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

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 large numbers 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 in this chapter shows clearly how maize production can be enhanced considerably by the application of urine. 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. About 500 gms of toilet compost are applied per planting station. This is about one pea tin full.

Application of urine to maize in peri-urban gardens

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 120days 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 the “tassel” (the male inflorescence) appears at the top of the plant - 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. In fact both the “tassel” and the “silk” appear at about the same time - 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 4^{th} to 10^{th} week of growth after planting. The last application of urine should ideally be applied during the grain filling stage 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 during the grain filling stage. The extra nitrogen applied when the cob is growing enhances this effect. Often farmers apply a generous dose of commercial fertiliser (ammonium nitrate) at the time of "silking" to get good harvests. Thus there is no disadvantage of applying more urine during grain filling.

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 zero 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+7weeks) and then at fortnightly intervals (0+9, 0+11weeks). 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 per plant, 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 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. Also 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 (or more) cobs will form.

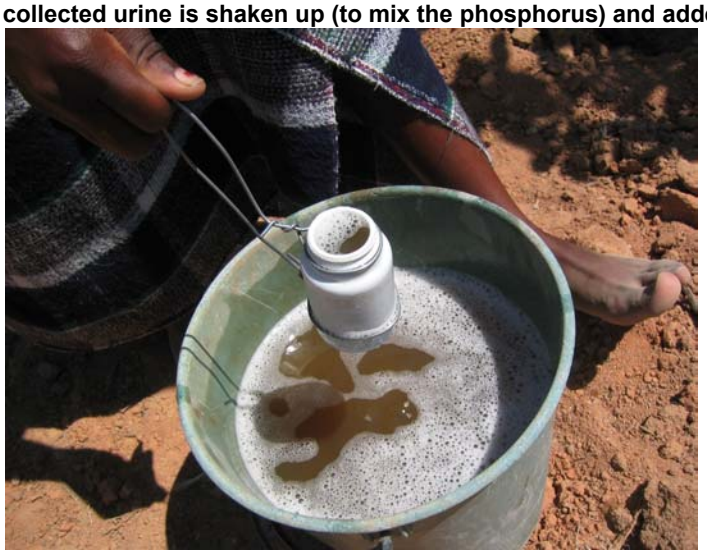
Urine fed plants growing on buckets about 13 weeks after germination

A field trial in Epworth near Harare

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 experiment, the field was dug and levelled beforehand and on planting day hundreds of small holes were dug in lines and rows ready for planting. 125mls of urine (which had been collected in 20 litre plastic containers previously) was applied to each "planting station. " This was followed by a 500gm plug of toilet compost. Two seeds were planted in the compost and covered over.

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 2nd 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 in a hollow next to the plant. Best to cover over after application. 125mls are added weekly to each plant, the last 2 applications are added fortnightly to make a total of 1000mls for each plant. This is equivalent to around 5gms nitrogen.

17th January 2005, first signs of tassel (left) and cob (right).

This photo was taken 31st January 2005 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 31st January 2005. 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 – Epworth 14th March 2005

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

Reaping and measuring the maize cobs

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

Final observations and cob measurement

In the current trial a small existing backyard maize field was chosen which also housed an ecological toilet **(*Fossa alterna*).** 200 maize were planted in 500gms of toilet compost 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 compost or 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

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

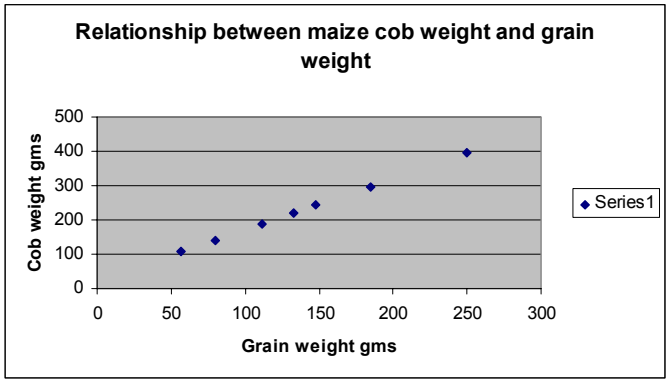
There was much variation between individual plants in all sections (apart from field 2) of the trial, mainly due to the variable existing nature of the soil even within each section of the experimental field, and probably due to earlier applications of manure, compost or fertilizer. This variation is 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.

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 worth while.



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Growing maize with the help of toilet compost and urine in containers

In almost every case maize is grown in backyard gardens and fields where large numbers of plants can be grown. However it is also possible to produce excellent table sized maize cobs by growing each plant in a container like a 10 litre bucket Whilst this may seem like an extravagant way of producing maize cobs for the table, yields of smaller numbers of maize suitable for green mealie consumption can be produced in this way very effectively by the weekly application of urine. Plastic bags can also be used to contain the soil and plant.

The following photos show the complete series of stages from seed planting to harvesting of 13 maize plants grown in 10 litre buckets and fed with urine. A single plant was used as a control and was not fed with urine. Planting day was 1st December 2004. 125mls undiluted urine was applied on this day under a 500gm plug of toilet compost in which the seeds were planted. Further applications of 125mls of urine were made on December 21 and 28, and January 5, 12, 19, and 26 and February 2, when 1000mls per plant had been applied. Urine application (125mls per plant) continued on Feburary 9, 16, 23, and March 2, making a total urine application per plant of 1.5 litres. The maize cobs were harvested on 9th March 2005, 14 weeks after planting day.


Planting day. 1st December 2005. Fill 10 litre buckets with topsoil. Scoop out hollow in soil and add 125mls neat urine. Add one pea tin full (500gms) toilet compost into hollow. The urine applicator is a plastic pill bottle fitted with wire handle which contains 125mls of liquid.


Add two maize seeds to the compost and press in. Cover with topsoil.


Water liberally. Make up as many buckets as possible. Allow to germinate and grow for 2 weeks above ground level before next urine application. Remove the weakest plant so that only one maize plant grows in each bucket. If no rain water daily.


Left photo plants on 25th December. Right on 5th January.


Left photo taken on 26th January - side and end view after 875mls urine applied. Note untreated plant on right of photo which is quite pale by comparison with treated plants. Photo on right shows healthy maize plant growing on 10 litres of soil placed in a plastic bag. Eventually the roots occupy much of the bag space, but still take up nutrients from urine. Same treatment of a distributed 1.0 to 1.2 litres urine works.


31st January – about 2 months after planting the first tassels and cobs appear

4th Febuary 2005. Most plants are now tasselling and young cobs forming. Note the control with no urine now falling well behind. At this stage 1000mls of urine has been applied to each plant. Urine application continues at the rate of 125mls per plant per week.


4th February 2005. Healthy plants. Each of the treated plants has now been given 1000mls urine. Urine application is continued well into the grain filling period of the cob. On the right note the "silk" at the tip of the young cob.

Harvesting Day – 14 weeks after planting seed

The 14 buckets lined up, the nearest with a plant not treated with urine, the rest treated with 1500mls urine. Urine application followed a schedule, most 125mls once a week. Buckets required regular watering if there was no rainfall.

A display of the cobs produced. The single cob on the left was not fed with urine and weighed 112 gms. The treated cobs show a mean weight of 302.61gms, about three times the weight of the untreated cob.

On a plate – grain yield from untreated maize (50gms) and maize fed with urine (250gms).