Plant trials using
Fossa alterna humus

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Poor top soils are so common in Africa, that soil enrichment is essential if any viable growth is to be achieved. Very often cattle manure is used to enhance the soil where it is poor, and this is a very successful method. But cattle are not owned by a considerable proportion of the population, and those living in the peri-urban areas may have no easy access to it. The alternative is to buy and import the manure, make compost or to use inorganic fertilisers. Compost making and application to gardens is a very practical method of solving the problem and must be encouraged (see chapter on gardening techniques). However the inorganic fertilisers are becoming scarce and expensive in Zimbabwe, at least, and they are certainly expensive over much of Africa, and beyond the means of most poor people. So other possibilities must be explored. The possibility of using humus derived from human excreta thus becomes a meaningful and practical option, because it costs almost nothing to produce and its supply is almost guaranteed year by year. As we have seen this can change a barren soil into one which has potential for growing vegetables.

The ultimate proof of the usefulness of eco-humus and urine in agriculture is to demonstrate its effect on plant growth and yield directly. This chapter describes a series of trials in which the growth and yield of vegetables planted in humus derived from the ***Fossa alterna*** were studied**.** In some cases the trials involved comparing the growth of vegetables planted directly in ***Fossa*** humus with plants grown on other soils. However this is an uneconomical way of using the humus. The best method is to mix the humus with less fertile soils.

Comparative growth trial in containers

One of the most rewarding ways of using the humus derived from ***Fossa alterna*** pits is to mix the humus with other soils and grow the vegetables in the mix. This can be done in varying proportions with soil/humus mixes of 1:1 and 2:1 being most practical. For containers, where the soils are contained, the most suitable mixture is a 50/50 mix of topsoil and ***Fossa*** humus. This simple procedure effectively doubles the volume of valuable soil produced and enhances the texture and nutrient level of the original topsoil considerably. Thus it is possible to record the growth of plants in the poor topsoil and compare this with the growth of plants in the ***Fossa*** enhanced topsoil. The use of containers is very convenient for plant trials. When mixing **Fossa** humus with soil in vegetable beds a 2 (soil):1 (humus) mix may be the most suitable.

The primary aim of these trials was to show that by taking humus derived from the family toilet, and by mixing it in equal proportions with poor top soil, a meaningful vegetable production could be achieved where little growth would have been possible before on poor topsoil alone. The addition of ***Fossa*** humus to a poor soil might be regarded as the first stage of soil enhancement. To improve the plant yield further, a second stage of soil enhancement would be required by using manure, compost or liquid plant foods, such as water/urine mix. These trials are revealing - they clearly show that the addition of ***Fossa alterna*** humus to poor topsoil, in equal proportions, can considerably enhance the properties of the topsoil, turning it from a soil in which plants do not grow well into a soil in which viable vegetable production can be achieved.

PLANT GROWTH TRIALS

A simple series of preliminary trials were undertaken to study the effect of the ***Fossa alterna*** humus on plant growth. The trials were undertaken in containers like 10 litre plastic buckets and cement basins. The aim was two fold.

First, to demonstrate the value of the eco-humus as an enhancer of the nutrient level in poor top soils, which are so common in Africa. Soil analyses reveal this improvement.

Second by measuring and comparing the yield of vegetables produced in poor soil and poor soil enhanced by the addition of ***Fossa alterna*** humus, after a fixed number of days of growth. Trials were undertaken with the following vegetables: spinach, covo, rape, lettuce, green pepper, tomato, onion and maize. Only small numbers of plants were used in these preliminary trials, and they must be seen as precursors for more elaborate trials using larger numbers of plants. The trials are described under type of plant.

Nutrient levels of trial soil.

Two types of poor soil were used in the trials, the first from Ruwa, the second from Epworth. The ***Fossa alterna*** humus used in these trials was taken from a single toilet. Final nutrient levels of the 50/50 mix of poor soil and ***Fossa alterna*** soil show an intermediate position between the samples as shown in the table. All samples were analyses using the method described in the earlier chapter.

Soil analysis	**pH**	**N**	**P**	**K**	**Ca**	**Mg**
1. Ruwa soil	5.5	27	5	0.29	:10.23	4.11
2. Fossa humus	6.5	319	196	3.26	:13.70	7.26
Result of 50/50 mix.	**6.4**	**91**	**247**	**0.88**	**3.05**	**2.49**

Soil analysis	**pH**	**N**	**P**	**K**	**Ca**	**Mg**
1. Epworth soil	**4.1**	**23**	**54**	**0.07**	**1.72**	**0.50**
2. Fossa humus	**6.3**	**197**	**299**	**2.94**	**26.64**	**4.77**
Result of 50/50 mix.	**6.4**	**78**	**356**	**1.01**	**15.75**	**1.78**

Note in both examples there is a considerable increase in nitrogen, phosphorus and potassium in the poor soil after it has been mixed with ***Fossa alterna*** soil. This is to be expected. However the exceptionally high levels of phosphorus in the resulting soils, which are consistent and have been found in other analyses cannot be explained.

The plant trials with *Fossa alterna* humus applied to poor soils

SPINACH – Trial 1.

Spinach is an adaptable plant and grows well on many soils. The initial trials with spinach were conducted in ten litre cement basins in which vegetable seedlings were planted in either poor (Ruwa) topsoil or the same topsoil mixed with an equal proportion of ***Fossa*** humus. The following figures show the weight of spinach grown over a 3 month period (July-Oct. 2002).

The photo shows 18 gms of spinach grown on poor Epworth soil (right) compared to 180gms of spinach grown on Epworth soil enhanced with *Fossa* soil (left), after a 3 month growth period.

SPINACH – Trial 2.

In a further series of trials, spinach seedlings were planted in 10 litre buckets containing Epworth soil and a mix of Epworth soil and ***Fossa*** humus. The soil from Epworth (a peri-urban settlement of some 100,000 persons close to Harare) is notoriously poor, and most residents are unable to grow crops in their gardens. Those that do must import manure or use commercial fertiliser. Significant improvements in growth were measured for spinach, covo and lettuce by enhancing the poor Epworth soil with ***Fossa alterna*** humus.

Growth/weight/yield of spinach produced in 10 litre buckets (gms)
(mean of 3 plants in each of 2 buckets)

	Fossa soil and poor mixed 50/50	Poor soil only (Epworth)
Leaf wt after 30 days (buckets 1&2)	243gms	32gms
Leaf wt after 30 days (buckets 3&4)	303gms	40gms
Total	**546gms**	**72 gms**

Note below weights of individual spinach (on 30 day trial)
On Epworth (poor soil) : 11, 10. 11, 20, 10, 10, Total (T) 72gms, Sample no (N) =6, Mean (M) = 12gms, Standard deviation (SD) = 3.95,
On 50/50 Epworth/Fossa alterna soil : 85, 80, 78, 118, 110, 75, Total, 546 gms, Sample no = 6, Mean = 91 gms, Standard deviation (SD) = 18.29.

The two samples are significantly different at the 95% level of confidence.

Thus the yield of spinach on Epworth soil was increased over 7 times as a result of enhancing it with ***Fossa alterna*** soil, without further enhancement. An analysis of the Epworth soil, the ***Fossa*** humus and the resulting mix is shown earlier. In a settlement like Epworth, such an enhancement would be regarded as very significant. In effect the *Fossa* humus turned a meaningless yield on poor soil to a meaningful yield on enhanced soil. In the case of spinach, this first crop was reaped and the plant continued to yield more leaves for further cropping. The same is true of covo.

The photo shows spinach grown on poor Epworth soil (left) compared to spinach grown on Epworth soil enhanced with *Fossa* soil (right), after 30 day growth period. The increase is seven fold.

COVO - Trial 1.

Covo is a popular vegetable in Zimbabwe and also in the sub region (e.g. Mozambique). Its leaves are tasty, and can be cropped from the main stem for a two year period. It is resistant to drought and copes quite well in poor soils. It can also be planted from cuttings. In this trial three covo seedlings were planted in neat ***Fossa alterna*** soil in a 10 litre cement basin and the growth was compared to identical seedlings planted in the poor soil from Epworth.

The photo shows 20 gms of covo grown on poor Epworth soil (right) compared to 161gms of covo grown on neat *Fossa* soil (left), after a 30 days growth period. This is an eight fold increase in yield.

Note below weights of individual covo (trial 30 days)

On Epworth (poor soil) : 10, 2, 8. Total 20 gms. Sample no =.3, Mean = 6.66gms, SD =4.16
On 50/50 Epworth/Fossa alterna soil : 62, 49, 50. Total 161gms, Sample no =.3, Mean = 53.66, SD = 7.23

The two samples are significantly different at the 95% level of confidence.

COVO - Trial 2.

In a further series of trials, covo seedlings were planted in four 10 litre buckets, 2 containing the poor Epworth soil and 2 containing a 50/50 mix of Epworth soil and ***Fossa*** humus. Once again significant improvements in growth were measured by enhancing the poor Epworth soil with ***Fossa alterna*** humus. In this case the yield of covo on Epworth soil was increased over 4 times as a result of enhancing it with ***Fossa alterna*** soil. Note this is a first cropping. Covo can be repeatedly cropped depending on soil fertility.

Growth/weight/yield of covo produced in 10 litre buckets (gms)
(mean of 3 plants in each of 2 buckets)

	Fossa soil and poor mixed 50/50	Poor soil only (Epworth)
Leaf wt after 30 days (buckets 1&2)	180 gms	41 gms
Leaf wt after 30 days (buckets 3&4)	177 gms	40 gms
Total weight	**357 gms**	**81 gms**

Note below weights of individual covo (trial 2 - 30 days)

On Epworth (poor soil) : 11, 10, 20, 20, 10, 10. T = 81 gms, N = 6, M = 13.5 gms, SD = 5.05.
On 50/50 Epworth/Fossa alterna soil : 50, 70, 60, 72, 20, 85. T = 357 gms, N = 6, M = 59.5 gms, SD = 22.66.

The two samples are significantly different at the 95% level of confidence

The photo shows covo grown on poor Epworth soil (left) compared to covo grown on Epworth soil enhanced with *Fossa* soil (right), after 30 day growth period. The increase is four fold.

RAPE - Trial 1.

1. Growing Rape in a shallow above ground vegetable garden with *Fossa* humus

This trial was undertaken in a one square metre brick enclosure built above ground on a plastic sheet (see chapter 6.). The soil mixture was made by combining 40 litres ***Fossa*** humus with 40 litres of poor sandy soil from the Ruwa, making a soil depth of only 75- 80 mm. A more suitable volume would have been 50 litres of eco-humus + 50 litres topsoil for this area, making a soil depth of 100mm, which is just adequate for shallow rooted vegetables. The soil was watered and then planted with about 50 rape seedlings. The bed was watered generally twice a day with borehole water only (ie no plant food of any type added). The bed was also covered with shade cloth. Rape seedlings were produced from seed in a seed tray. The growth of rape was good. The same technique could be used over a wider area.

During the growing period of 4 months (June to October 2002) 3.1 kg of rape were reaped from the first and second harvest. Almost the entire nutrient supply for this small garden was derived from the 40 litres of ***Fossa*** eco-humus (the sandy Ruwa soil had almost no nutrients in it). Thus once again we see a very real use for the eco-humus. Almost no growth of the rape took place on Ruwa soil alone on a control basin. If all the ***Fossa alterna*** humus had been used to grow rape about 40 kg would have been produced. In this case, the production could have been enhanced by additional feeding with a 3:1 water/urine mix applied twice a week. However that was not the point of the trial.

In the case sited above, the ***Fossa alterna*** humus was itself a mix of poor soil and excreta only, with no inclusion of leaves or vegetable matter. The nutrients were further diluted by combining with another poor soil. The table below records this sequence. The vegetable output is thus even the more remarkable.

Nutrient levels in soils

Soil source	pH	N	P	K	Ca	Mg
Natural soil added to ***Fossa*** pit	**4.9**	**50**	**13**	**0.18**	**2.95**	**0.78**
Resulting eco humus from ***Fossa***	**6.5**	**319**	**196**	**3.26**	**13.70**	**7.26**
Natural soil (Ruwa) added to ***Fossa*** humus	**5.1**	**14**	**23**	**0.10**	**1.12**	**0.48**
Final soil mix	**6.4**	**91**	**247**	**0.88**	**3.05**	**2.49***

One sees the considerable enhancement of nutrient levels in the soil removed from the ***Fossa*** pit compared to the soil placed into the ***Fossa*** pit. And for the second time, one sees considerable enhancement of nutrient levels in the soil resulting from the combination of this ***Fossa*** humus with a very poor naturally occurring soil (Ruwa). And yet despite being mixed with poor soil twice, the end result was still a positive result for vegetable growth. It is remarkable that with such dilution with poor soils, the nutrients available in the humus excreta can still result in meaningful yields of vegetables without the addition of any further plant food.

Harvest of rape growing in an above the ground vegetable garden.
Almost 100% of nutrients derived from *Fossa alterna* humus

LETTUCE

Three lettuce seedlings were planted in each of 2 X 10 litre buckets containing poor Epworth soil and also 2 X 10 litre buckets containing a mix of Epworth soil and ***Fossa*** humus (50/50 mix). The total weight of lettuce grown after 30 days on the buckets of Epworth soil alone was **122 gms** compared to **912 gms** grown on Epworth soil enhanced with ***Fossa alterna*** humus. This is a 7 fold increase in production of the poor soil as a result of enhancing it with ***Fossa alterna*** humus.

Growth/weight/yield of lettuce produced in 10 litre buckets (gms)
(mean of 3 plants in each of 2 buckets)

	Fossa soil and poor mixed 50/50	Poor soil only (Epworth)
Total wt. after 30 days (buckets 1&2)	447 gms	56 gms
Total wt after 30 days (buckets 3&4)	465 gms	66 gms
TOTAL	**912 gms**	**122 gms**

Note below weights of individual lettuce (30 day trial)

On Epworth (poor soil) : 15, 20, 21, 25, 19, 22: T = 122 gms, N = 6, M= 20.33 gms, SD = 3.33
On 50/50 Epworth/Fossa alterna soil : 130, 160, 157, 150, 155, 160,. T= 912 gms, N = 6, M = 152 gms, SD = 11.40

The two samples are significantly different at the 95% level of confidence.

The photo shows lettuce grown on poor Epworth soil (left) compared to lettuce grown on Epworth soil enhanced with *Fossa* soil (right), after 30 day growth period. The increase is seven fold.

GREEN PEPPER

Most plants thrive on the undiluted eco-humus. The green pepper shown in the photo below has shown exceptional growth when planted in undiluted eco-humus after a 4 months of growth period. In this case the green peppers were grown in ***Fossa*** humus without mixing and comparisons made with identical seedlings grown on a 50/50 mix of ***Fossa*** humus and Ruwa soil and also in the basic Ruwa soil. The photos reveal the huge difference in growth. The weight of green peppers produced after 4 months on neat ***Fossa*** soil was **415 gms** (first crop). This compared to **89 gms** produced on the 50/50 mix of Fossa and Ruwa soil and only **19 gms** on the Ruwa soil only. The minuscule production on the Ruwa soil, reveals now poor it is as a growing medium for plants.

Weight of Green pepper produced after 4 months

Soil type	Weight produced
Ruwa soil	**19gms**
50/50 mix of Ruwa and ***Fossa*** soil	**89 gms**
Fossa soil without dilution	**415 gms**

These figures reveal that some hardy plants like green pepper can grow well in undiluted ***Fossa*** humus. However the humus is very rich and best diluted with an equal or larger volume of top soil.

It is not only the nutrients in the soil which are important to ensure good growth. Soil texture is also an important factor which determines how well a plant will grow. Experience has shown that by mixing ***Fossa alterna*** humus with most topsoils including sandy soils and red soils improves the texture considerably enabling roots to penetrate the media more. Thus by mixing the eco-humus with other soils, the texture of the parent soil may be improved as well as nutrient level.

Green pepper growing on buckets of undiluted *Fossa* soil (left), poor Ruwa soil (right) and a 50/50 mix of the two (centre). A 20 fold increase in yield from poor to rich soil

TOMATO

Initial trials were conducted in ten litre cement basins in which vegetable seedlings were planted either in poor topsoil (Ruwa) or the same topsoil mixed with an equal proportion of ***Fossa*** humus (5 litres + 5 litres). The following figures show the weight of tomato grown over a 3 month period (July - October 2002) in each ten litre basin.

	Fossa soil and poor mixed 50/50	Poor soil only (Ruwa)
Tomato	**735** gms	**73 gms**

Note below weights of individual tomato (harvested after 3 months)

On Ruwa soil (poor soil) : 33, 10, 30. T= 73gms, N = 3, M = 24.33, SD= 12.62
On 50/50 Ruwa soil/Fossa alterna soil: 20, 40, 50, 60, 50, 50, 40, 50, 40, 50, 40, 50, 40, 45, 50, 30, 30. T = 735 gms, N = 17, M = 43.23, SD = 9.83

The two samples are significantly different at the 95% level of confidence.

A ten times yield in tomatoes was obtained by mixing eco-humus with the poor topsoil which was itself unable to produce any meaningful growth of tomato at all. However the nutrients held in 5 litres of ***Fossa*** humus led to the reaping of 735 gms tomatoes. The full 500 litres of annual output of humus might have let to a crop yield of 73.5 kg tomatoes. However in this particular trial, the total yield of tomatoes, even in the mixed soil was well below which could be expected from well manured or fertilised soil. Special techniques are required to get the best crop of tomatoes. They require a rich soil, with plenty of potassium in the later stages of growth to promote full fruit development.

MAIZE

Maize is certainly the most important crop grown in Southern and Eastern Africa and a study of its reaction to eco-humus is important. In this trial, comparisons were made with maize grown in poor Epworth soil and Epworth soil enhanced with ***Fossa alterna*** humus (50/50 mix).

Maize seedlings were planted in four 10 litre buckets, 2 containing poor Epworth soil and 2 a mix of Epworth soil and ***Fossa*** humus (for soil analysis - see early in chapter). The maize seedlings were planted on 28th September Significant growth were initially observed in the Epworth soil enhanced with ***Fossa alterna*** humus. The growth of maize on the plain Epworth soil was very poor by comparison. However by 5th November, nutrient deficiency was beginning to reveal itself, even in maize plants growing on ***Fossa*** enhanced Epworth soil - with the oldest leaves on the maize showing some signs of yellowing (an indication of reduced nutrient availability), as the nutrients in the basin were used up. When a plant like maize starts to struggle for nutrients, the available nutrients are directed to the youngest leaves, and withdrawn from the oldest - which shows up as yellowing in the basal leaves, lightening in colour of all leaves and subsequently as a reduced yield of maize cobs. The full potential of growth was never reached in any of the 12 maize plants grown in this trial.

After about 3 months of growth the cobs were removed from the plants, stripped of their covering and weighed. The following data was recorded.

Growth/weight/yield of Maize produced in 10 litre buckets (gms)
(mean of 6 plants in 2 buckets)

	Fossa soil and poor mixed 50/50	Poor soil only (Epworth)
Mean cob wt after 3 month	**18.33 gms**	**0.41 gms**

The cobs produced in all plants in this trial were very low weight. Cob weights for maize grown on ***Fossa alterna*** /Epworth soil combinations were **30, 10, 20, 30, 14,** and **6** gms respectively (one per plant). Cob weights for maize grown on Epworth soil were **2 gms** and **0.5gms only**. This reveals the exceptional poor nutrient value of the soil in Epworth (near Harare) where at least 100,000 people live. ***Fossa alterna*** humus did enhance the output, but not nearly sufficiently to produce a meaningful yield.

Although adding *Fossa* humus to Epworth soil enhanced the growth of maize, this was not sufficient to produce a meaningful crop. Urine treatment is required to gain good maize harvests from poor soil.

Maize is the most important food crop grown in Southern and Eastern Africa and requires a considerable nutrient input for grow to its full potential. The relatively small volumes of eco-humus produced in the ***Fossa alterna*** annually (about 500 litres)**,** particularly, when they are combined with an equal volume of naturally occurring top soils (to make 1000 litres), are sufficient to sustain a good annual production of vegetables in the backyard. But this eco-humus by itself if quite insufficient to have an influence on crops like maize plants, which are grown in large numbers and are hungry feeders. The conclusion to be drawn is that ***Fossa*** humus is more productively used in growing vegetables in the backyard, rather than enhancing maize growth. However, on very poor soils it might best be used, in combination with urine, for production of both maize and vegetables.

The best way of enhancing maize growth is in two stages. Improving the nutrient and humus content in the top soil first (by adding eco- humus or manure) and then elevating and sustaining the nutrient level further by the further application of a liquid feed like urine and water. The use of urine as an enhancer of plant growth, including maize is described later in this book.

ONION

Early trials were conducted in ten litre cement basins in which onion seedlings were planted either in very poor topsoil from Ruwa or the same topsoil mixed with an equal proportion of ***Fossa*** humus. The following figures show the weight of plants grown over a 4 month period (July - November 2002 - trial 1 and August - December - trial 2).

Wt of onion produced in 10 litre basin (gms)

	Fossa soil and poor (Ruwa) mixed 50/50	Poor soil only (Ruwa)
Onion (trial 1)	**391 gms** (10 plants)	**141 gms** (9 plants)
Onion (trial 2)	**558 gms** (10 plants)	**271 gms** (10 plants)

Note below weights of individual Onions (harvested after 4 months)
Trial 1.
On Ruwa soil (poor soil) : 38, 15, 18, 10, 8, 18, 10, 8, 16. T = 141 gms, N = 9, M = 15.66, SD = 9.30
On 50/50 Ruwa soil/ Fossa alterna soil: 47, 20, 55, 41, 58, 26, 29, 40, 45, 30. T = 391, N = 10, M = 39.10,
The two samples are significantly different at the 95% level of confidence.
Trial 2.
On Ruwa soil (poor soil) : 42, 40, 5, 40, 22, 30, 5, 40, 30, 29. T = 271, N = 10, M = 27.1. SD = 14.65
On 50/50 Ruwa soil/ Fossa alterna soil: 92, 80, 60, 40, 20, 80, 70, 50, 40, 20. T = 558, N = 10, M = 55.8, SD 25.82.

The two samples are significantly different at the 95% level of confidence.

Normally onion should be left to mature for 6 months, at least, to gain maximum weight. In these trials onions were weighed early to give a comparison between the growth potential on onion of poor soil and also soil enhanced with ***Fossa alterna*** humus. In both cases the onion yield was at least doubled by the addition of ***Fossa*** eco-humus to the poor Epworth soil. In fact the best mix for onion is to plant in rich soil mixed with leaf mould and to feed regularly with a water-urine mix. In much richer soils fed with a water-urine (3:1) feed, twice or three times a week, 1.4 kg of onion can be produced in a 10 litre basin in a 4 month period (see urine trails). The ***Fossa alterna*** soil, when mixed with poor soil does not provide the ideal medium for impressive yields of onion or maize by themselves. However, supplemented with urine, they can produce excellent crops.

The reaped onions reveal the enhancing effect of *Fossa alterna* humus on very poor top soils. The yield on poor Ruwa soil (141 gms) has been increased to 391 gms in *Fossa* enhanced Ruwa soil, an increase of nearly 3 times. This is a significant increase in onion production. However the best onion crops are produced on very rich organic soil. They are hungry feeders.

Plant trials with *Fossa alterna* soil on an existing vegetable bed

This trial was carried out at Woodhall Road between November 2003 and January 2004 to test the influence of ***Fossa alterna*** soil (with and without urine application) upon an existing vegetable bed. The addition of ***Fossa alterna*** soil to an existing bed is perhaps one of the most likely methods of using the humus. The influence of both eco-humus and urine will vary greatly depending on the existing state of the soil and the plant. Where nutrient levels are depleted, the influence may be considerable. Where nutrient levels are adequate, the effect will be less noticeable. In this case existing nutrient levels were quite high in the soil.

In this case, the influence of the humus and urine was tested on two green vegetables, rape and spinach, which are both popular in Zimbabwe. The existing bed was re-dug and soil mixed as best as possible and divided into three equal sections, A, B and C. Each bed measured 1.5m X 3.5m (5.25 sq.m.). ***Fossa alterna*** soil was applied to two of the beds (A and C) at the rate of 12 X 15 litres spread over the bed and mixed into the topsoil (see chapter). Local topsoil was applied to the centre bed (B), also at the rate of 12 X 15 litres spread over the whole bed and mixed in. 25 spinach and 25 rape plants were planted in each bed (on 22nd November). These were watered regularly to keep in good health. After 11 days urine treatment started on bed C with a 3:1 mix being applied to the bed, three times per week (2 X 8 litres per application). At all other times all beds were watered in the same way. Soil samples of the ***Fossa alterna*** humus were analysed on several occasions, with two samples being analysed from each bed before planting and after initial watering. Further samples were taken after urine application (see later chapter).

During the trial there was no evidence of nutrient deficiency in any of the beds, even in the centre bed (B). This shows that the bed already had sufficient nutrients to sustain vegetable production, as would be expected in an existing bed. The aim was to demonstrate any additional benefit from the addition of humus and urine.

Results

All the vegetables were harvested on a single day 28 days after the initial application of urine to bed C. Each plant was harvested and weighed. Since both spinach and rape can be harvested several times a single small leaf was retained by the plant after cutting to allow the plant to continue to grow. The results of the first harvest are shown below. In a few cases plants were taken by rats and a low plastic wall was built around the vegetable garden.

Bed A (topsoil+ecohumus)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	4153 gms	25	166.12 gms
Rape	2478 gms	23	107.73 gms
Bed B (topsoil)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	2349 gms	24	97.87 gms
Rape	1928 gms	25	77.12 gms
Bed C(topsoil+ecohumus+urine)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	3918 gms	24	163.25 gms
Rape	2488 gms	23	108.17 gms


The vegetable garden associated with the *Fossa alterna* at Woodhall Road. On the left, the day of planting vegetables 22nd November 2003. 25 spinach and 25 rape seedlings were planted on each of the 3 beds. The bed on the extreme left and right have been enhanced with *Fossa alterna* soil. The bed in the centre has existing topsoil. The right photo shows the state of the beds on 10th December.


The beds the day before harvesting on 30th December 2003. Vigorous growth is seen throughout. The bed improved with *Fossa alterna* soil showed an increase of 70% for spinach production and 40% for rape production over the unimproved bed, which was already clearly good. On the right harvesting and measuring each plant (see results below).

1. Plant growth

In the bed mixed with extra ***Fossa alterna*** soil, spinach harvest was increased by 1.7 times (after 4 weeks) and rape 1.4 times (after 4 weeks), despite the existing bed being already quite adequate in terms of soil nutrients. After 6 weeks and two croppings the increase had been reduced slightly to1.6 times (spinach) and 1.3 times (rape). After 8 weeks and three croppings the total weight of spinach cropped on Bed A was 4754 gms, compared to 3027 gms on Bed B and 4425 gms on Bed C. After 8 weeks and three croppings the total weight of rape cropped on Bed A was 3233 gms, compared to 2736 gms on Bed B and 2698 gms on Bed C. Thus overall the application of the humus increased the spinach crop by 1.57 times and the rape crop by 1.18 times.

However the application of urine in this particular case does not seem to have had much beneficial effects on the overall growth of either rape or spinach. This negligible effect may have been the result of either an over application of urine, or an application which was in excess of what the plants required. In this case both appear applicable, as existing levels of NPK were quite adequate without any further urine application being necessary. Towards the end of the trial vegetables planted in the urine fed bed were beginning to die out, no doubt due to over feeding with nitrogen derived from urine. 3 weeks after the second cropping all the rape plants had died out. This will be discussed in more detail in the section on plant trials with urine.

The results of this trial also reveal that the extra nutrients provided by the ***Fossa alterna*** humus do not sustain increased plant growth for much over 2 months, and the main effect is during the month following application of the humus. The figures show a depletion of both spinach and rape output after successive croppings. This would be expected to be generally the case for plants that are cropped repeatedly. But in urine fed basins, crop output of spinach was maintained at a high level during the second month of cropping spinach when the current trial was running. This indicates a depletion of nutrients in the soil or adverse conditions for growth in the chosen bed. Clearly the best option for beds is combine the use of both ***Fossa alterna*** humus and diluted urine to the beds to sustain maximum output throughout the year. As indicated earlier, the application of other organic materials like leaf or garden compost to the bed also helps production greatly. Note that the addition of humus, not only adds nutrients but provides a better soil environment for the application of urine.

The bed used in this case was surrounded by trees so full sunlight came later in the morning and was not identical for each of the beds with the centre bed being the most sunned. The growth potential for all plants including vegetables depends on a variety of factors of which soil fertility is an important one. Regular watering, either by natural rainfall or by artificial watering is essential for a good crop. Also the best crops are produced where there is plenty of sunshine. In the present case, the sun did not arrive on the bed until mid to late morning, and this would have had an overall reducing effect on the final production.

Individual weights

BED A. Spinach gms.
90,65,110,120,188,174,188,103,173,263,170,160,260,175,169,218,150,258,160,240,228,138,90,213,50.
T=4153. N= 25. M=166.72.
BED A. Rape gms.
149,28,58,52,23,198,185,220,140,55,128,42,111,130,22,104,78,70,131,156,118,242,38. T=2478. N=23. M=107.73.
BED B. Spinach gms
100, 90, 102, 124, 80, 83, 130, 98, 58, 102, 138, 184, 40, 70, 192, 91, 58, 132, 70, 90, 110, 60, 42, 105.
T=2349. N = 24. M= 9787.
BED B. Rape gms
60, 130, 42, 128, 47, 70, 38, 60, 46, 60, 170, 142, 58, 90, 62, 100, 72, 118, 35, 48, 86, 37, 87, 40, 102. T=1928. N= 25. M=77.12.
BED C. Spinach gms
82, 34, 110, 40, 179, 100, 268, 202, 368, 211, 115, 178, 198, 423, 153, 183, 177, 118, 249, 128, 50, 99, 42, 211.
T=3918. N=24. M=163.25.
BED C. Rape gms
162, 222, 100, 142, 122, 130, 49, 82, 163, 39, 135, 60, 50, 47, 60, 34, 90, 189, 61, 37, 207, 140, 167. T=2488. N=23. M=108.17.

Second harvest

Both spinach and rape can be harvested several times from a single plant if the conditions are suitable. In this case the initial crop was cut and weighed from beds A, B and C four weeks after urine application (on bed C). A second crop was cut and weighed 2 weeks later (after 6 weeks of urine application on bed C) and about 7-8 weeks after planting. The second crop cut 2 weeks after the first crop was much less than the initial crop as shown below.

Bed A (topsoil+ecohumus)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	429 gms	19	22.57 gms
Rape	576 gms	18	32.00 gms

Bed B (topsoil)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	508 gms	20	25.40 gms
Rape	622 gms	22	28.27 gms

Bed C(topsoil+ecohumus+urine)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	405 gms	17	23.82 gms
Rape	210 gms	10	21.00 gms

Third harvest

A third small crop was cut and weighed 4 weeks after the first harvest, 2 weeks after the second harvest and 8 weeks after initial urine application on bed C). The second crop cut 2 weeks after the first crop was much less than the initial crop and the second crop as shown below.

Bed A (topsoil+ecohumus)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	172 gms	12	14.3 gms
Rape	179 gms	14	12.78 gms

Bed B (topsoil)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	170 gms	18	9.44 gms
Rape	186 gms	14	13.28 gms

Bed C(topsoil+ecohumus+urine)	**Total harvest**	**No. plants**	**Mean wt per plant.**
Spinach	302 gms	12	25.16 gms
Rape	0 gms	0	0 gms

2. Nutrient levels

The humus derived from the ***Fossa alterna*** was high in all major nutrients as the 2 initial samples show (mean N: 655, mean P: 296, mean K: 5.26). This was mixed with the existing vegetable bed soil at a rate of 2 parts garden soil to one part ***Fossa*** humus. The resulting mixed soil contained NPK as follows. Bed A (mean N: 207, mean P: 325, mean K: 4.16). Bed C (mean N: 367, mean P: 328, mean K: 1.42). By comparison the existing vegetable garden soil contained NPK as follows. Bed B (mean N: 304, mean P: 316, mean K: 1.37).

All 3 beds were then thoroughly watered and planted with seedlings and then re-watered again. After a few days the soil was sampled again. This time the results were as follows: Bed A (mean N: 253, mean P: 308, mean K: 2.02). Bed C (mean N: 367, mean P: 305, mean K: 2.89). By comparison the existing vegetable garden soil contained NPK as follows. Bed B (mean N: 116, mean P: 156, mean K: 1.04). Thus as the plants were growing the application of the eco-humus had increased the NPK levels significantly, but even existing levels were quite adequate for normal plant growth. After a further 4 weeks, and the day before cropping, further samples were taken. The results were as follows: Bed A (mean N: 151.5, mean P: 323, mean K: 1.73). Bed B: (mean N: 97.5, mean P: 259, mean K: 0.79). By comparison, bed C after 4 weeks of urine showed: mean N: 199.5, mean P: 302, mean K: 1.65). No sample showed any sign of a lack of nutrients. All samples were quite adequate for plant growth.

Soil analysis (N, and P as ppm and K, Mg and Ca as ME/100gms

Fossa alterna soil	pH	N	P	K	Ca	Mg
Sample 1.	6.8	720	307	3.32	27.04	13.08
Sample 2.	6.8	590	286	7.20	27.56	12.80

Bed samples before watering

Bed A	ph	N	P	K	Mg	Ca
Sample 1.	7.1	214	331	6.75	34.78	5.13
Sample 2.	7.4	200	320	1.58	32.64	4.98

Bed B	pH	N	P	K	Mg	Ca
Sample 1.	7.1	275	329	1.40	31.10	4.77
Sample 2.	7.1	333	304	1.34	33.74	4.93

Bed C	pH	N	P	K	Mg	Ca
Sample 1	6.8	294	358	1.26	24.58	4.70
Sample 2.	7.1	174	298	1.58	32.46	4.61

Bed samples after watering

Bed A	pH	N	P	K	Mg	Ca
Sample 1.	6.9	295	289	1.32	26.66	8.00
Sample 2.	7.0	211	327	2.72	30.32	6.88

Bed B	pH	N	P	K	Mg	Ca
Sample 1.	7.0	118	176	0.99	17.74	3.44
Sample 2.	7.0	115	137	1.10	12.45	2.91

Bed C	ph	N	P	K	Mg	Ca
Sample 1	7.0	400	296	3.44	30.42	7.90
Sample 2.	6.7	334	315	2.34	33.02	8.00

Bed samples – 4 weeks after urine treatment to Bed C.

Bed A	pH	N	P	K	Mg	Ca
Sample 1.	6.9	160	312	1.65	24.96	7.26
Sample 2.	7.0	143	334	1.82	29.62	6.20

Bed B	pH	N	P	K	Mg	Ca
Sample 1.	7.2	119	341	0.82	31.08	4.46
Sample 2.	6.9	76	177	0.77	13.45	3.25

Bed C	pH	N	P	K	Mg	Ca
Sample 1	6.4	217	290	1.50	19.49	5.06
Sample 2.	6.7	182	314	1.80	27.60	5.76

Overall conclusions

These simple plant trials reveal the considerable value of humus derived from the ***Fossa alterna*** when applied to very poor sandy soils in equal proportions in containers (see table below). The effect is also positive even when applied to existing vegetable beds, at a ratio of one part ***Fossa alterna*** soil to two parts top soil, although the increased yield is less. Every year a single family ***Fossa alterna*** will provide at least 0.5 cubic metres of humus which can be mixed with an equal volume of very poor topsoil to make one cubic metre of suitable planting medium for vegetables. This one cubic metre mix of rich soil will provide enough material to fill 100 ten litre buckets or basins, or 7 shallow trenches (each 3 m long, 0.3m wide and 0.15m deep), or about 10 square metres of shallow vegetable garden, about 10cm deep. At the slightly lower rate of application of 2 parts topsoil to 1 part humus about 16 sq.m. of vegetable bed can be invigorated.

The production of vegetables from such a back yard vegetable garden might be considerable. Using figures revealed in from the trials in containers, one can estimate that **27 kg of spinach** (first crop only at least two crops can be reaped) or **17 kgs of covo** (first crop only - covo can be cropped for an extensive period) or **37 kg rape** or **45 kg lettuce** or **41 kg green pepper** or **73 kg tomatoes** or **40- 50 kg onion** could be grown on the annual output of ***Fossa*** humus mixed with local topsoil. Obviously there would be a mix of these crops produced in practice. As can be seen from the equivalent weight of vegetables grown on poor soils alone, this is a remarkable enhancement in vegetable production compared to what have been possible without the eco-humus. Crop yields are consistently increased by adding eco-humus to poor soils from doubling to over a ten fold increase. However the actual increase in yield would depend on the existing nutrient status of the treated vegetable bed. For an already fertilised bed, one could expect an increase in yield of about 50%.

Summary of plant trials in containers described in this chapter.

Plant. Top soil type. Growth period.	Weight at cropping Top soil only	Weight at cropping 50/50 mix topsoil/FA*soil
Spinach on Epworth 30 days.	72 grams	546 grams (7 fold increase)
Covo on Epworth 30 days.	20 grams	161 grams (8 fold increase)
Covo 2. on Epworth 30 days.	81 grams	357 grams (4 fold increase)
Lettuce on Epworth. 30 days	122 grams	912 grams (7 fold increase)
Onion on Ruwa 4 months	141 grams	391 grams (2.7 fold increase)
Green pepper on Ruwa 4 months	19 grams	89 grams (4.6 fold increase)
Tomato on Ruwa 3 months	73 grams	735 grams (10 fold increase)

Whilst such an output would not sustain the family throughout the year, it is a meaningful contribution to vegetable crop yield, and in areas which are deprived would be seen as valuable addition to the family's food supply. Since the value of the humus must be seen in addition to the value of the improved and long lasting nature of the sanitary facility itself, the overall benefit is considerable.

As with all methods which take advantage of fertile soil for vegetable production, the soil nutrients do become depleted as they are used for plant growth. Therefore the fertility of the soil itself must be restored by re-mixing with more recently made eco-humus or with other compost. In this way the fertility of the soil is maintained - what is taken up by the plants is put back. This is the best way of maintaining a healthy annual crop of vegetables.

Another important point to mention is that the results shown in this chapter apply mostly to ***Fossa alterna*** soils mixed with naturally occurring soils of exceptionally poor quality. Sadly such soils are common where people live in many parts of Africa. Epworth, one source of the poor soil used in these trials, comes from an area close to Harare where over 100 000 people live. Ruwa is typical of so many other sandy areas in Zimbabwe where huge numbers of people live where the soil has been depleted of nutrients, as a result of erosion, leaching and constant use of land without re-fertilisation. In Zimbabwe 70% of rural farmers work on a soil which is labelled as poor or very poor in terms of the nutrient and humus content. Most soils are sandy and have a low pH. Few soils in the rural and even peri-urban and urban areas can sustain any form of healthy crop production without meaningful inputs of both humus and nutrients (Farai Mapanda (pers.comm). Thus any form of fertile soil which can be locally produced and mixed with the poor local topsoil can only be seen as advantageous.

In all these cases, there is an urgent need to replenished the fertility of the soil. This can be achieved by cattle manuring or composting where alternative means are too expensive. It is in such places that the value of the humus derived from the ***Fossa alterna***, maybe most eagerly sought. Obviously where ***Fossa alterna*** humus is used on garden soils which already hold higher level of nutrients, then the effects will be less dramatic than those described in this chapter (see later chapter). The important point is that ***Fossa*** humus does contain meaningful amounts of valuable nutrients which are important to plant growth and by applying them to any soil, the nutrient levels are restored or increased. In addition the physical condition of the natural soil is improved where ***Fossa alterna*** humus is added. Thus what ever soil is considered the overall effect is one of enhancement and improvement.

Yet another important point to stress is that the annual production of eco-humus from the family latrine (***Fossa alterna***) is only sufficient to enhance the family backyard vegetable garden and no more. But this backyard production of vegetable matter can be increased significantly in areas where the soil is poor. The results also reveal that the eco-humus may have limited application with crops like maize, which are grown in very large numbers. But there is nothing to stop the gardener enhancing the effects of the eco-humus further by applying urine. This can be applied in diluted form to vegetable gardens or neat to maize in the fields. This can produce excellent results with maize as well as green leafy vegetables, as we shall see later. Also garden compost, manure, leaf compost and other liquid feeds should also be used to enhance the soil and subsequent vegetable production. Extra nutrients can be provided by inorganic fertilisers, but these will not be used to any extent in the organic farming promoted by eco-san. In fact it would be normal practice to add liquid feeds or manure or compost in the vegetable garden to produce optimal growth of vegetables.

In addition, the process operating in the ***Fossa alterna*** is entirely natural, and the humus which is withdrawn is nothing less than a marvel of Nature. A strong link is made between the sanitation and agriculture. The latrine becomes a humus factory. The second pit of the ***Fossa alterna*** can be used as a pit composter during the first year or it can be used as a site to make leaf mould. This leaf mould alone can make considerable improvements to poor soils.

The potential for this system is enormous. The ***Fossa alterna*** is cheap to build and easy to maintain and there is a valuable end product. But the routine upkeep of the ***Fossa alterna*** does require more effort and attention than the standard pit latrine. The excavation and mixing and reuse of the eco-materials in agriculture requires time and determination. It is hoped that the return of improved yields of food will make all the effort worthwhile. In a world where the soils are poor and there is always a need for more food, such an effort is surely worthwhile.

The 10 litre cement basin proved to be a useful container to conduct plant trials. Here the poor growth of rape on poor Epworth soils (left) is compared with the much improved growth of rape on the same poor soil enhanced with *Fossa alterna* humus. In almost every case the difference is striking. The influence of the humus is particularly noticeable on very poor sandy soils, which are very common in Africa. The humus applied to sandy soils also helps the process which enables the nutrients in urine to enhance vegetable growth. *Photo by Brian Mathew.*