Making and applying fertilisers in solution form in pot experiments

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ABSTRACT

This protocol describes how fertiliser solutions can be made and applied to already established plants in pot experiments. Before planting, fertiliser can be directly applied in solid form by evenly mixing it into the soil. This however cannot be done once the experiment has been initiated with plants already established. The fertiliser will hence have to be added to the soil with minimal disturbance and one way of doing this is by applying it in solution form. Adding fertiliser in solution form in pot experiments is particularly useful when second or third fertiliser applications have to be made for fertiliser applied in two or more split applications. Split applications of fertilisers are common for highly leachable fertilisers (e.g. urea), as this helps extend nutrient availability to growing plants. For various reasons, solid fertiliser application methods like *banding* or *broadcasting* are not suitable for pot experiments, hence the application of fertilisers to soils in established pot experiments in solution form. Fertiliser calculations are needed to determine the amount of fertiliser to add to pots. This protocol gives one example of a fertiliser calculation, but you will need to do your own reading for further understanding. See the attached document for guidance.

Fertilizer Calibration.pdf

MATERIALS TEXT

- Already established plants in soil filled pots
- Fertiliser (e.g. urea)
- Analytical balance (1 ± 0.0001 g)
- Marker pen
- Pipette (5 ml, 10 ml and 25 ml)
- Tap water or distilled water
- Measuring cylinders (5 ml, 10 ml and 25 ml)
- Volumetric flasks (500 ml, 1 L, 2 L, 5 L)

1 **Determining the amount of fertiliser to add to the soil in each pot**

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. We shall use an example to demonstrate this. Our example involves the application of nitrogen (N) at a field based rate of 120 kg/ha to our pots, which each contain a mass of soil which is equivalent to 5 kg of oven dry soil. Note that fertiliser is calculated based on its application to an oven dry mass of soil. Now the N will be applied in two split applications with a third of it having been already applied at planting. We now need to calculate the remaining amount of N to be added to soils in each pot with now already established plants. The fertiliser urea will be used to supply the N and we shall begin the calculations from the beginning i.e. by calculating the amounts of fertiliser to be added in both split applications. Our pot experiment has 100 pots in total but only 80 of these shall be receiving N, the other 20 are control treatments that must not be supplied with N. Note that another N containing fertiliser could be used to supply the needed N. A single nutrient (straight fertiliser) N containing fertiliser is however more suitable, if our interest is only N. Easily soluble analytical reagent grade N containing compounds could also be used to provide the N or any other needed nutrient.

We shall begin by calculating the total amount of N to be added to the soil in each pot using the specified fertiliser rate of 120 kg N/ha. This rate however needs to be converted to a fertiliser rate that gives us the amount of fertiliser to be added to each kilogram of soil. The rule of thumb is that at a depth of 15-20 cm, a 1 ha area of a field contains 2, 000 ton or 2,000,000 kg of soil. The field rate for N application in kg N/ha can hence be converted to kg N/kg of soil, as follows;

$$rate\ of\ N = {}^{120\ kg\ N}/_{1\ ha}$$

But 1 ha contains 2,000,000 kg of soil, thus;

$$rate\ of\ N = {}^{120\ kg\ N}/_{2,000,000\ kg}$$
$$= 0.00006\ kg\ N/kg\ of\ soil$$
$$= 0.06\ g\ N/kg\ of\ soil$$

The field based rate in kg N/ha has now been converted to a rate in g N/kg of soil (or kg N/kg) of soil and it has been determined that 0.06 g N will be added to each kilogram of soil using the fertiliser rate of 120 kg N/ha. Our pots however contain 5 kg of soil and the mass of N to be added to the pots hence has to be calculated, as follows;

$$\frac{0.06\ g\ N}{x} = \frac{1\ kg\ of\ soil}{5\ kg\ of\ soil}$$
$$=> x = \frac{0.06\ g\ N \times 5\ kg\ of\ soil}{1\ kg\ of\ soil}$$
$$=> x = \frac{0.06\ g \times 5\ \cancel{kg\ of\ soil}}{1\ \cancel{kg\ of\ soil}}$$
$$= 0.3\ g\ N$$

The results show that 0.3 g of N will be added to the 5 kg of soil in each pot. The N will however be supplied by the fertiliser urea. It is thus important for us to determine the amount of urea that shall be added to the 5 kg of soil in each pot to supply the 0.3 g of N. Now each bag of urea contains 46% N, thus if a bag is 100 kg then it contains 46 kg of N out of a 100 kg of urea, similarly 100 g of urea would contain 46 g of N. With this knowledge we can now calculate the amount of urea that will supply the needed amount of N, as follows.

$$\frac{46\ g\ N}{0.3\ g\ N} = \frac{100\ g\ urea}{x}$$
$$=> x = \frac{0.3\ g\ N\ \times 100\ g\ urea}{46\ g\ N}$$
$$=> x = \frac{0.3\ \cancel{g\ N}\ \times 100\ g\ urea}{46\ \cancel{g\ N}}$$
$$= 0.652\ g\ urea$$

We now know the total amount of urea to be applied to the 5 kg of soil in each pot to supply the required amount of N. Now remember that the urea will be applied in two split applications, with one-third being applied at planting and the other two-thirds as a second application, applied at about one month after planting. The first application had already been applied at planting and now we need to determine how much urea will be applied to each pot during the second split application of N. The calculations are as follows;

$$two - thirds\ of\ the\ urea$$

$$= \frac{2}{3} \times full\ amount\ of\ urea\ to\ be\ added$$

$$= \frac{2}{3} \times 0.652\ g\ urea$$

$$= 0.435\ g\ urea$$

The results indicate that the second split application of N will involve the addition of 0.435 g of urea to each pot. As we shall be applying the urea in solution form to the soil in pots we need to make the urea fertiliser solution. A large quantity of fertiliser solution has to be made and portions/volumes of it distributed to each pot according to the number of treatments. To make the large quantity of fertiliser solution, we must first decide on the volume in which the required amount of urea (or other fertiliser) per pot will be dissolved in before pouring it into a pot. This volume though small must be sufficient enough to completely dissolve the urea. You can carry out a test to ensure this. In our example we shall use a 10 ml volume. Thus 10 ml of urea solution will be added to each pot. ***Note*** *that for treatments requiring twice/half as much N, twice/half the volume suggested to be used to supply the N will have to be added to supply double/half the amount of N. This should be factored in the calculations that follow. Our example will not however show this as it is a simplified example.*

We now need to determine the total quantity/volume of urea solution to be prepared for the entire experiment. To do this we first need to know the total number of pots in the experiment that shall receive the N. Now remember that only 80 pots out of the 100 pots shall receive the urea. The calculations are thus as follows;

$$total\ volume\ of\ urea\ solution\ to\ be\ prepared$$

$$= volume\ to\ be\ added\ to\ each\ pot \times number\ of\ pots$$

$$= 10\ ml \times 80\ pots$$

$$= 800\ ml$$

$$\approx 1000\ ml$$

The results of the calculation indicate that a 1000 ml (1 L) urea solution should be prepared. Note that an 800 ml solution is not prepared as only defined volumes are used to make the solutions using volumetric flasks. This helps to make precise solution mixtures. Distilled water is better to use for making the fertiliser solutions, however tap water can also be used if you are watering the plants with tap water. Now that we know the volume of the urea solution, we now need to calculate the amount of urea that shall be dissolved into this volume to make the urea fertiliser solution, as follows;

$$mass\ of\ urea\ to\ be\ dissolved\ in\ 1000\ ml\ of\ distilled\ water$$

$$=> \frac{0.435\ g}{x} = \frac{10\ ml}{1000\ ml}$$

$$=> x = \frac{0.435\ g \times 1000\ ml}{10\ ml}$$

$$=> x = \frac{0.435\ g \times 1000\ \cancel{ml}}{\cancel{10\ ml}}$$

$$= 43.467\ g$$

Thus the urea fertiliser solution will be made by dissolving 43.467 g of urea into 1000 ml of distilled water.

2 Applying the fertiliser solution to pots

Volumes of the fertiliser solution will now be added to each treatment pot. A pipette will be used for greater accuracy, but a measuring cylinder could also be used. Using our example each treatment pot will hence receive 10 ml of the urea solution, which will supply plants with two-thirds of 0.3 g of nitrogen at the second application of N.

Fig 1. Cassava plants under various fertiliser treatments