o} C	RM	55 ^{o} C	RM
1	69.63	66.54	21.62	19.67	5.0	4.5
3	80.02	68.21	11.93	13.67	4.5	1.5
5	86.17	69.97	14.24	20.89	4.0	2.3
6	86.26	72.53	14.57	21.09	2.2	1.8
7	94.54	76.72	15.10	27.46	3.6	3.8
8	97.65	83.03	15.73	27.65	3.8	4.0
9	106.2	84.56	16.85	28.41	3.5	3.7
10	111.2	85.89	17.24	29.88	3.9	3.8
12	113.4	71.64	17.98	31.62	4.1	4.0
13	121.7	77.11	18.26	33.70	4.4	4.3
14	125.9	86.90	19.03	34.05	4.9	4.5
15	130.3	93.38	19.42	36.94	5.0	4.8
16	138.1	95.42	19.99	37.09	5.1	5.0
17	140.6	98.74	20.56	38.56	5.3	5.0
19	141.2	102.01	21.13	39.73	5.5	5.1
20	142	103.31	22.25	40.15	5.6	5.2
21	143.9	104.07	22.97	40.72	5.7	5.3
22	145.5	105.66	23.61	41.47	5.7	5.4

Table 6: Nitrates, phosphates, potassium values of Humanure+ Rise Husk

Day	*Humanure + Risk Husk*					
	Nitrates		*Phosphates*		*Potassium*	
	55 °C	RM	55 °C	RM	55 °C	RM
1	27.77	25.43	08.89	09.65	1.6	1.9
3	11.22	12.24	14.17	10.99	0.1	2.3
5	07.46	19.55	27.84	19.99	0.9	1.7
6	10.48	07.55	35.07	32.68	1.5	4.8
7	16.72	08.03	31.70	46.49	1.9	4.2
8	15.54	08.50	39.44	45.67	1.8	4.3
9	16.08	08.98	45.96	46.89	1.6	4.6
10	16.98	09.47	52.99	47.96	1.7	4.7
12	17.79	10.79	55.63	49.11	1.9	4.9
13	19.13	11.84	58.78	50.74	2.0	5.0
14	21.56	14.37	59.46	51.60	2.1	5.1
15	22.14	15.54	63.52	58.51	2.5	5.4
16	22.45	16.46	65.71	64.96	2.7	5.5
17	23.79	17.85	66.64	67.28	2.8	5.6
19	24.73	19.84	67.04	71.23	2.9	5.8
20	25.65	21.67	68.29	74.20	3.0	5.8
21	26.61	25.76	69.13	75.82	3.1	5.9
22	27.33	29.27	70.80	76.45	3.2	5.9

Table 7: Nitrates, phosphates, potassium values of Humanure + Wood Ash

D	*Humanure + Wood Ash*					
	Nitrates		*Phosphat*		*Potassiur*	
	55 °C	RM	55 °C	RM	55 °C	RM
1	09.92	08.87	12.07	10.14	2.9	3.2
3	10.41	09.95	12.20	10.75	2.8	3.3
5	11.96	10.23	12.43	11.29	2.9	3.5
6	12.10	11.66	13.74	12.73	3.1	3.4
7	12.98	13.04	14.12	13.27	3.1	3.3
8	13.87	13.89	14.96	14.07	3.4	3.5
9	14.55	15.11	15.04	15.27	3.8	3.6
10	15.85	17.79	15.67	16.08	4.5	3.8
12	16.63	18.60	16.45	16.96	4.7	3.9
13	17.29	19.34	17.18	17.48	4.8	4.6
14	18.68	20.47	18.04	18.16	4.9	5.5
15	20.06	22.85	19.16	18.87	5.0	6.7
16	21.82	23.26	20.20	19.71	5.1	7.1
17	23.58	26.73	21.00	20.63	5.3	7.4
19	25.64	29.91	21.90	21.09	5.4	7.8
20	25.99	30.20	22.61	22.75	5.6	8.5
21	27.58	31.55	23.36	23.80	5.9	8.9
22	31.01	32.76	25.76	24.19	6.0	9.5

3.9.1 Degradation of Nitrate

The nitrate values are high at both the experimental temperature and at room temperature in the mixture which has saw dust as an additive. The other two mixtures however show the similar values at 55^0c but the nitrate values are high in the mixture of wood ash in room temperature than the one with rice husk as an additive as shown in the figure 3.17 and 3.18

3.9.2 Degradation of Phosphate

From the figure 3.19 and 3.20 we can observe that phosphate values are high in rice husk at both the temperature. The other two mixtures have similar values at 55^0c but saw dust shows higher values than wood ash at room temperature.

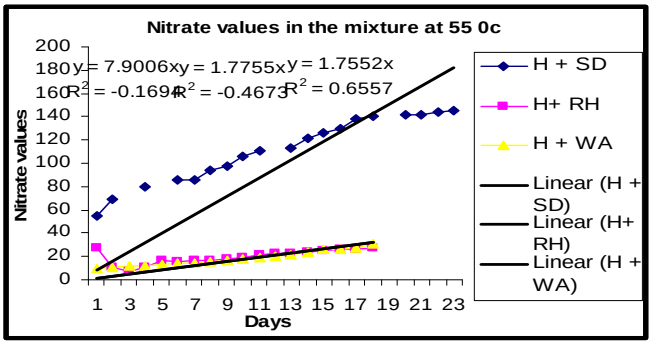

Figure 3.17: Nitrate values in the mixtures at 55^0 c

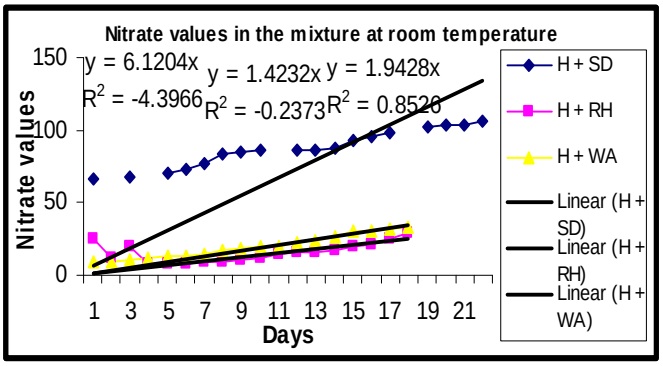

Figure 3.18: Nitrate values in the mixtures at room temperature

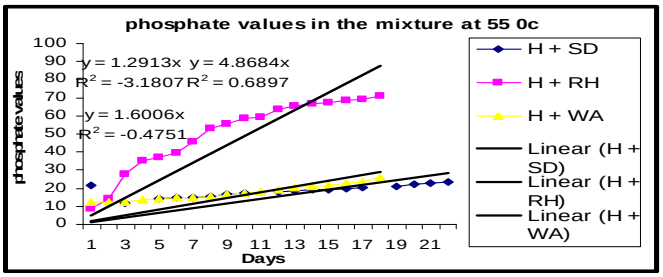

Figure 3.19: Phosphate values in the mixtures at 55^0 c

3.9.3 Degradation of Potassium

From the figure 3.21 and 3.22 it was very clear that the potassium values in wood ash are high at both the temperatures. Rick husk though shows higher values than saw dust at 55^0 c Celsius, has similar values at room temperature.

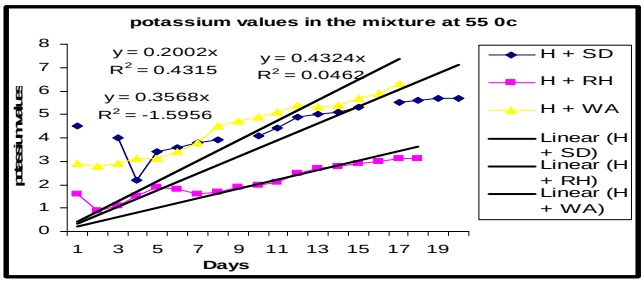

Figure 3.21: Potassium values in the mixtures at 55^0 c

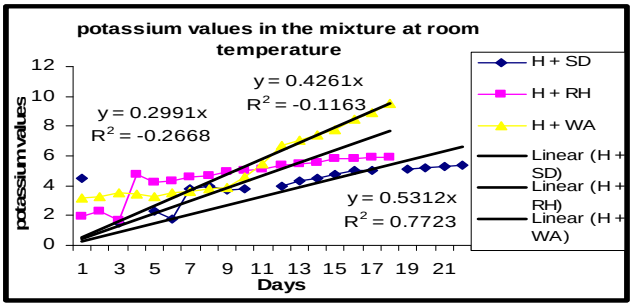

Figure 3.22 Potassium values in the mixtures at room temperature

3.10 Multiple Regressions Co-efficient

Table 8: Multiple Regressions Equation with Co-efficient

The Degradation Equation						*Regression co-efficient*	
Variables		*Y*	*X1*	*X2*	*X3*	*R*	*R2*
N	At 55^0c	2.95	1	1.98	2.01	0.99746	0.99493
P		3.62	1	1.54	2.62	0.99239	0.98483
K		3.57	1	1.65	2.61	0.97918	0.95878
N	At Room Temp	2.81	1	0.96	1.92	0.99170	0.98645
P		3.92	1	1.98	2.92	0.99285	0.98576
K		3.61	1	0.68	2.50	0.98134	0.96303

This equation gives a fair idea as to how the degradation takes places at different temperatures in various additives. Tables show the values of multiple regression equation of NPK degradation of humanure with various additives at 550 Celsius and at room temperature.

3.11 Descriptive Statistics

Descriptive statistics was applied to the values obtained to know the mean, median, mode and standard deviation values. The tables 1, 2 and 3 shows the descriptive statistics of Humanure with saw dust, Humanure with Rice Husk and Humanure with wood ash respectively.

Table 9: Descriptive Statistics for Humanure + Saw dust

	Min	Max	Mean	SD	No of samples
No of days	1	22.00	12.11	06.37	18
Nitrates at 55 o C	69.63	145.5	115.24	24.88	18
Nitrates at RM	66.54	105.7	85.87	13.48	18
Phosphates at 55 o C	11.93	23.61	18.47	03.31	18
Phosphates at RM	13.67	41.47	31.26	08.31	18
Potassium at 55 o C	02.20	05.70	04.54	00.94	18
Potassium at RM	01.50	05.40	04.11	01.17	18

Table 10: Descriptive Statistics for Humanure +Rice Husk

	Min	*Max*	*Mean*	*SD*	*No of samples*
No of days	1	22.00	12.11	06.47	18
Nitrates at 55 ^{o} C	07.46	61.22	22.41	11.23	18
Nitrates at RM	07.55	52.24	17.95	10.84	18
Phosphates at 55 ^{o} C	08.89	70.80	52.84	18.12	18
Phosphates at RM	09.65	76.45	50.01	20.86	18
Potassium at 55 ^{o} C	00.10	03.20	02.07	00.81	18
Potassium at RM	01.70	05.90	04.63	01.34	18

Table 11: Descriptive Statistics for Humanure + Wood ash

	Min	*Max*	*Mean*	*SD*	*No of samples*
No of days	01.00	22.00	12.11	06.37	18
Nitrates at 55 o C	9.920	28.43	18.21	06.09	18
Nitrates at RM	8.87	35.40	19.93	08.20	18
Phosphates at 55 ^{o} C	12.1	25.76	17.55	04.18	18
Phosphates at RM	10.14	24.19	17.71	04.45	18
Potassium at 55 ^{o} C	02.80	06.00	04.40	1.11	18
Potassium at RM	03.20	09.50	05.41	02.26	18

4. Conclusions

The following conclusions were draw from the study:

1) The NPK values, organic carbon, organic matter in the soil after harvesting the crop were quite high and physical growth of plant was optimal on plots where Humanure and eco-fertilizers was applied, thus increasing the nutrient values and fertility of the soil.
2) The yield of the crops were highest on the eco-fertilizers plot, and Humanure amendments maintain soil aggregate stability and contribute to a soil's water holding capacity, benefit soil physical properties as well increased biological activity, enhancing the soil fertility on each application which in turn increase yield.
3) The application of eco-fertilizers is the best alternative. This also reduces the waste disposal consequences on the environment.
4) Experiments reveals that the additive saw dust shows high nitrate values at room temperature as well at 55 ^{0} c, whereas rice husk and wood ash shows high phosphate and potassium values at above mentioned experimental temperature.
5) The optimal rate of degradation is found to be in nitrate at 55 ^{0} c and at room temperature with multiple regression co-efficient being 0.99492 and 0.98645 respectively.
6) The optimal decay of phosphate and potassium was found to be at room temperature with the regression co-efficient being is 0.9857 and 0.96302 respectively.

5. Future Scopes

1) The Eco-fertilizers can be treated with other household organic wastes to reap better nutrient values.
2) The Humanure can be used along with cow dung to produce bio-gas.
3) Eco-toilets can play an important role in rail and air ways; conserving the water, reducing the storage space of waste.

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