Evaluating the Efficacy of Different Manures in the Cultivation of Aubergine and Green Pepper – a Case study of the Maltese Islands

Kimberly Terribile, Malcolm Borg, Daniel Grech, Liberato Camilleri, Ruben Sakrabani*
Corresponding Author: kimberly.terribile@mcast.edu.mt
**Centre for Agriculture, Aquatics & Animal Sciences, Institute of Applied Sciences, MCAST*

Abstract: The Maltese agricultural sector faces many challenges including lack of organic matter in its soils. The use of organic fertilizers such as cattle or rabbit manure partly addresses this problem. Different doses of manure of rabbit and cattle manure at specific irrigation regimes were used to assess the growth of crops and production of fruit on aubergine and green pepper plants. The overall mean number of green peppers recorded was significantly different than the mean number of aubergine for all four doses of manure applied, using both rabbit and cattle manure, up to an optimum mean number of fruit produced, the optimum being reached at dose 3 for green peppers and dose 4 for aubergines. Additionally, the mean number of fruit was significantly higher when grown in rabbit than in cattle manure. The mean weight of fruit recorded varied significantly between green peppers and aubergines at the highest dose of rabbit manure. When Nitrogen Use Efficiency (NUE) was investigated, the highest nutrient efficiencies were achieved at the higher fertilizer application rates of rabbit manure while for aubergines, the weight increase was not as significant and it may therefore be possible to compromise yield for a better efficiency.

Keywords: Aubergine, green pepper. rabbit manure, cattle manure, Nitrogen Use Efficiency, agricultural management.

Introduction

Maltese agriculture faces great challenges due to the severe scarcity of water (Conrad and Cassar 2014). Water availability and demand allocation call for optimal renewal resources exploitation, integrated use management, and management policy. Since Maltese soils lack humus and thus organic matter, they are a limited non-renewable resource (Hallet *et al.* 2017) Therefore, the use of organic fertilizers, including farmyard manure, is important for the soil.

Waste management legislation in Malta is shaped by the requirements of a number of EU directives mainly the Waste Framework Directive 2008/98/EC as transposed by the Waste Regulations (Government of Malta 2011a). The regulations provide the general requirements of waste management in the islands. Of particular relevance to the management of agricultural waste is the Nitrates Directive as transposed by Subsidiary Legislation 504.43 Protection of Waters against Pollution caused by Nitrates from Agricultural Sources Regulations as well as Subsidiary Legislation 504.108 Nitrates Action Programme Regulations.

Agriculture in Malta is practically split into two sectors: rain-fed and irrigated agricultural land. Forage crops are usually grown on rain-fed land whilst vegetable crops and fruit are grown on irrigated land. Irrigated land is more labour intensive than rain-fed land and this is usually reflected in = fertilizer use where soils with cultivated wheat and olives have the lowest values of nitrogen (104 kg/ha for wheat and 89 kg/ha for olives), while soil with cultivated aubergines and green peppers have the highest nitrogen content (335 kg/ha for aubergines and 333 kg/ha for green peppers) (Parliamentary Secretary For Agriculture Fisheries and Animal Rights 2014). The total nitrogen in inorganic fertilizers used in 2017 was 568 tonnes (Eurostat 2018).

Farmers are obliged to apply fertilizers according to guidelines, following an open period for manure and inorganic fertilizer application, as well as keeping records, amongst other requirements (Parliamentary Secretary for Agriculture Fisheries and Animal Rights 2018). Amongst other restrictions, in order to implement the requirements of the Nitrates Directive, the Nitrates Action Programme Regulations (Government of Malta 2011b) require that, firstly, livestock manure to be spread on fields between 16 March and 14 October if dry matter is at least 30% in accordance with the requirements of the regulations; secondly that livestock manure is stored on fields, subject to the provisions of the regulations.

A study by Sustech Consulting that was carried out in 2008 identified that cattle manure is the source of half of the dry manure in the Maltese islands (Sustech Consulting, 2015). This amounts to approximately a third of wet manure as well as half the nitrogen. Manure from rabbits represents very little of the total (around 2% of total dry weight and less than 1% of wet). In addition, pig slurry represents over half the wet volume; dry pig manure only represents around 13% and contributes approximately 22% of nitrogen; poultry dry matter represents around a third of the total; whereas wet matter constitutes just approximately 7% (E-Cubed Consultants and Adi Associates 2015). According to the Food and Agriculture Organization of the United Nations' report on nitrogen inputs to agricultural soils from livestock manure, the annual Nitrogen Excretion Rates for cattle in Malta is 49.73 kg N per animal per year (FAO 2018).

Maltese farmers grow several fruits such as grapes, oranges, strawberries, and peaches and vegetables such as green onion, cabbages, carrots, beans, aubergines, and green peppers. From the total annual volume of 41,092 tonnes of vegetables sold through official markets (Pitkali; Farmers' Central Co-operative Society; Gozitano) in 2014, 653 tonnes (1.59%) were green pepper and 777 tonnes (1.89%) were aubergine. In the same year, in terms of annual wholesale value, green peppers amounted to Eur 522,000 and aubergine annual wholesale value was registered at Eur 377,000. In terms of volume of crop (tonnes) produced in 2014, the production of green peppers peaks between June (80 tonnes) and October (72 tonnes) reaching a peak in July (96 tonnes). This reflects the open field production in 2014. The production between November (34 tonnes) and May (45 tonnes) varies between 22 and 43 tonnes, which are generally produced in greenhouses (NSO 2016). The production of aubergine peaks between June (84 tonnes) and October (94 tonnes) reaching a peak in July (113 tonnes). This reflects the open field production in 2014. The production between November (52 tonnes) and May (54 tonnes) varies between 29 and 52 tonnes, which are generally produced in greenhouses (ibid.).

For the purposes of this study, N supply will be considered through manure and its applicability for the purposes of application to crops and the potential uptake by crops. This uptake of N by crops is based on an estimate of the 2015 value for utilized agricultural area, set at 11,618 (hectares) on the basis of the values reported by the National Statistics

Office (E-Cubed Consultants and Adi Associates 2015). The N uptake by crops is calculated on the basis of the estimated uptake per hectare (NSO 2008). Manure production in Malta is primarily derived from the farming of livestock, including cattle, pigs, poultry, sheep, rabbits, and goats (E-Cubed Consultants and Adi Associates 2015). This study will focus on cattle and rabbit manure and its rate of application for growing crops on the islands. The authors believe that one of the principal challenges for the agricultural waste sector is the excess nitrogen with respect to the application to land and the Nitrates Directive. In terms of the application of manure to land, the stdy will examine (i) the variability of manure sources and (ii) investigate different manure doses and their influence on crop yields. This study aims at giving a better assessment of the cultivation of green pepper and aubergine, under local conditions, using different manure sources, and specific irrigation regimes in order to reduce reliance on chemical fertilizers and improve resource efficiency. The main objective is to evaluate efficacy of different manure sources and doses on growth of crops and production of fruit.

Materials and Methods

Study area

The Maltese Islands are situated at circa 96 km to the south of Sicily and 290 km away to the northern side of North Africa, specifically at 35.9375° N, 14.3754° E on the Global Positioning System. The islands are characterized by a semi-arid climate with hot and dry summers and mild, cold winters (FAO 2006).

Experimental set-up

Calculation of manure dose in accordance with the Nitrates Directive

Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources has the general purpose of 'reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution' (Art. 1). A threshold nitrate concentration of 50 mg/l is set as the maximum permissible level, and the directive limits the application of livestock manure to land in excess of 170 kg N/ha/yr. Therefore, in accordance with this directive, Maltese farmers are allowed to apply a maximum rate of 20 tonnes per hectare (0.83% N content in manure) of rabbit manure and 30 tonnes per hectare (0.56% N content in manure) of cattle manure. This maximum dose was used to work out the application rate of rabbit and cattle manure for the purpose of this study. Alternative doses were then calculated with respect to this baseline.

Variable manure dose calculations

One of the purposes of this study is to investigate the application rate of manure. Following the dose calculated in Section 2.2.1, different rates were determined as follows: Doses 1, 2, 3, and 4 were set up to be half,as recommended, 1.5 times, and twice the dose proposed by the Nitrates Directive. The rates of application that resulted are shown in Table 1.

Dose	Rabbit manure (g/pot)	Cattle manure (g/pot)
Dose 0[1]	0	0
Dose 1	63	96
Dose 2	127	190
Dose 3	190	286
Dose 4	254	380

[1] Control

Table 1: *A table showing the rates of application of rabbit and cattle manure in g/pot, as applied for the purpose of this study*

Greenhouse set-up

The experimental set-up was composed of 90 replicates of aubergine and green pepper plants that were set up in a greenhouse. Five replicates were used for each dose and, in total, there were 20 green pepper and 20 aubergine plants planted in rabbit manure; another 20 green pepper plants and 20 aubergine plants planted in cattle manure; and 5 green pepper and 5 aubergine plants which were set up as a control with no addition of manure. Pots (each having an area of 0.0638m^2) were distributed in a randomized block design and the manure was mixed with the soil throughout the depth of the pot.
Plants were irrigated for 12 weeks following a specific irrigation regime. On the day of harvest, the number of fruit and weight of fruit (g) were measured and results recorded.

Results

Assessing treatment effects by dose

Data for the mean number of fruit and mean weight of fruit (g) were analysed using SPSS version 24.0 software (SPSS Inc., Chicago, IL). The One-Way Anova test was used to compare the mean number of fruit and the mean weight of fruit (g), first between different fruits, that is, green pepper and aubergine, for each particular dose (Table 2 – Table 9) and then between different doses of manure for each particular plant (Table 10 – Table 13). This task was carried out for rabbit manure and cattle manure separately.

Dose	Plant	Mean number of fruit	Std. Deviation	P-value
63.6 g /pot	Green Pepper	5.60	1.517	0.001
	Aubergine	1.60	0.548	
127 g /pot	Green Pepper	6.40	2.191	0.001
	Aubergine	1.40	0.548	
190 g /pot	Green Pepper	8.20	2.168	0.000
	Aubergine	1.80	1.304	
254 g /pot	Green Pepper	6.00	2.550	0.004
	Aubergine	1.40	0.548	

Table 2: *A table showing the One-Way Anova test results for mean number of fruit produced for each particular doze of rabbit manure*

Plant	Dose	Mean number of fruit	Std. Deviation	P-value
Green Pepper	63.6 g /pot	5.60	1.517	0.268
	127 g /pot	6.40	2.191	
	196 g /pot	8.20	2.168	
	254 g /pot	6.00	2.550	
Aubergine	63.6 g /pot	1.60	0.548	0.838
	127 g /pot	1.40	0.548	
	190 g /pot	1.80	1.304	
	254 g /pot	1.40	0.548	

Table 3: *A table showing the One-Way Anova test results for mean number of fruit produced for each particular doze of rabbit manure for green pepper and aubergine plants*

Dose	Plant	Mean number of fruit	Std. Deviation	P-value
95.5g /pot	Green Pepper	5.80	1.304	0.000
	Aubergine	1.00	0.707	
190g /pot	Green Pepper	5.40	1.673	0.001
	Aubergine	1.40	0.548	
286g /pot	Green Pepper	6.00	2.646	0.005
	Aubergine	1.40	0.548	
380g /pot	Green Pepper	7.40	3.362	0.008
	Aubergine	1.80	1.095	

Table 4: *A table showing the One-Way Anova test results for mean number of fruit produced for each particular doze of cattle manure*

Plant	Dose	Mean number of fruit	Std. Deviation	P-value
Green Pepper	95.5g /pot	5.80	1.304	0.586
	190g /pot	5.40	1.673	
	286g /pot	6.00	2.646	
	380g /pot	7.40	3.362	
Aubergine	95.5g /pot	1.00	0.707	0.450
	190g /pot	1.40	0.548	
	286g /pot	1.40	0.548	
	380g /pot	1.80	1.095	

Table 5: *A table showing the One-Way Anova test results for mean number of fruit produced for each particular doze of cattle manure for green pepper and aubergine*

Dose	Plant	Mean weight of fruit	Std. Deviation	P-value
63.6 g /pot	Green Pepper	161.00	59.165	0.445
	Aubergine	127.20	73.271	
127 g /pot	Green Pepper	135.60	86.518	0.750
	Aubergine	118.80	73.761	
190 g /pot	Green Pepper	173.20	45.659	0.480
	Aubergine	138.80	93.323	
254 g /pot	Green Pepper	210.80	62.528	0.007
	Aubergine	92.40	40.327	

Table 6: *A table showing the One-Way Anova test results for mean weight of fruit produced for each particular doze of rabbit manure*

Plant	Dose	Mean weight of fruit	Std. Deviation	P-value
Green Pepper	63.6 g /pot	161.00	59.165	0.358
	127 g /pot	135.60	86.518	
	196 g /pot	173.20	45.659	
	254 g /pot	210.80	62.528	
Aubergine	63.6 g /pot	127.20	73.271	0.777
	127 g /pot	118.80	73.761	
	190 g /pot	138.80	93.323	
	254 g /pot	92.40	40.327	

Table 7: *A table showing the One-Way Anova test results for mean weight of fruit produced for each particular doze of rabbit manure for green pepper and aubergine*

Dose	Plant	Mean weight of fruit	Std. Deviation	P-value
95.5g /pot	Green Pepper	117.40	26.633	0.106
	Aubergine	65.60	57.644	
190g /pot	Green Pepper	144.60	50.664	0.236
	Aubergine	107.80	39.575	
286g /pot	Green Pepper	119.80	60.093	0.284
	Aubergine	84.80	32.089	
380g /pot	Green Pepper	189.60	67.367	0.051
	Aubergine	94.80	63.618	

Table 8: *A table showing the One-Way Anova test results for mean weight of fruit produced for each particular dose of cattle manure*

Plant	Dose	Mean number of fruit	Std. Deviation	P-value
Green Pepper	95.5g /pot	117.40	26.633	0.160
	190g /pot	144.60	50.664	
	286g /pot	119.80	60.093	
	380g /pot	189.60	67.367	
Aubergine	95.5g /pot	65.60	57.644	0.603
	190g /pot	107.80	39.575	
	286g /pot	84.80	32.089	
	380g /pot	94.80	63.618	

Table 9: *A table showing the One-Way Anova test results for mean weight of fruit produced for each particular dose of cattle manure for green pepper and aubergine*

Dose	Manure	Mean number of fruit	Std. Deviation	P-value
1	Rabbit	6.00	2.550	0.479
	Cattle	7.40	3.362	
2	Rabbit	8.20	2.168	0.188
	Cattle	6.00	2.646	
3	Rabbit	6.40	2.191	0.441
	Cattle	5.40	1.673	
4	Rabbit	5.60	1.517	0.829
	Cattle	5.80	1.304	

Table 10: *A table showing the One-Way Anova test results for mean number of green pepper fruit when comparing rate of application of rabbit and cattle manure*

Dose	Manure	Mean weight of fruit	Std. Deviation	P-value
1	Rabbit	210.80	62.528	0.620
	Cattle	189.60	67.367	
2	Rabbit	173.20	45.659	0.152
	Cattle	119.80	60.093	
3	Rabbit	135.60	86.518	0.846
	Cattle	144.60	50.664	
4	Rabbit	161.00	59.165	0.171
	Cattle	117.40	26.633	

Table 11: *A table showing the One-Way Anova test results for mean weight of green pepper fruit when comparing rate of application of rabbit and cattle manure*

Dose	Manure	Mean number of fruit	Std. Deviation	P-value
1	Rabbit	1.40	0.548	0.486
	Cattle	1.80	1.095	
2	Rabbit	1.80	1.304	0.545
	Cattle	1.40	0.548	
3	Rabbit	1.40	0.548	1.000
	Cattle	1.40	0.548	
4	Rabbit	1.60	0.548	0.172
	Cattle	1.00	0.707	

Table 12 *A table showing the One-Way Anova test results for mean number of aubergine fruit when comparing rate of application of rabbit and cattle manure*

Dose	Manure	Mean weight of fruit	Std. Deviation	P-value
1	Rabbit	92.40	40.327	0.945
	Cattle	94.80	63.618	
2	Rabbit	138.80	93.323	0.256
	Cattle	84.80	32.089	
3	Rabbit	118.80	73.761	0.776
	Cattle	107.80	39.575	
4	Rabbit	127.20	73.271	0.178
	Cattle	65.60	57.644	

Table 13. *A table showing the One-Way Anova test results for mean weight of aubergine fruit when comparing rate of application of rabbit and cattle manure*

The correlation between the mean number of fruit (green pepper and aubergine) for each particular dose of rabbit manure (Figure 1) and cattle manure (Figure 2) were analysed. The correlation between the mean weight of fruit (green pepper and aubergine) for each particular dose of rabbit manure (Figure 3) and cattle manure (Figure 4) was analysed.

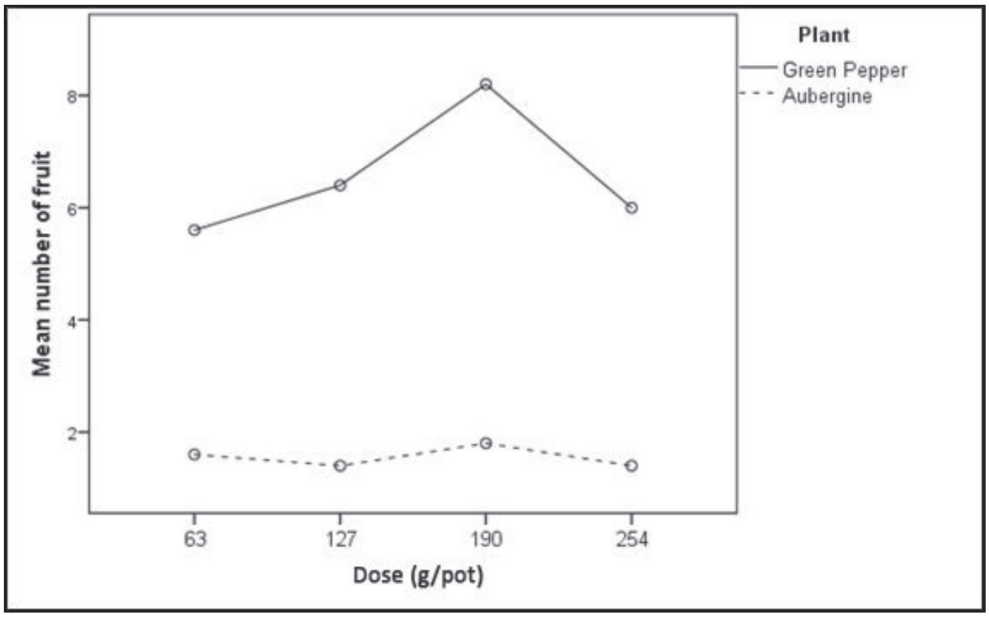

Figure 1: *A graph showing the mean number of fruit (green pepper or aubergine) produced for each particular dose of rabbit manure that was applied*

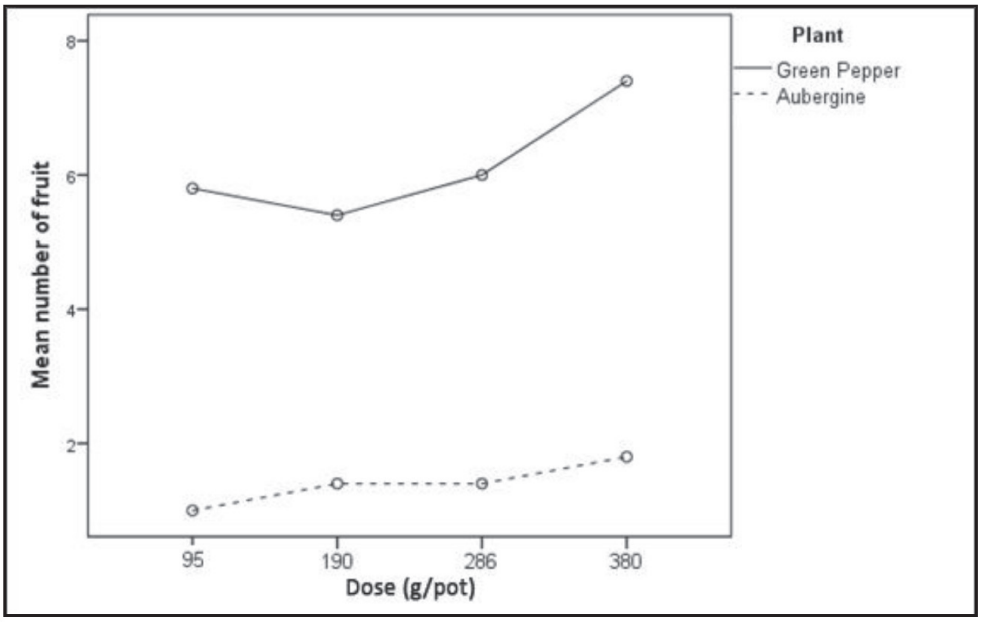

Figure 2: *A graph showing the mean number of fruit (green pepper or aubergine) produced for each particular dose of cattle manure that was applied*

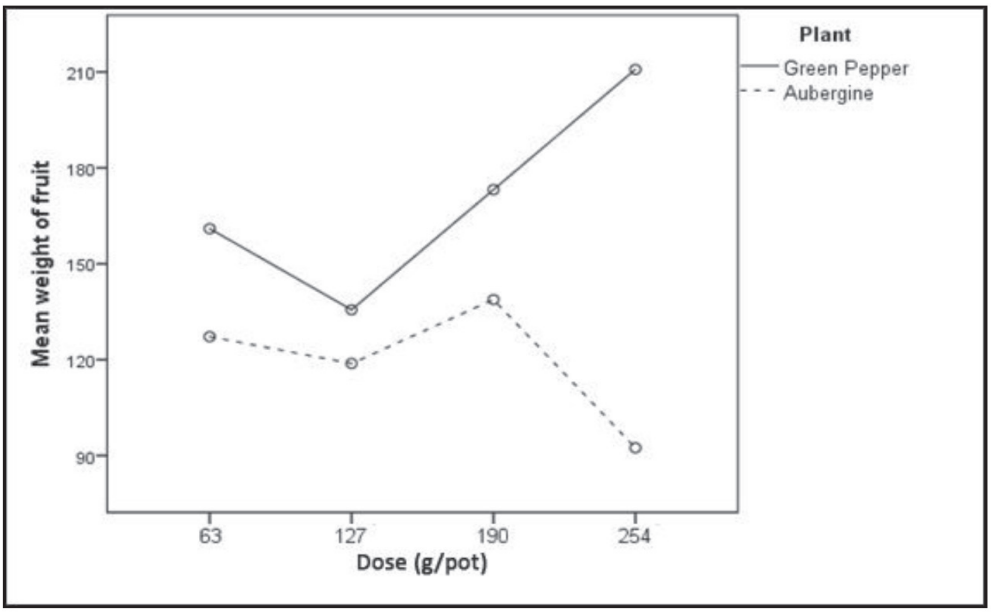

Figure 3: *A graph showing the mean weight of fruit (green pepper and aubergine) produced for each particular dose of rabbit manure that was applied*

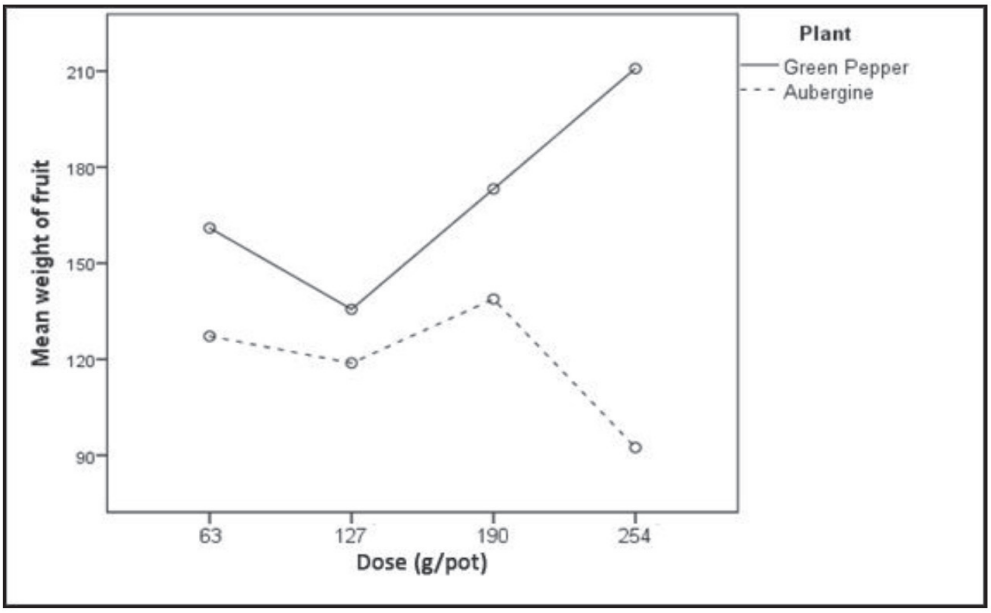

Figure 4: *A graph showing the mean weight of fruit (green pepper or aubergine) produced for each particular dose of cattle manure that was applied*

The null hypothesis specifies that the mean number of fruit and mean weight of fruit vary marginally between the plants or doses and is accepted if the P value exceeds the level of significance (0.05). The alternative hypothesis specifies that the mean number of fruit and mean weight of fruit vary significantly between the plants or doses and is accepted if the P value is less than the level of significance (0.05). For the rabbit manure, the mean number of fruit varied significantly between the two plants (green pepper and aubergine) and this applied for all the five doses of manure; the mean weight of fruit varied significantly between the two plants for 'dose 4' only. For the cattle manure, the mean number of fruit varied significantly between the two plants (green pepper and aubergine) and this applied for all the five doses of manure. However, the mean weight of fruit varied marginally between the two plants and this applied for all the four doses (Figure 5).

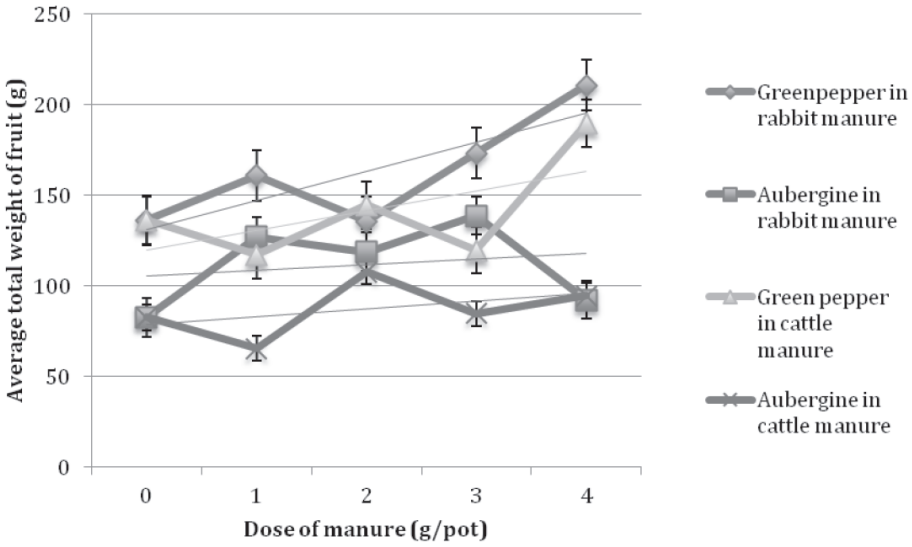

Figure 5: *A plot showing the average total weight of fruit (g) per dose of rabbit and cattle manure (g/pot) applied. The bars represent the standard error for each point*

For both the rabbit and cattle manures, the mean number of fruit and mean weight of fruit statistically vary marginally between the five doses and this applies for the two plants. However, a closer look shows a higher mean number of fruit produced when applying 'dose 3' of rabbit manure, that is, one-and-a-half times that established by the Nitrates Directive. Contrastingly, when using cattle manure, a higher mean number of fruit was produced when using 'dose 4', that is, twice that by the Nitrates Directive. When comparing manure doses for both green peppers and for aubergine, the mean number of green pepper fruit and mean weight of green pepper fruit did not vary significantly.

Nitrogen Use Efficiency

In the study, 162 mg/L of Total Extractable Nitrogen were recorded in cattle manure samples, 206 mg/L in rabbit manure samples, and 140 mg/L in the soil. Given that the

Total Extractable Nitrogen was determined, then the NUE was defined as seen in the following equation

$$NUE = \frac{\text{Yield (total weight of fruit from 5 replicate plants)}}{\text{Total Extractable Nitrogen} * 5 \text{ replicates}}$$

Results for NUE as well as for the Total Carbon Nitrogen (TCN) and Total Organic Carbon (TOC) were tabulated (Table 14). These results show that there is only marginal difference between cattle and rabbit manure in terms of C:N ratio. In terms of NUE for green peppers, the highest nutrient efficiencies were achieved at the higher fertilizer application rates; for aubergines, there seems to be no particular variation with variable doses of manure (Figure 6).

Manure type	Fruit	Dose	Total N (%)	Total C (%)	C/N ratio	Total OC (%)	TEN (mg/L)	NUE (Yield/TEN)
Cattle	Green pepper	1	2.40	30.81	12.81	28.49	162.00	1.2293
		2						0.7611
		3						0.4189
		4						0.4989
	Aubergine	1						0.6869
		2						0.5674
		3						0.2965
		4						0.2495
Rabbit	Green pepper	1	2.31	33.75	14.55	30.32	206.00	2.5434
		2						1.0677
		3						0.9116
		4						0.8299
	Aubergine	1						2.0095
		2						0.9354
		3						0.7305
		4						0.3638

Table 14: *Results for Total Carbon Nitrogen, Total Organic Carbon and Nitrogen Use Efficiency in cattle and rabbit manure*

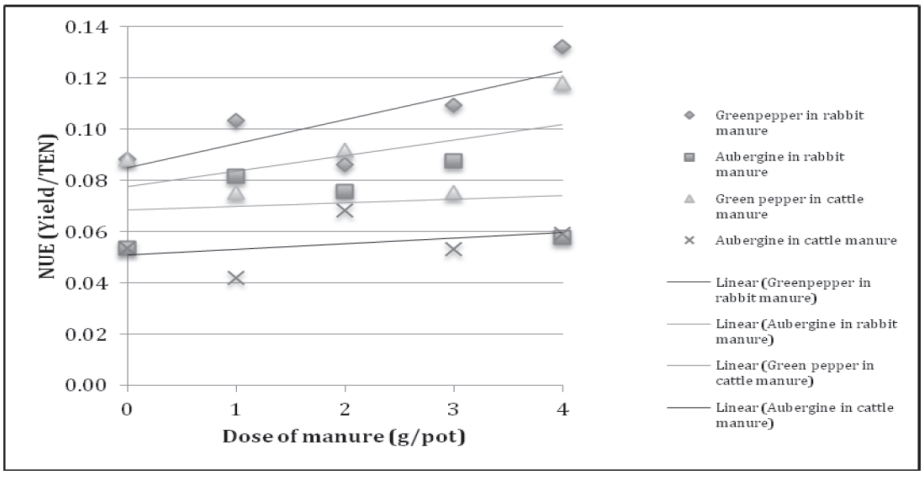

Figure 6: *A plot showing the Nitrogen Use Efficiency (calculated through Yield and Total Extractable Nitrogen) per dose of manure (g/pot) applied for green pepper or aubergine plants*

Discussion

In 2014, a Waste Management Plan for the Maltese Islands (2014–20) was published to address waste management issues, with ever-increasing public costs and implications on environmental pollution. This followed the then unsustainable scenario with regards to waste management in the islands.

There are two major aspects that need to be addressed to improve the situation. Firstly, the strategic framework for agricultural waste management needs to be implemented following the Agricultural Waste Management Policy for the Maltese Islands. Enforcement is crucially important to ensure best practice. Secondly, importance should be given to the required processing and treatment of the mechanical and biological waste generated on the islands, particularly at the recently set-up Malta North Mechanical and Biological Treatment Plant, which was inaugurated in 2016 and which treats the organic fraction and which may also possibly treat animal manure that would not have been managed by farmers.

The management of the nitrogen component of agricultural wastes represents only one part of the complex issue to be addressed. It is recommended that the solid content in comparison with the liquid fraction be given its due importance, particularly since this is of relevance to the nitrogen availability. It is with this in mind that this study focused on using the solid component of cow and rabbit waste as an organic fertilizer for the growth of crops such as aubergines and green peppers. The results show that when analysing the mean number of fruit produced (Figure 1), there seems to be an optimum dose of 190g/pot (dose 3) of rabbit manure. This is 1.5 times higher than the dose, recommended by the Nitrates Directive. It seems that when using an even higher dose of 254g/pot (dose 4), that is, double the Nitrates Directive dose, too much nitrogen was supplied. This subsequently led to a lower production of fruit and hence a lower mean number of fruit produced. When comparing these results to those produced when using cattle manure (Figure 2), it is possible that the optimum dose is either 380g/pot (dose 4) or even a higher dose, as, in this case, the optimum dose is not portrayed through the results that were extracted even though there is an apparent trend in the results obtained.

Analysis of mean weight of fruit produced (Figures 3 and 4) reveals that there is a difference between the mean weights of green pepper and of aubergine produced, as well as a difference between the effects of using rabbit or cattle manure. Yet, these differences are more probably due to the different crop type than to the number of fruit produced or the dose of manure used. However, a better parameter to evaluate the effectiveness of fertilizers by relating to the crop yield obtained and the fertilizer dose applied would be found through the use of NUE, as recorded in Table 14. The results for NUE were plotted as shown in Figure 5. The NUE results in Figure 5 show that the highest nutrient efficiencies when growing green peppers were achieved at the higher fertilizer application rates. Higher NUE resulted at high doses of manure yielding added benefits and, hence, the higher doses of manure (doses 3 and 4) were more efficient in terms of nutrients for the green peppers. Alternatively, the linear trends show that for aubergines there seemed to be no particular variation in NUE with variable doses of manure. Therefore, when comparing rabbit to cattle manure, it was seen that rabbit manure was used more efficiently. When total weight of fruit (g) was investigated, Figure 6 resulted.

-The results for NUE (Figure 5) were compared with the results for total weight of fruit (Figure 6). Considering the weights recorded for green pepper, given that both the NUE and the average total weight increase between doses 2 and 4 then, in this case, efficiency is positively correlated with better yield. Contrastingly, in the case of aubergines, while the NUE slightly increases between doses 2 and 4, the weight increase is not as significant as in the case of green peppers. Hence, when growing aubergine, it may be possible to compromise yield for a better efficiency. This is based on the assumption that only one variable is being considered, while in agriculture there are usually other external parameters that may be involved. The TCN and TOC were also investigated (Table 14). The results show that there is only marginal difference between cattle and rabbit manure in terms of C:N ratio. Additionally, low ratios signify that the nitrogen is easily mineralizable. The lower C:N ratio indicates that the nitrogen mineralization from cattle manure is faster than rabbit. However, in terms of Nitrogen Use Efficiency (Figure 5), rabbit manure seems to be more efficient. In comparison, the differences between the two manures seem to be only marginal and therefore there seems to be no great variation between these options.

This study is an attempt at investigating the applicability of manure dosage, using different crops grown in the islands. The mean number of green peppers recorded was significantly larger than the mean number of aubergines produced, up to an optimum mean number of fruit produced, even though this may be due to crop type. Additionally, the mean number of fruit was significantly higher when grown in rabbit than in cattle manure. It was also seen that an optimum dose for rabbit manure was reached at 190g/pot, whereas the optimum does not seem to have been reached when using cattle manure. If this study had to be repeated, it is recommended that doses of manure even higher than double the Nitrates Directive be used, particularly when cattle manure is applied. This ensures that the optimum rate of application is found beyond which it is expected that the plant would go into a vegetative state and produce a lower mean number of fruit.

The mean weight of fruit recorded varied significantly between green peppers and aubergines at the highest dose of manure, though there was a similar trend between aubergines and green peppers when using the same manure. In terms of NUE, for green peppers the highest nutrient efficiencies were achieved at the higher fertilizer application rates while for aubergines the weight increase was not as significant. Considering the weights recorded for green peppers, it was found that efficiency is positively correlated with better yields. Contrastingly, in the case of aubergines, it may be possible to compromise yield for a better efficiency. It is recommended that the weight of plant be recorded in order to investigate the correlation between the dose of manure used and the weight gained, up to an optimum weight.

While this study investigates the applicability of manure dosage using different crops grown in the islands, it is limited by being a pot experiment. This presents several limitations in comparison to real-life scenarios. Firstly, the root zone of the plants was compromised and limited to a defined volume of soil and nutrient availability. The plants' roots would have probably reached further out than the pots' volume in search for nutrients and water. Secondly, artificial fertilizers were not used in this experiment while in reality farmers use artificial fertilizers to sustain the crops' growth and fruit formation. Thirdly, water was delivered by two drip points which may have led to different conditions from those in the open fields. These two crops are usually watered by drip irrigation with irrigation point distances of 3 cm in the row, creating different water dimensions in the soil. Additionally, the experiment was carried out in a controlled environment to

avoid natural inputs. This approach was chosen to reduce natural inputs, mainly that of water on the crop. Finally, one must also consider that the time of year when this crop was grown does not match with the time of year farmers grow these crops in the greenhouses.

Considering these conditions, it is advised that. if the results are used as an indication for any possible future formulation of guidelines in the islands or if it is taken for field decisions, the limitations mentioned are taken into consideration. This study is also first of its kind in Malta to the best knowledge of the authors.

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