Growing maize with the help of toilet compost and urine on poor sandy soils

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Maize is the single most important crop in Southern and Eastern Africa – being the staple diet for hundreds of millions of people in the sub-region. And most of these people live on poor sandy soils, which cannot support a good crop of maize without fertiliser, or adequate quantities of cow manure. For those living in the urban areas and peri-urban fringes, cow manure may be scarce and commercial fertiliser too expensive to buy. Yet millions of people eek out a living in these settlements by growing their own crops of maize and vegetables every year in back yard plots and gardens close to the home. It is a means of self survival in conditions which are often harsh and where malnutrition abounds. The simple question is then asked – can the use of toilet compost and urine, in combination, significantly increase the production of these backyard gardens, and thus make the effort worthwhile.

The work reported earlier by Aquamor shows clearly how maize production can be enhanced considerably by the application of urine (a major source of nitrogen which the maize plant demands in quite large quantities). Maize is a “greedy feeder” and requires considerable amounts of nitrogen to grow at its best and provide generous harvests. It also requires adequate amounts of phosphate in its early stages to enhance the growth of the root system and the young stem above ground. Normally, if commercial fertilizer is used a single maize plant is given at least 10gms of a mix of nitrogen, phosphorus and potassium in the ratio 1:2:1 (in Zimbabwe this fertilizer is known as Compound D). The elevated phosphorus content helps early root formation and shoot growth. At 4 weeks (or when the plant is at knee height) a further application of 10gms or more of ammonium nitrate is given. This is normally sufficient to carry the plant through its full vegetative growth. These two applications of “granular slow release” commercial fertilizer offer each plant between 4 and 5 gms of nitrogen, about the same as is found in one litre of urine produced by people who have a low protein diet - sadly the great majority who live in Zimbabwe. Very often an extra dose of ammonium nitrate is given when the young maize cob or cobs start to grow. This is thought to be an important application where bumper crops are required. It is generally known that the more nitrogen is applied the better the harvest. What is important is that the nutrients supplied first help the root and early shoot system, with the bulk of the nitrogen being applied to assist vegetative growth and cob formation during the life of the plant. So it helps if this application of nitrogen can be extended into the period of “grain filling” when the cobs themselves are growing. Grain filling normally starts about 10 weeks after the seed is planted. The cobs continue to gain in weight from 4 to 6 weeks after their formation. Good rains or adequate water supply are very important during this phase.

These requirements are well served by first planting the maize seed in a “plug” of toilet compost made in the soil. This compost is well aerated and contains humus – a requirement particularly useful for sandy soils. It also provides a supply of phosphorus and some nitrogen, suitable for the germination and early growth of the plant. Toilet compost also makes an excellent potting soil and is an ideal medium for the germination of seeds of many kinds. This compost is particularly valuable where local topsoil, like fine sandy soil, may not provide the ideal medium for germination.

Where cattle manure is available, it is applied to maize fields either as a top dressing or in hollows made in the ground. If the manure is available in quantity, it may be spread over the surface and dug in with a single cupped handful being applied to each planting station (the name given to the site of planting). If the manure is in shorter supply, a cupped double handful is applied to each planting station. This is about 500gms or one pea tins worth. The
total amount of compost derived every year from a family toilet, such as a *Fossa alterna*, is in the order of 700 litres, enough for over 1000 planting stations if 500gms (one pea tin full) are used in each planting station. This compost can be used for many purposes as we have seen, but some of this is well used in the production of maize. The family may choose to divide the compost, with some going to the vegetable garden and the rest on the maize field. The toilet compost by itself however, even 3 kilograms, will not provide sufficient food for the maize to produce a good crop in poor soil. It is the urine which provides the great bulk of nitrogen.

In preparing for the main 2004/5 field trial using urine as a source of nitrogen, a series of pre-trials with maize growing in buckets were undertaken to establish certain principles of urine application. In some cases comparative studies were made between the application of urine and commercial fertiliser. Whilst it is obvious that the environment of a bucket is quite unlike that of a garden or field, many important aspects of the application of urine can be studied in this way.

The next section describes these backyard trials with maize growing in buckets.
1. PRE-TRIALS WITH MAIZE GROWING IN BUCKETS

Toilet humus (500gms) has been added to both buckets of poor sandy soil taken from Ruwa. In addition urine has also been applied regularly to the bucket on the right, enhancing the growth considerably. The usefulness of the humus is to provide an idea medium in which to plant the seed and valuable early phosphorus. The great bulk of the food for the maize will come from the urine which is rich in nitrogen.

Benefit of urine application at time of seed planting. The two plants on the left received 125mls urine at seed planting time, those on the right did not. Already a small difference in the growth rate can be perceived. The urine is best applied to the soil below the humus in which the seed is planted. Urine applied to the humus may reduce the percentage of seeds germinating. More importantly, the humus must remain dry when the normal procedure of “dry planting” is carried out, when the seed is planted just prior to the main rains and awaits the rainfall for germination).
These 5 maize plants are growing in buckets of very poor sandy soil from Epworth peri-urban settlement near Harare. On the extreme right the plant is growing in untreated soil. All other plants have been planted in 500gms toilet compost placed in a hollow made in the soil. The compost in the bucket on extreme left was also treated with 100mls neat urine. Seed planting day was 13th October 2004. Seeds emerged on 20th October. Urine application to young plants began on 3rd November. This photo was taken on 14th November. Looking from left to right the plants had been given the following amounts of urine: 225mls (initial 100mls (13th Oct) + 125mls (Nov 3), 125mls (single dose, Nov 3), 250mls (2 doses of 125mls Nov 3 and 10), 200mls (2 doses of 100mls 3rd and 10 of Nov). Even at this early stage the influence of the application of compost and urine can easily be seen.

Three maize plants on Friend Foundation soil. Planting day 2nd October 2004, emergence 9th October. Seed planted in right bucket in plain soil. Seed planted in centre bucket in 500gm humus (no urine). Seed planted in left bucket in 500gm humus + 100mls urine. Photo taken on 14th November 2004. At this stage the plant on left had received 475mls urine (100 (initial) +125mls (27th Oct)+250mls (10th Nov) ), the middle plant had received 225mls (100mls (Oct 23 )+ 125ms Nov 6). Friend Foundation soil has more humus than Epworth soil.
Levels of urine required compared to normal fertiliser

Some idea of the amount of urine required can be seen from pre-trials where soil from various locations are placed in 10 litre buckets and the plant grown in the bucket with daily watering. This is quite a different environment from the normal maize field, but can provide valuable information, especially when comparing different regimes of urine application with normal commercial fertilisation.

Experiment 1.

In the trial bucket 1 (left hand side) the seedling maize was given 6gms Compound D at planting and another 6gms ammonium nitrate at 4 weeks. Bucket 2 was planted with 80gms toilet compost and 100mls urine. Bucket 3 was planted with 150mls urine with an additional 100mls added at 4 weeks. Buckets 4 – 7 were given 150mls urine once a week. Urine application started on 4th July 2004 and ended on 30th October 2004, a total 2.5 litres per plant. Water was also applied daily. This in fact is a very high application rate and not very practical, but provides excellent cobs. Photo taken 18th November 2004.

The resulting maize cobs. Maize fed with commercial fertiliser weighed 259gms (left). Maize fed weekly urine (4 – 7 on right) had weights 281gms, 256gms, 300gms and 267gms). These are comparable with or more than maize fed with commercial fertiliser at this dose. Poorly fed maize make smaller cobs. The maize fed 80gms toilet compost and 100mls urine (2) made a cob 138gms in weight. The maize fed a total of 250mls urine (3a and 3b) made two cobs (47gms and 128gms) totalling 175gms. The best dose of urine lies around one litre per plant per season. Clearly 250mls is inadequate.
Experiment 2

Experiment with growth of maize in poor sandy soil from Ruwa. Numbered 1 to 6 from left to right.
1: maize plant with no treatment. 2: 10gms 1:2:1 applied at seedling stage and 10gms ammonium nitrate at 4 weeks. 3: 80gms toilet compost + 100mls urine. 4: 150mls urine at seedling and 100mls urine at 4 weeks. 5: 500gms toilet compost + 1.2 litres urine at 100mls per week. 6: 1.2 litres urine at 100mls per week. Seedlings planted 13th August 2004. Last urine application 30th October 2004. Cobs measured 3rd December, Photo taken 3rd December 2004.

Removed cobs
From left to right 1 – no treatment. 2 – commercial fertiliser 3 - 80gms toilet compost + 100mls urine. 4 – total 250mls urine 5 and 6 (LHS) each given total of 1.2 litres urine (100mls at weekly intervals)
Larger amounts of urine applied lead to much larger cobs being formed.
In this experiment undertaken in 10 litre buckets the most productive plants were those where urine was applied weekly at the rate of 100mls per week for 12 weeks, totalling 1.2 litres per plant over the main growth period. This suited the conditions in the buckets where water is applied daily or even twice daily to keep the plants turgid. Under these conditions some of the urine nitrogen is flushed away and lost to the plant. The same applies to urine nitrogen applied to poor sandy soils after heavy rain, where the soluble and very mobile nitrogen can be leached away into deeper soil. Under these conditions the more regular addition of nitrogen (urine) helps to overcome the loss of nitrogen due to leaching. Cob weight was increased over 40 times by the regular addition of urine. This exceeded even commercial fertiliser and greatly exceeded the application of smaller amounts of urine.

In this experiment, urine application was stopped after 12 weekly applications of 100mls (1.2 litres per plant), when the cobs were half grown. Water application continued for another month and the diameter of the cobs was measured daily. The graph below shows that cob growth continued for 2 to 3 weeks after the cessation of urine application, but then tailed off markedly. In this case nutrients would at first have been derived from the soil but later on from the leaf which was well stocked with nitrogen following regular applications of urine during the main growth period which lies between the 4th and 10th week of plant growth.
Sequence of adding the urine (active growth stage)

In order to add 4 – 5 gms of nitrogen to the plant, one litre of urine must be applied, in stages, throughout the plants life. The bulk of this amount should be applied during the first 10 weeks after planting or up to time of tasselling and cob formation. It is during this critical 4 – 10 week period that the main growth of the maize plant takes place and the most nitrogen is picked up by the roots and stored in the vegetative plant structure above ground (mainly in the leaves). This one litre can be added in 8 allocations of 125mls each at weekly intervals, or 4 allocations of 125mls and 2 allocations of 250mls. Alternatively 4 applications of 250mls can be given. The exact sequence is given below. However it is desirable that nitrogen application extends into the period of cob grain filling. Thus if one litre of urine is used, the last two applications can be applied a fortnight apart and not a week apart as this will then extend the period into grain filling. The photos below show the early stages of comparative growth of maize plants planted in poor sandy Epworth soil in buckets at various stages in the early application of one litre of urine.

On the left a day or so after first seed emergence on 5th November 2004. The two blue coloured buckets on the left had no urine applied at planting, the two buckets on the right (yellow and pink) each had 125mls applied on planting day. The photo on the right was taken on 19th November, 3 weeks after planting day which was 29th October 2004. This clearly shows the effect of the initial below ground application of urine. The plants are more advanced. On this day 125mls of urine was applied to buckets 2, 3 and 4 with the bucket on the extreme left being untreated, as a control.

The photo on the left was taken on 3rd December 2004, 5 weeks after seed planting day which was 29th October 2004. This clearly shows the effect of urine application of urine. On this day 125mls of urine was applied to buckets 2, 3 and 4 with the bucket on the extreme left being untreated, as a control. The photo on the right was taken on 17th December 7 weeks after planting day. The growth of all urine treated plants is now considerable. At this stage (numbering buckets from left to right) B1 had received 0 urine, B2-375mls urine, B3 - 500mls urine and B4- 500mls urine. At this stage and for experimental reasons, the applications to bucket 4 were stopped. Urine application continued on buckets 2 and 3. Urine application should continue at least until the 9th week when the cobs start to grow. Extra urine on the 10th or 11th week is also valuable. The most important aspect of urine application is that the bulk of the urine applied is done so between the 4th and 10th week after planting.
The photo on the left was taken on 31st December, 9 weeks after seed planting (29th October). At this stage bucket no 4 (pink) had received 500mls urine and whilst more could have been added, the urine applications were stopped deliberately to assess cob size after 500mls of urine treatment. Urine treatment continued on buckets 2 and 3. At this stage bucket 1 (left) had received no urine, bucket 2 had received 500mls and bucket 3, 625mls. The method of application varied slightly in each case. In bucket 2 there was no initial application of urine into the soil at seed planting. Note that no two individual maize plants grow exactly identically. On the right a photo taken at around 0+10 weeks. The plants in buckets 2, 3 and 4 have all tasselled and small cobs are starting to grow. Grain filling now starts. An extra boost of 125mls of urine has been added to bucket 2.

Photo taken 14th Jan, when urine application ended on buckets B and C, with urine application on C ending earlier. At this stage the total application of urine applied was as follows: Bucket A zero. Bucket B 875mls, Bucket C (yellow) 750mls, bucket D 500mls. Note yellowing of basal leaves in bucket D. Final cobs on the right. From bucket B, 253gms, bucket C, 215gms and bucket D, 167gms. Cob weight is related to urine applied. Good table sized cobs should exceed 300gms.
These various experiments reveal that a good target to aim for is the application of one litre of neat urine per plant. This should be applied during the growing season and extending into early cob formation. Extra nitrogen applied during the grain filling stage (as seen in the two examples where 1200mls urine was applied) leads to extra cob weight. The experiments also reveal that an application of urine at the time of planting seed is valuable as this helps to accelerate early growth. This urine is best applied to the soil beneath the plug of toilet compost in which the seeds are planted. If urine is applied directly around the seed the success of germination may be reduced and early leaves may become scorched.

The application of this litre of urine can be achieved in several ways. In the various bucket and field trials described here, a urine dispenser of 125mls capacity was made from a standard plastic pill bottle fitted with a wire handle. One litre of urine is dispensed by 8 applications of the dispenser. To extend into and beyond the tenth week after seed planting the following schedule was devised for urine application:

1\textsuperscript{st} application at seeds planting below toilet compost in which seed planted (Zero time)
2\textsuperscript{nd} application 3 weeks after planting (0+3 weeks)
3\textsuperscript{rd}, 4\textsuperscript{th}, 5\textsuperscript{th}, 6\textsuperscript{th} application at weekly intervals (0+4, 0+5, 0+6 and 0+7 weeks).
7\textsuperscript{th} application 0+9 weeks
8\textsuperscript{th} application 0+11 weeks (total one litre).

This method was used in one of the field test sites (Epworth) and the same amount of urine (one litre) was applied in a reduced number of applications in another site (Mt Hamden). In both cases the final doses of urine are applied when the cobs are forming.

If additional urine can be applied in the field during the grain filling stage, then it can be beneficial to do so. This extra application of nitrogen is carried out traditionally if there is sufficient fertiliser available. However in both field experiments described below, urine application was stopped once one litre was applied to each plant.
2. Field Trials - applying the results of these pre-trials to the field

Growing maize in buckets is not the same as growing plants in the field or backyard vegetable garden. In buckets the roots become root bound, although they take up the nutrients applied very effectively. Normally maize roots can spread out at least to half a metre below ground level and more to collect nutrients. However these experiments offer useful information when applying the same technique to the field. In fact the use of toilet compost and urine is best applied to smaller fields or homestead maize plots (rather than larger fields), where the number of plants is small (a few hundred) and where the plants are close to the house or toilet where the urine is collected. It is an ideal technique for smaller gardens and plots found in peri-urban and urban settlements or in the rural areas where small fields are worked near the homestead. It is not very practical to apply this technique to large fields as the amount of urine required would be huge. But large numbers of households in the sub-region derive much benefit from these smaller gardens and plots and the technique described here may be ideal.

In growing maize using urine on poor sandy soils, a number of factors must be taken into consideration. The first is that urine nitrogen when converted to nitrate (by soil bacteria) is highly soluble and mobile in the soil. Thus an important consideration is the effect of leaching (or washing away) of the nitrogen derived from urine in very porous sandy soils during heavy rains. This leaching effect is very pronounced in sandy soils which are common throughout Zimbabwe and can lead to a heavy loss of nitrogen. By comparison phosphorus moves little in the soil. A rain of 10mm can lead to a downward movement of water of 10cm. Thus the rain will drive the nitrogen down deeper into the soil. Applying lots of urine to a sandy soil when the plant is still very young is a waste of time and urine, simply because the root system of the young plant is not yet deep or extensive enough to take up the nitrogen from deeper down. Things change a lot as the plant grows. During the period 4 or 10 weeks the maize growth is rapid and that applies to the root system as well as to the vegetative structure above ground level. So later on, the extended root system is better able to pick up nitrogen further down in the soil. Then the effects of leaching are not so important.

The life of the maize plant itself can be set at about 16 weeks (about 120 days or 4 months) between planting and harvesting. The planted seeds take about one week to appear at the soil surface (with rain or with irrigation) and the best time for the first urine application above ground is 2 weeks later (3 weeks after germination). The rapid growth period for the maize plant is between 4 and 10 weeks after planting. Then tasselling (at about 10 weeks and this coincides with the formation of the very young maize cob. This is followed by a period of rapid growth of the maize cob, known as “grain filling” which lasts about 4 – 6 weeks. During this stage the tiny young cob fills with starch and proteins. This period lasts until maturity at about 16 weeks. The plant requires plenty of nutrients during the rapid growth period and also adequate water. Good yields are obtained if this application extends into grain filling. Adequate water (rain) is also required during the post tasselling, grain filling stage.

A good marker is the appearance of the “silk,” the female inflorescence which grows at the tip of forming cob. Around the same time the “tassel,” the male inflorescence appears at the top of the plant. These both become visible around 10 weeks after planting. Pollen from the tassel must fertilise the silk to produce a fully formed cob. During the normal growing season from mid November to mid March, this tassel forms towards the end of January or early February. The actual time depends on the date of germination, and this itself is depended on the early rains leading to a germination which is sustained by more rain. Most of the nitrogen from the urine should be applied between the 4th to 10th week of growth after planting. The last
application of urine should ideally be applied during the early growth of the cob. By this time most of the nitrogen and other nutrients from the soil and urine should have been given to the plant for storage in the leaves and stem where together with water and sunlight they are converted into sugar and starch and transferred to the cob (grain filling stage). The extra nitrogen applied when the cob is growing enhances this effect. Often a generous dose of commercial fertiliser is applied at the time of silking to get good harvests. Thus there is no disadvantage of applying more urine after silking.

For these various reasons it makes sense to supply only part of the one litre of urine at first, as the small root system is unable to collect heavy doses which may be washed down into the soil and lost. The loss of nitrogen due to leaching following heavy rain is particularly common in poor sandy soils. It is well established amongst maize growers that applying nitrogen (in the form of ammonium nitrate as a top dressing (“top”) to the soil during heavy rainy can be wasteful. As the plant grows, so does its root system, and its ability to take up larger doses of accumulated nitrogen which may sink deeper into the soil. As each application of urine is applied the amount of nitrogen in the planting station increases.

The amount and frequency of adding the urine to the plant can vary considerably. If we take one litre as a good figure to aim for and the period up to 10 weeks being the time when most of it must be applied, we can now work out the most suitable regime.

Experiments have revealed that it does pay to add some urine at planting time, as this “brings the plant forward” but because neat urine may reduce the success of seed germination and may also scorch young leaves, it is best to add the urine to the soil below the plug of compost in which the seeds are planted. The procedure is to dig out the hole in the soil, add the urine (125mls or 250mls), then add the compost, plant the seeds in the compost (usually 2) and then cover.

If we set the planting day as 0 and the seeds germinate on that day, 125mls of urine can be applied to the soil first, followed by the plug of 500gms of compost in which the two seeds are planted and covered with ground soil. Then one hopes for rain. If rain comes sufficient to soak the soil then one week is given for the seeds to germinate and appear at ground level and another 2 weeks is allowed for the plants to grow and establish themselves before the next urine application. Then a further 125mls urine can be applied at 0+3 weeks and thereafter at weekly intervals (0+4, 0+5, 0+6, 0+7) and then at fortnightly intervals (0+9, 0+11). This totals 8 applications of 125mls each which totals one litre. By this stage the tassel and the cob should be forming. Extra urine can be applied if available.

An alternative regime is to add the 250mls at planting and another 125mls at 0+3 weeks, and 0+5 weeks, then 250mls at 0+7 and 0+9 weeks. This totals 5 applications amounting to 1000mls applied. The amount of urine applied over time is the same, but it is built up in a larger quantity before application because more is required per plant. However when 250mls of urine is applied, double the amount of urine is required compared to a 125ml application. The amount and frequency of urine application will be coupled to the amount of urine being generated by the family at the time. This can only be decided on the spot. Once the method has been understood, the family may prefer to apply a 20 litre drum full, in 125mls applications, as it accumulates. A 20 litre drum full will treat 160 plants at 125mls per plant. If the family meets with success with the technique, it may learn to store urine before the maize season in preparation for enhanced applications to larger numbers of plants.
The day of germination may not be the same as the planting day. This will always be the case for dry planting when the seed is planted ahead of the main first rain of the season. In this case (which will be the norm), day 0 must be set at the day of the first heavy rain which will soak the ground and induce germination. If maize is planted late (later in November or early December) the yield will be reduced. The best yields come from early planting (late October and early November) with artificial watering until the main rains begin. This method which may be possible on small plots surrounding a homestead if a well or piped water is available. For most people however the onset of the rains is a crucial time. It should occur mid November (there will have been some rain during October, but this does not persist). The final yield is much dependent on adequate rains falling on time and throughout the growing season, something that cannot always be guaranteed. Once the day of germination has been set and confirmed with the first plant appearance above ground, then all other urine application days can be set.

However if early rains come and then go away, the seeds may germinate and then wither away. Sadly this is not an unusual pattern in Zimbabwe. The only answer – replant. This means going through the procedure again.

As a general rule of thumb, any urine which is added to the maize plant will have a beneficial effect. The poorer the soil, the more noticeable the effect. The addition of compost also helps, not only in providing some nutrients, but also in providing a good planting medium and soil organisms for converting urine nitrogen. Also to a certain extent the compost improves water retention, although if small amounts of compost are used, as in this case, this will have only a minor effect, since the root system eventually extends over an area and depth well beyond the compost zone. In the end the final yield depends on a number of important factors as well as the provision of adequate amounts of urine. Adequate sunlight is required and good drainage of the soil to avoid “wet feet.” Also the best maize plants grow where only one plant grows in each planting station. If secondary shoots develop on the stem, they are best removed so that each plant has only one main stem. The amount of urine or nitrogen applied will influence the number of cobs which form. Normally a single cob may form, but if the amount of nitrogen applied is generous two cobs will form.
Guidelines for growing maize
with the help of toilet compost and urine

A combination of toilet compost and urine can be used to replace the normal feeding of maize with commercial fertiliser in backyard gardens and small maize fields. About 500gms of toilet compost (one pea tin full) and around one litre of neat urine are used to provide all the nutrients required. Toilet compost contains a variety of nutrients including nitrogen, phosphorus and potassium, although not as much nitrogen as in the urine. The phosphorus content of the compost is most valuable to the young plant and is required for early root formation and vegetative growth. The toilet compost is also an excellent medium in which to plant the seed. However the humus alone does not supply enough nutrient to take the plant to anywhere near full production. Urine is required for this, since it contains a great deal of nitrogen. The lower levels of nitrogen compared to phosphorus in the toilet compost are ideal for the young plant. The urine, which contains a lot of nitrogen, but less phosphorus by comparison, is ideal once the young plant has become established. The toilet compost is collected from the Fossa alterna pit (or alternatively from an Arborloo pit where a tree has not been planted) after about 12 months of composting. Each year a family Fossa alterna will provide about 700 litres of toilet compost, enough for at least 1000 plants. This compost can be used to plant vegetables or maize. Urine can be collected in 20 litre plastic containers before planting. This can be done by men urinating into bottles and storing in the larger containers, or placing a funnel and pipe in the container and using as a urinal. Women can collect urine in potties and then pour the valuable liquid into the 20 litre container.

With normal fertiliser each plant is treated with 10gms Compound D (1:2:1 – one part nitrogen 2 parts phosphorus and one part potassium) at planting. This contains 8% nitrogen or nearly one gram. After 4 weeks or when the plant is at knee height, a further 10gms of ammonium nitrate is added (34.5% nitrogen). 10gms contains about 3.4gms nitrogen. The combination of these two applications of fertiliser contains about 4.5gms of nitrogen. In Zimbabwe most people produce urine which also contains between 4 and 5gms nitrogen per litre (Hakan Johnson. pers.comm.). So if the same amount of nitrogen is applied through the urine as is normal applied through chemicals, approximately one litre of urine is required for each plant. This one litre of neat urine is applied in a series of smaller doses through the growing season. Thus 100 plants will require about 100litres of urine through the season, which last between 3 – 4 months. Less urine can be supplied, but generally the more urine is applied, the larger the maize cobs will be.

It is possible to apply the one litre of urine in a reduced number of larger applications, say 4 lots of 250mls or two lots of 500mls. But in sandy soils which are very porous, one heavy storm may wash away (leach) much of the nitrogen near the roots zone into deeper soil, where it may not be available to the plants. This is especially true when the plants are young. So it is wise to add smaller amounts of urine more often. Also if smaller amounts of urine are applied more often, the family may be able to cope in keeping up the supply. If large doses are required, then increased storage capacity is required. It is wise to continue applying the urine to the plant at least until the the cob has begun to grow. This is about 10 weeks after planting. Applications of further urine after this time can also be beneficial. Remember that urine nitrogen is very soluble unlike the commercial fertiliser which is a slow release granular formulation. This means that urine nitrogen is more easily lost by leaching following heavy rain then the granules.
The schedule.

There is some variation in the best technique depending on the soil characteristic. Very poor sandy soil, which is very common in Zimbabwe, will require more urine to feed the plants than soil which is richer and has more humus. This schedule is currently recommended.

1. The field or garden is prepared before planting as normal by ploughing or digging. The area required depends on the number of plants. Maize seed are planted around 30cm apart and in rows around 90cms apart. So 100 plants will occupy an area of just over 3m X 10m. Each planting site is known as a “planting station.”

2. Planting day should be around mid November in Zimbabwe. The seeds can be planted in dry conditions prior to the rains, a method known as “dry planting.” A soon as the rains start and the soil becomes wet the seeds will germinate.

3. On planting day (mid November), a small shallow hole is scooped out of the sandy soil with a small hoe (badza) or trowel.

4. Add 125mls of neat urine to each hole (with a prepared dispenser) like a small plastic pill bottle with wire handle). Add the urine to all the holes. The urine is shaken up in the 20 litre container first to release sediments of phosphorus, and then poured into a plastic bucket which is carried around the site.

5. Now add one pea tin full (about 500gms) of toilet compost (or other compost) into each hole. A family compost toilet will provide enough humus for over 1000 such pa tins after a full year of use and a year of composting. The compost can be placed in a wheel barrow and a tin full scooped up and placed in each hole.

6. Then plant seed in each plug of compost. If seed is scarce plant a single seed. In Zimbabwe 95% of seeds planted will germinate. If there is doubt plant two seeds in each plug of humus. Push down the seed into the humus and cover over with top soil.

7. Wait for the rains. Once the soil has become wet the seed will germinate and the young plant will take about one week to come to the surface.

8. Allow the seedlings grow for a further two weeks before applying more urine. During this two weeks remove the weakest plant if two seeds have been planted and both germinate. If there is no germination in a planting station, sow another seed in the site.

9. After 2 weeks growth above ground level apply another 125mls of neat urine. This can be applied to small holes scooped or dug out into the sandy soil, near the plant.

10. If planting day is day zero apply 125mls urine (on seed planting day 0 ) and then 0+3 weeks, 0+4weeks, 0+5weeks, 0+6weeks, 0+7weeks, 0+9weeks and 0+11weeks. Total 1000mls. Alternatively apply 250mls at planting, 125mls at 0+3 and 0+4 weeks and then 250mls at 0+6 weeks and 0+9 weeks. Total 1000mls.

11. It is also possible to apply the urine in four 250ml applications (initial at planting + after 3 weeks followed by 2 applications of 250mls fortnightly (the second being around the time of tasselling).

12. As the plant begins to grow any secondary stems should be removed, so all the nutrients derived from the urine go into a single main stem. Weeds are also removed, as they can take up valuable nutrients.

13. Any urine applied after the cob begins to form can lead to extra weight of the cob.

14. The plants are allowed to mature and dry off. Green maize can be taken off earlier. Maize for grinding is kept on the plant for longer.

15. It is useful to have one patch of maize in which no urine or other fertiliser is applied as this can be compared to the fertilised sections for others to see.
Photos showing maize trial in the field at Epworth near Harare

Epworth was chosen as an experimental site to demonstrate the effectiveness of urine as a fertiliser for maize. Epworth is a large peri-urban settlement of about 200,000 people. Epworth soil is very poor soil and without fertiliser or manure maize crops are poor.

The field is prepared by digging and holes are made 30cms apart in rows 90cm apart. The 20 litre drum of collected urine is shaken up (to mix the phosphorus) and added to a 20 litre bucket. Date 5.11.2004

Using a dispenser, 125mls of urine is added to every hole

This is followed by one pea tin full (500gms) of toilet compost taken from the *Fossa alterna* or other composting toilet. Two seeds are then planted in the compost and pressed down and then covered with the topsoil. If seeds are in short supply then a single seed can be planted. Over 90% of registered maize seed will germinate. Another seed can be planted if a single seed does not germinate.
The seeds are pressed into the compost and covered with topsoil awaiting the rains.

On the left the field site at Epworth showing the Fossa alterna from where the humus was taken. Picture on right taken 2\textsuperscript{nd} December 2004 when the maize had started to grow.

If two seeds had germinated, which was normally the case, one was removed and planted elsewhere. Adding the second 125mls application of urine to the young plant.
Photos taken on 3rd January 2005. On the left photo the plants on the lower left were not treated with urine. Plants in mid picture and right had been treated. The difference is obvious. On the right photo, the lush growth of plants following urine treatment is clear to see.

Digging small hole near to plant step prior to urine application. On the right, the urine has been stored in the 20 litre plastic container. It is poured into a bucket and then dispensed with the small pill bottle dispenser next to each plant.
Applying the 125mls of urine next to the plant

On the left photo, maize nearest the camera are untreated with urine. Plants further away have been treated. On the right, another view of treated and untreated plants. Photo 3rd Jan. 2005.
Photos taken on 17th January 2005. The difference between urine treated and untreated plants increases as time passes.

A further 125mls urine is applied to each of the treated plants

17th January 2005, first signs of tassel (left) and cob (right).
Photos taken on 31st January 2005

This photo was taken at the time when the last of the urine was applied. In the treated area (right) the growth of maize has been good and cobs are already forming. On the left the untreated area shows smaller and paler plants with little cob formation.

Healthy lines of maize with healthy cobs growing in treated zone. On the right two cobs are growing, revealing that the urine application as per the schedule is adequate. On this day the final 125mls of urine was added making the total application one litre per plant. The first application was made at planting, the second to 6th application a week apart. The last two applications were spread a fortnight apart. This regime carries the application of urine nitrogen into the grain filling stage.
Harvesting day – 14th March 2005

On the left the plants in the control section not treated with urine. On the right the urine treated section

Reaping the maize cobs
Each cob was measured on a scale. The harvest from urine treated plants.

Maize growth in nearby field without any feeding. The growth is poor and the cobs small.

Final observations and cob measurement

Epworth is a large peri-urban settlement of about 200,000 people close to Harare. It was chosen as an experimental site to demonstrate the effectiveness of urine as an alternative to commercial fertilizer for maize production because it is characteristic of the conditions under which millions of people live both in peri-urban and rural areas in Southern Africa. Natural Epworth topsoil is sandy, porous, almost without nutrients and applied nutrients can easily be lost by leaching during heavy storms. Without commercial fertilizer or manure, maize and vegetable crops are generally very poor on soils of this type. However despite this backyard soil in Epworth is characteristically patchy with variable nutrient level. This is because over the years sections of land have been fertilized with manure and compost, particularly in delineated vegetable gardens. Also there is some fertilization of maize crops for those who can afford to buy. So there is some carry over of nutrients from year to year.

In the current trial a small existing backyard maize field was chosen which also housed an ecological toilet (Fossa alterna). 200 maize were planted and treated with a total of one litre urine during the vegetative and grain filling stages (as indicate above). A further 40 plants were not treated with urine. 40 additional plants were treated with standard fertilizer. At harvesting and for comparison a small sample of cobs was also taken from an adjacent field where no treatment of any type had taken place. Seed was planted in mid November and cobs harvested in mid March a period of 4 months.
Results

<table>
<thead>
<tr>
<th>Section</th>
<th>No. Plants</th>
<th>Mean cob Wt. (gms)</th>
<th>Equivalent grain wt. (gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated (field 2)</td>
<td>15</td>
<td>82.4</td>
<td>41</td>
</tr>
<tr>
<td>Untreated (field 1)</td>
<td>36</td>
<td>138.11</td>
<td>75</td>
</tr>
<tr>
<td>Treated: commercial fertilizer (field 1)</td>
<td>34</td>
<td>166.97</td>
<td>97</td>
</tr>
<tr>
<td>Treated: urine (1 litre per plant – field 1)</td>
<td>196</td>
<td>243.11</td>
<td>148</td>
</tr>
</tbody>
</table>

There was much variation between individual plants in all sections (apart from field 2) of the trial, mainly due to the variable existing nature of the soil even within each section of the experimental field, and probably due to earlier applications of manure, compost or fertilizer. This variation is characteristic of such fields and gardens. This variation was less evident in the urine fed section, where the treatment had a significant effect on maize growth and cob size – with more consistently larger cobs. Overall mean cob weight was increased by 1.76 times (138gms to 242gms) by urine application when compared to the untreated section. When plotted against grain weight, this increase in cob weight (X 1.76) represents a doubling in the yield of grain. When plotted on a graph, a 138gm cob yields 75gms of freshly stripped grain compared to the larger 243gm cob which yields 148gms of grain. The relatively high mean for untreated maize (field 1) was probably due to a sub-surface bed of manure or compost in one patch of the control zone which promoting healthy growth of a few plants making up 27% of the total cob weight in this section. The mean cob weight of urine treated maize (243gms) was about three times the mean cob weight (82gms) of sample cobs taken from another untreated field nearby, more typical of the area, where cob weights were more consistently poor. In terms of grain weight this is an increase of four times. The urine was produced by the family itself and probably contained about 5gms/litre nitrogen, approximately the same as the nitrogen applied with commercial fertilizer. Residents in the area were impressed by the effect of urine treatment, which was plainly visible and cost nothing, but did require effort on the part of the householder. **Put in simple terms the treatment of one litre of urine per plant over the growth period resulted in a doubling of grain output.** This must be seen as a result worth the effort.

![Relationship between maize cob weight and grain weight](image)

**Series 1**
The response of the maize in this trial to commercial fertilizer was surprisingly (and uncharacteristically) poor, with only a 1.2 times increase in mean cob weight. This may have been due to the very poor and irregular rainy season characterized by single heavy storms followed by long periods without rain. Under these conditions soluble nitrogen (from urine or ammonium nitrate) may be quickly lost into deeper soil by leaching in these porous sandy conditions. The more regular weekly application of urine, undertaken in this experiment, appears to have partly overcome the leaching effect.

The real test of the practicability of this type of treatment comes during subsequent growing seasons following the demonstration. Will the urine treatment method be repeated and copied by others? For a small maize field of 200 plants a total of 200 litres urine was required and the man and wife of the household coped with this production during the period of the experiment. But if larger numbers of maize plants were treated in the same way, collection and storage of urine would need to take place prior to the planting of maize. Urine can be stored in 20/30 litre plastic containers. Whilst the cost of these containers would be high initially, their use would continue over many years, making the overall investment worthwhile.

The rainy season during this trial in Zimbabwe was considered to be poor and well below average. Poor maize harvests were reported for much of Zimbabwe. The main rainy season was characterised by heavy storms with much rain with long intervals without rain. These characteristics are not ideal for maize growth. The period of grain filling which is so important to a good crop was also one with almost no rain. Thus grain filling was far from optimal.

Despite these various factors it was possible to determine the extent of the increased harvest by comparing different areas of the same field. But this experiment and others reveal the great individual variation in plant growth in all sections of the chosen fields revealing considerable variation of the status of the soil in different parts even of the same field. This is no doubt due to previous applications of manure, compost or fertiliser still having an influence.
Comparisons with maize growth in more fertile soil

For comparative reasons a similar trial was undertaken at the Friend Foundation in Tynwald near Harare. In this case a plot was chosen where animal manure (mainly donkey and dog) had been previously added to the soil over a period of time. This had the overall effect of enriching the soil, although the enrichment was patchy.

Area 1 of the plot was planted with 70 maize which were treated with 1000mls of urine, applied over the growth and grain filling period in 5 applications. The seed was planted in 500mls of toilet compost. Area 2 of the plot was planted with 50 maize in toilet compost with a single 125ml application of urine. Area 3 of the plot was planted with 70 plants which were not treated with toilet compost or urine. The remainder of the plot (area 4) was planted with maize growing on manure treated soil without any further addition of urine or toilet compost. Maize was planted on 6th December 2004 and reaped on 24th March 2005. In each area the cobs from plants was measured. In area no. 4 which was the largest, a sample of 20 plants were measured. The results are as follows.

<table>
<thead>
<tr>
<th>Area</th>
<th>Additional Treatment</th>
<th>total wt cobs (no.)</th>
<th>mn.cob wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>toilet compost + 1litre urine</td>
<td>24 354gms (68)</td>
<td>358.14</td>
</tr>
<tr>
<td>2</td>
<td>toilet compost + 125mls urine</td>
<td>18 050gms (51)</td>
<td>353.92</td>
</tr>
<tr>
<td>3.</td>
<td>Original manure only</td>
<td>13 457 (66)</td>
<td>203.89</td>
</tr>
<tr>
<td>4.</td>
<td>Original manure only</td>
<td>6 708 (20)</td>
<td>335.40</td>
</tr>
</tbody>
</table>

Overall conclusions

Under conditions where the soil is already enriched with manure, the presence of toilet compost and urine appears to have made little difference to the overall growth of the maize plants and final weight of cobs. The patchiness of the general area in terms of soil fertility is revealed by the differences in cobs weights from areas 3 and 4, neither of which were treated with either urine or toilet compost. The fertility derived from the manure enriched soil appears to have overridden the effects of toilet compost and urine in this experiment, where the application of either 1000mls urine or 125mls urine made little difference to the final yield of plants. The experiment also revealed that even within a small plot or field there can be much variation in the growth of maize plants depending on the nature of previous additions to the soil over localized areas. This was also revealed in the maize trial undertaken in Epworth.

In terms of cob size harvested, those from Tynwald were considerably larger than those from Epworth. The overall size of cobs harvested from all areas in the Tynwald soil was 305gms (overall mean) considerably larger than the overall mean of 211gms harvested overall from Epworth. This is entirely due to the quality of the soil in which the plants were growing and the fact that Tynwald soil had far more humus and was able to retain water better than the sandy soil of Epworth. Maize plants treated with one litre urine in Epworth had an overall mean size of 243gms compared to 358gms in Tynwald.

Total cob wt harvested and number of plants with overall mean (Epworth)

| Untreated – area 1 | 4 972gms (36) = mean 138.11 |
| Untreated – area 2 | 1 236 gms (15) = mean 82.4 |
| Commercial fert treated | 5 677 gms (34) = mean 166.97 |
| Urine treated (1000mls) | 47 651gms (196) = mean 243.11 |
The value of animal manure

The Friend Foundation site in Tynwald is actually an animal sanctuary where animals of all types are homed and cared for. Several hundred dogs together with larger animals like donkeys and horses are looked after. In previous years the disposal of the huge amounts of dog manure caused considerable problems at the Foundation. The writer was asked to try to solve the problem.

In previous years the large amounts of dog compost were placed in 1 cubic metre pits together with soil and trees were planted on filled pits, much in the same way as the Arborloo pits work. This work was reported previously in Ecological Sanitation in Zimbabwe Vols 2 and 3. Eventually, mainly as a result of a lack of watering and general maintenance some of the trees died and the unutilised compost remained in the pits. However at some point in time, the compost was dug out of the pits and placed on maize fields. This process followed the traditional practice of applying cow manure to maize fields in the rural areas of Zimbabwe. The effect of this composted dog manure on the maize harvest was seen to be very effective by the residents with good harvests being gathered without commercial fertiliser being applied. Fresh pits were dug and the dog manure and soil were added in pits nearer the maize fields. A new regime of processing dog manure was instigated. Composted manure was carried to the field prior to the rains and made into heaps. It was then spread out and dug in to the topsoil just prior to planting. Extra manure was also added to rows of maize as the seeds were planted. This compost treatment appears to have given the maize sufficient nutrient to carry the plants through to full cob formation. Some individuals who could afford added extra ammonium nitrate as a top dressing prior to the grain filling stage. However most plots were not treated with fertiliser. The Foundations earlier annual routine of supplying fertiliser to staff was stopped as costs rose.

During the 2003/4 season and again during the 2004/5 season almost all the maize plants grown at the Foundation were fertilised with composted dog manure which was in abundant supply. The relatively small amounts of human compost produced from the five Fossa alterna toilets were also used in the same way to fertilise maize fields.

Thus the concept of composting both human and animal faeces in shallow pits by adding soil, and then digging out and applying to the fields, has become a routine at this station. The process has been adopted without prompting by the staff because it works and because it costs nothing. The saving of cash for fertiliser is considerable.
Maize field with dog manure treatment (rear) and without treatment (foreground).

Maize field with dog manure treatment and subsequent ammonium nitrate treatment.