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## Adding solid fertilisers to soil in pot experiments V.2

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**We use this protocol and it's working**

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## Abstract

This protocol describes how rates of granular/dry fertiliser can be calculated and added to soil in pot experiments before planting.

## Guidelines

It is important for you to clean all apparatus (shovels, pots, brushes etc.) before use. This can be done by simply washing the equipment with tap water and soap. Do not forget to thoroughly rinse off the soap with clean tap water. All equipment must be left to properly dry before use.

## Materials

- Soil
- Fertiliser (e.g. urea, TSP, muriate of potash)
- Large plastic sheet (2 cm × 5 cm)
- Weighing scale (5-20 kg capacity)
- Empty pots
- Analytical balance
- Small plastic bags (2 cm × 15 cm)
- Marker pen
- Mechanical kitchen/hanging scale (20 kg capacity)
- A brush or small broom to sweep soil with
- A dust pan

## Troubleshooting

## 1 Determining the amount of fertiliser to add to soil in pots

Field based fertiliser rates (in kg/ha) are often used and converted to pot based rates (in g/kg or mg/kg of soil) in pot experiments. This however involves some calculations. Fertiliser application to a field however also involves calculations. In this protocol we shall go through a few calculations, but I encourage you to read the article pasted below for further understanding on how fertiliser calculations are carried out.



In this protocol we shall learn the fertiliser calculations using one example. In our example we shall be adding potassium to soil, at a rate of 80 kg/ha. This rate is however a field based rate and needs to be converted to an equivalent pot based fertiliser rate, before we can determine the amount of fertiliser to add to the soil in our pots. We shall be placing an air dry mass of soil which is equivalent to 5 kg of oven dry soil to each pot.

**Note:** Fertiliser is always calculated as an amount to be added to an oven dry soil. We shall use the fertiliser muriate of potash (MOP), also known as potassium chloride (KCl) to supply the potassium. You must however note that amount of potassium in muriate of potash is indicated as potassium oxide. Each bag of muriate of potash usually contains 60% potassium oxide ( $K_2O$ ).

We shall first begin by calculating the amount of potassium to be added to the mass of soil contained in a 1ha area of a field. **Note:** The general rule of thumb is that a furrow slice of a 1 ha field with a 15–20 cm depth, is approximately 2,000 ton or 2,000,000 kg. With this information we can calculate the amount of potassium to be applied to a kilogram of soil by calculating the amount of potassium to be applied to the mass of soil in a 1 ha furrow slice at a rate of 80 kg K/ha. The calculation is shown below:

80 kg of potassium needs to be applied to 1ha, but remember that a 1 ha furrow slice of soil contains 2,000,000 kg of soil. We can thus express the fertiliser rate from kg K/ha to the amount of potassium to be applied to a kilogram of soil (kg K/kg of soil), as follows;

$$\begin{aligned} & \text{Amount of K to be added to each kilogram of soil} \\ &= \text{mass of K (kg)} / 1 \text{ ha furrow slice} \\ &= \text{mass of K (kg)} / \text{mass of soil in a 1 ha furrow slice (kg)} \\ &= 80 \text{ kg K} / 2,000,000 \text{ kg of soil} \\ &= 0.00004 \text{ kg K/kg of soil} \\ &= 0.04 \text{ g K/kg of soil} \end{aligned}$$

The results of the calculation show that if potassium is supplied at a rate of 80 kg K/ha, then each kilogram of soil will receive 0.04 g of K. However, remember that our pot will hold 5 kg of oven dry soil. We can hence calculate how much potassium will be added to the 5 kg of soil contained in the pot as follows;

$$\begin{aligned} & \text{mass of K to be added to 5 kg of oven dry soil} \\ &= \text{rate at which K will be applied per kg of soil} \times \text{mass of soil} \\ &= 0.04 \text{ kg K} / \text{kg of soil} \times 5 \text{ kg of soil} \\ &= 0.04 \text{ kg K} / \text{kg of soil} \times 5 \text{ kg of soil} \\ &= 0.2 \text{ g K} \end{aligned}$$

We now know the amount of K that will be added to 5 kg of oven dry soil using a field rate of 80 kg K/ha. We however have to calculate the equivalent amount of potassium oxide that will supply the needed amount of K (remember that potassium is usually expressed as K<sub>2</sub>O in marketed fertiliser). To do this, we need to determine the amount of K in K<sub>2</sub>O using the molecular mass of K<sub>2</sub>O, as follows;

*mass of 1 mole of  $K_2O$*

$$= 2(K) \times O$$

$$= 2(39.0983) \times 15.9994$$

$$= 94.196 \text{ g}$$

*mass of K in 1 mole of  $K_2O$*

$$= 2(K)$$

$$= 2(39.0983)$$

$$= 78.1966 \text{ g}$$

Using the ratio between the mass of 1 mole of  $K_2O$  and the K it contains we can now calculate the equivalent mass of  $K_2O$  that can give 0.2 g of K i.e. the calculated amount of  $K_2O$  that will be added to the 5 kg of soil in each pot. This is done as follows;

$$\begin{aligned} \frac{94.196 \text{ g } K_2O}{x} &= \frac{78.1966 \text{ g } K}{0.2 \text{ g } K} \\ \Rightarrow x &= \frac{94.196 \text{ g } K_2O \times 0.2 \text{ g } K}{78.1966 \text{ g } K} \\ \Rightarrow x &= \frac{94.196 \text{ g } K_2O \times 0.2 \text{ g } K}{78.1966 \text{ g } K} \\ &= 0.241 \text{ g } K_2O \end{aligned}$$

Remember that muriate of potash (MOP) sold on the market is not 100% pure  $K_2O$  and that it only contains 60%  $K_2O$  (60% i.e. 60/100). Thus if a bag of MOP is 100 kg then it contains 60 kg of  $K_2O$  out of the whole 100 kg of MOP, and 100 g of MOP would similarly contain 46 g of  $K_2O$ . The amount of MOP that should be added to give our 0.2 g of K should hence be calculated as follows;

$$\begin{aligned}\frac{60 \text{ g } K_2O}{0.241 \text{ g } K_2O} &= \frac{100 \text{ g } MOP}{x} \\ \Rightarrow x &= \frac{0.241 \text{ g } K_2O \times 100 \text{ g } MOP}{60 \text{ g } K_2O} \\ \Rightarrow x &= \frac{0.241 \text{ g } K_2O \times 100 \text{ g } MOP}{60 \text{ g } K_2O} \\ &= 0.402 \text{ g of } MOP\end{aligned}$$

The amount of muriate of potash to be added to 5 kg of oven dry soil in each pot at a rate of 0.04 g K/kg of soil (i.e. 80 kg/ha) is thus 0.402 g.

**Note:** Our example has only shown a calculation for the addition of one nutrient, however more than one nutrient is usually required to be added. The same format of analysis can however be used to arrive at the needed amounts of fertiliser for other nutrient additions. Do not forget to further read on making fertiliser calculations, as this example is not exhaustive. Also note that the above calculations may vary if the potassium is to be applied in two split applications. Sometimes fertiliser is also applied in incremental amounts and if this is the case, always calculate the fertiliser needed to supply the highest rate and then calculate the other amounts from subdivisions of this calculated amount. Keep all this in mind when carrying out your fertiliser calculations.

## 2 Weighing the fertiliser to be added to pots

Continuing with our example we shall now have to weigh out the amount of muriate of potash to be added to each pot. You will need an analytical balance with an accuracy of  $1 \pm 0.0001$  g for this. A balance with this accuracy may however not be found in some labs and thus a balance with an accuracy of  $1 \pm 0.001$  g can also be used. Make sure you have enough small plastic bags representative of the number of fertiliser treatments. Do not forget to correctly label and separately pack the weighed packets of fertiliser for easy identification. Always count the number of packets of fertiliser weighed and compare them with the number of required fertiliser treatments. Fertiliser can be hygroscopic so it must be packed in air tight plastics. Also try to weigh the fertiliser quickly with minimal exposure to open air to prevent the hygroscopic action. Thoroughly wash the weighing apparatus (weighing boat and spatula) before and after use. This helps avoid contamination, particularly when you are weighing different fertilisers consecutively.



**Fig 1. Fertiliser packed in small plastic bags in readiness for being added to soil in pots**

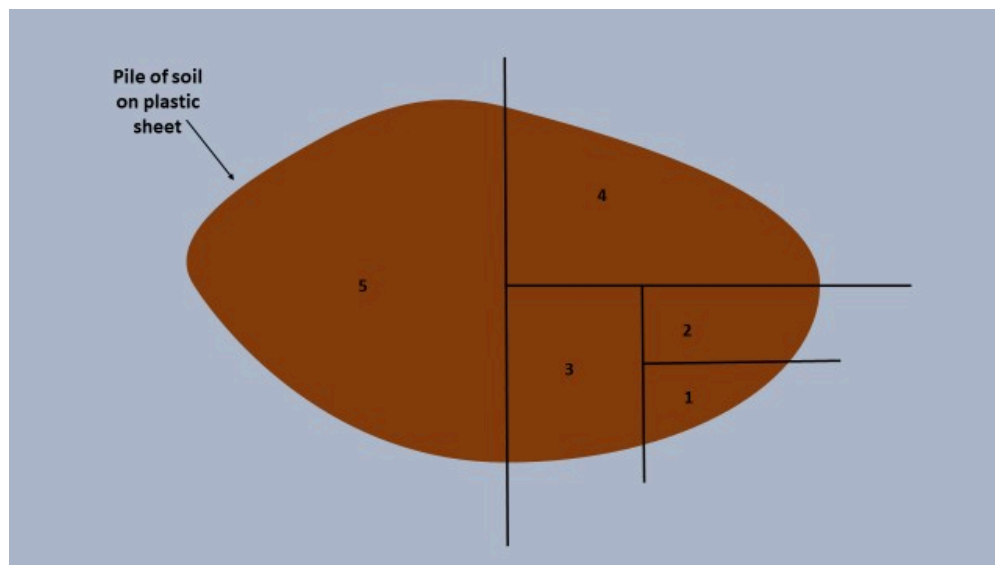
### 3 **Mixing the fertiliser into the pots**

You will need a large thick plastic sheet for mixing the soil and fertiliser. The plastic sheet must be spread on the ground. Mixing fertiliser into soil is best done on the ground on all fours. A concrete floor is best for the job. The task is also better carried out by two people, particularly if fertiliser will be mixed into soil of more than 5 kg. Note that it can be labour intensive to mix fertiliser into every single pot when pots are more than 50 in number. Thus, in order to make the task manageable, it is best to mix fertiliser into at most a 20 kg mass of soil all at the same time. Using our example this would mean that soil from four pots will be thoroughly mixed together with fertiliser. It is important to note that only soil from pots that will receive the same fertiliser treatment can be mixed together. Fertiliser that is to be added to each pot is what is combined and added to the bulked pile of soil. It helps to first weigh out the needed amount of soil in each pot. It is soil from these pots and their respective fertilisers that are bulked and mixed together. Carefully think through this step and plan how your fertiliser will be mixed.

**Note** that fertiliser is mixed into soil in a certain way. It is first all mixed into a small amount of soil and then into a larger amount of soil and so on. Fig 2 shows how a pile of soil can be divided to facilitate this kind of mixing. The pile of soil is first divided into two equal parts. One of the two parts is then divided into two and finally one of these two



parts is also divided into two parts. The pile of soil now has 5 parts, these parts are shown in Fig 2 and have been numbered to facilitate this explanation. Mixing is thus carried out as follows (using Fig 2): All the fertiliser to be added to the soil is first thoroughly mixed into the soil in part 1, once this is done the fertiliser plus soil in part 1 is then thoroughly mixed with the soil in part 2 and once this is done the mixed soil and fertiliser (parts 1 and 2) is then thoroughly mixed together with the soil in part 3 and this mixture (parts 1, 2 and 3) is then mixed together with soil in part 4 and this mixture (parts 1, 2, 3 and 4) is then thoroughly mixed with the soil in part 5. The mixing should first be carried out by one person, while the soil being mixed is a little, but the other person must soon join in to synergise the mixing action as the quantity of soil increases. Once all the parts have been combined the soil should then be all thoroughly mixed together as one mass. Once mixing is over, the bulked soil now well-mixed with fertiliser must be placed back into each pot. The soil must be weighed to ensure that each pot has an air dry mass of soil equivalent to the oven dry mass required in each pot. A mechanical hanging scale or kitchen scale can be used for weighing and not necessarily an analytical balance. Do not forget to label the pots correctly.



**Fig 2. A bulked pile of soil on a plastic sheet**

The mixing process enables the thorough and even mixing of small amounts of fertiliser to large masses of soil. This mixing procedure should still be used if you decide to add fertiliser to one pot at a time. **Note:** To avoid contamination thoroughly sweep off any soil and dust from the plastic sheet after each bulk of soil has been mixed together with fertiliser. As this may not be a very thorough way of cleaning the plastic sheet, it is advisable that you start by first mixing treatments that will receive lower rates of fertiliser before mixing in those that shall receive higher rates of fertiliser.



