FERTILIZER USER GUIDE MANUAL FOR TEA

(*Camellia sinensis* (L.) O. Kuntze)

TEA RESEARCH FOUNDATION OF KENYA (TRFK)

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FOREWORD

The Tea Research Foundation of Kenya and its predecessor has for the last 50 years carried our research on tea nutrition and land husbandry culminating in the development of a holistic integrated plant nutrient management package for the tea crop.

In the tea context, integrated nutrient management aims to optimize the condition of the soil, with regard to its physical, chemical, biological and hydrological properties for the purpose of enhancing tea productivity, whilst minimizing land degradation. This guidebook presents practical field level management practices for fertilization of the tea crop using mineral and natural fertilizers, farm yard manures and soil amending agents.

The practices presented herein are derived from accumulated research outputs carried out throughout the major tea growing regions of Kenya and are time tested for their efficacy.

The handbook is a must have for every tea grower.

F.N. Wachira, PhD.
Director/CEO

INTRODUCTION

Tea (*Camellia sinensis* (L.) O. Kuntze) is a perennial woody plant, harvested by plucking of its young tender shoots normally comprising two leaves and a bud. Under manual harvesting, tea is plucked every seven to fourteen days, and every fourteen to twenty one days under mechanical harvesting, resulting in excessive depletion of soil nutrients annually. Judicious application of fertilizer is therefore necessary in order to maintain optimum production of tea yields and thus minimize crop loss due to nutrient deficiency for high and sustainable income to the tea farmer.

1.0 Crop nutrition and Fertilizer practices

Green-leaved plants grown as agricultural crops require essential nutrient elements for sustainable growth and high yields. To remedy nutrient deficiencies, fertilizer usage and evaluation techniques should be considered so as to guard against crop loss and instead target high crop yields.

Fertilizer field experiments on tea in all major tea growing areas of Kenya have shown that the magnitude of the increase in yield tend to diminish, as the total level of fertilizer nutrient increases. This is a general finding for crops that show a beneficial response to fertilizer application, and is known scientifically as the *Law of Diminishing Returns*. The economic implication is that, the value of the additional crop yield may well at first exceed the cost of applying fertilizer, but eventually lower additional crop will be obtained for each increment in fertilizer, that no monetary gain will be achieved.

Research on chemical analyses of both soils and plant tissues have been used as an attempt to estimate tea plant fertilizer needs as regards nutrient reserves. If a nutrient is in very low supply, the chemical approach can be valuable in detecting the actual or potential danger of deficiency. Leaf analysis has served as a useful tool in detecting gross deficiencies of certain nutrients in tea in Kenya.

Table 1.1: *Elements essential for plant growth and their sources*

Element (Symbol)	Available forms	Source / comments
MACRONUTRIENTS		
Carbon (C)	-	Air and water / Fundamental constituents of organic matter,
Hydrogen (H)	-	
Oxygen (O)	-	
Nitrogen (N)	NH_4^+, $NO3^-$	Atmosphere and fertilizers.
Phosphorus (P)	$H_2PO_4^-$, HPO_4^{2-}	
Potassium (K)	K^+	Soil minerals and fertilizers.
Magnesium (Mg)	Mg^{2+}	
Calcium (Ca)	Ca^{2+}	
Sulphur (S)	SO_4^-	
Sulphur (S)	SO_2	Atmosphere.
MICRONUTRIENTS		
Boron (B)	$B(OH)_4^-$	Soil minerals and fertilizers. Can cause crop failures if absent. They can also become toxic if present in large amounts.
Chlorine (Cl)	Cl^-	
Copper (Cu)	Cu^{2+}	
Iron(Fe)	Fe^{2+}	
Manganese (Mn)	Mn^{2+}	
Molybdenum (Mo)	MoO_4^{2-}	
Zinc (Zn)	Zn^{2+}	
OTHERS		
Aluminium (Al)	Al^{3+}	Although not rated as an essential nutrient, it is important for the healthy growth of tea. Can be harmful if present in large amounts.

A fertilizer program to guide the tea grower on types, rates, application interval, etc. of fertilizer use has been developed over the years by conducting field experimental research in different tea growing sites of Kenya. The findings have proved to be of considerable value as a starting point to guide the grower, hence the publication of the current manual.

Generally, a scientifically designed fertilizer experiment should not only fix fertilizer rates and examine the crop response that results, but should also try to study the effects of various nutrients and their interaction on crop responses.

2.0 Fertilizers

Definition

The term “fertilizer” is generally defined as a nutrient-carrying material of mineral-like appearance. A fertilizer may be a chemical compound synthesized in a factory, or a mineral mined and used either raw, or after mechanical treatment, or an organic material which has undergone intensive alteration in a manufacturing process plant.

Description of fertilizers

It is conventional to define the nutrient in terms of percentage (of the dry matter) of a hypothetical compound of that nutrient element.

Nitrogenous fertilizers are invariably quoted on the basis of the % N content. Nitrogen is always present as the ammonium (NH_4^+) or the nitrate (NO_3^-) form.

Phosphorus in fertilizer is expressed either as P_2O_5 or P, its elemental symbol. The symbols are used to define the percentage nutrient contents in the phosphate fertilizers.

Potassium is expressed as its oxide form, K_2O or ‘potash’, and K, its elemental symbol.

Sulphur contents are usually expressed as %S, its elemental symbol.

NPK compound fertilizers

Compound fertilizers are nutrient carrying chemical compounds specifically manufactured under controlled international chemical processing techniques for specific agricultural applications.

The Kenyan tea industry requires that the compound fertilizer, include NPK 25:5:5, NPK 26:5:5, NPKS 25:5:5:5 or any other formulation of NPK(S). The other nutrient contents should be present at low levels as per the specification and recommendation e.g. calcium level of below 3%.

Straight fertilizers

These are chemical compounds that are made and sold as individual fertilizers. Each may contain more than one nutrient. They can be formulated as powders, crystals, pellets, granules or prills. Examples include:-

- Sulphate of ammonia or Ammonium sulphate (SOA).
- Ammonium sulphate nitrate (ASN).
- Urea.
- Di-ammonium phosphate (DAP).
- Single super phosphate (SSP).
- Triple super phosphate (TSP).
- Phosphate rock (RP).
- Muriate of potash or Potassium chloride (MOP).
- Sulphate of potash or Potassium sulphate (SOP).
- Epsom’s salts, Kieserite and magnesium oxide.
- Gypsum (Calcium sulphate).

Table 2.2: *Composition of common fertilizers and soil amendment compounds used in tea.*

Fertilizers	Nutrient content (%)							
	N	P_2O_5	P	K_2O	K	S	Ca	Mg
SOA	21					24		
ASN	26					12		
Urea	46							
DAP	18	46	20					
SSP		20	9			10-12	20	
TSP		40-60	18-20			0-2	14	
RP		25-30	11-13				20-30	
MOP				50-60	42-50			
SOP				48-52	40-44	15-17		
Epsom salt						13		10
Kieserite						23		17
Gypsum						19	23	
Sulphur						99		
Brimstone 90®						90		
$Al_2 (SO_4)_3$						14		
NPK 25:5:5	25	5	2.2	5	4.2			
NPKS 25:5:5:5	25	5	2.2	5	4.2	5		
NPK 26:5:5	26	5	2.2	5	4.2			
NPKS 22:6:12:5	22	6	2.6	12	10	5		
NPK 20:10:10	20	10	4.3	10	8.3			

Soil amendment materials

These are chemical compounds used to correct the soil pH when it has gone too alkaline or too acidic; to suit the specific recommended agricultural practice for particular crops in respective tea growing zones. Application requires expertise knowledge and recommendation in handling of the particular material(s).

Sulphur

Sulphur is used in tea growing as a soil amendment, to increase the acidity of too alkaline soils. Sulphur in high concentration can damage roots in its elemental decomposed form.

Aluminum sulphate
The compound is primarily used for acidifying soil. Its sulphur is water- soluble. Aluminium sulphate even in its high concentration does not damage tea roots.

Brimstone90®
This is a recent amendment material for lowering high soil pH and has successfully been experimented by TRFK in field trials. The product has better handling properties in the form of regular and consistent pellets and its slow release characteristics make it suitable as a nutrient through normal blending.

Liming materials
Several methods are documented for managing of acid soils. They include use of;
(i) Agricultural lime (Calcium hydroxides and calcium oxides).
(ii) Dolomitic lime (Calcium and magnesium hydroxides).
(iii) Phosphorus sources (e.g. Mijingu rock phosphate).
(iv) Organic manures.

In mature tea, direct application of lime as in (i) and (ii) to manage acidity is not recommended because it often results to the lowering of tea yields due to the antagonism (or depression of uptake) of potassium by the high calcium or magnesium in the lime. However, this process can be done prior to planting of tea or replanting in case of very acidic sites. A recommendation on use of 2-6 tonnes of dolomitic lime per hectare per year can be done prior to replanting depending on the initial soil pH.

Generally, the list in Table 2.2 contains fertilizers and soil amendments, which are familiar to the tea industry. New compounds and modifications of existing fertilizers are being developed and may come into the market from time to time. Soil in its original state is a good resource, and once mishandled could be seriously adulterated.

The grower is therefore advised that in case of unfamiliarity with a fertilizer or a soil amendment compound, one should seek guidance from the TRFK. The grower is also notified that calcium ammonium nitrate (CAN) is not recommended for tea in Kenya.

Blended fertilizers
Mixing straight fertilizers or compound fertilizers in order to produce the required formulations makes blended fertilizers. Thus the formulation NPK 25:5:5 can be made by mixing ammonium nitrate and NPK 15:15:15 in the ratios 2:1 or two thirds of Ammonium Nitrate and one third of NPK 15:15:15. Similarly the same formulation can be made using three straight fertilizers containing the three nutrients. However, the more the individual straight fertilizers included in the blend, the more likely the incompatibility of the blend in terms of the keeping qualities as well as segregations during handling.

Hence, blended fertilizers are only appropriate if they are applied soon after blending. Good blends are obtained where the particle sizes, shapes, and densities are similar.

Fertilizer storage
Fertilizers normally packed in plastic bags should be stored in a dry place, preferably in an enclosed store. Most tea fertilizers are not listed as dangerous, although some like ammonium sulphate are liable to emit small quantities of ammonia gas in an unventilated store. However, they are safe indoors.

3.0 Foliar application of nutrients

Tea has been found to absorb a number of nutrients efficiently, when solutions, suspensions or dust of nutrient-containing chemicals are applied to their surface. Where a rapid cure of nutrient deficiency is required, especially for nutrients that are needed in low concentration in tissues, foliar nutrition can be a useful technique. Where a nutrient deficiency arises because soil conditions do not permit efficient uptake by the roots, i.e. during dry and cold seasons, only then do foliar applications become the best means of restoring balanced nutrition. Zinc deficiency in tea in Kenya has for example been remedied by foliar application, while a similar finding has been made for copper in Malawi.

Routine application of zinc
For tea in plucking, Zinc oxide can be used in a light foliar spray at a rate of 3 kg per hectare in 200 litres of water. The application can be repeated in six-month intervals. Alternatively, Zinc sulphate at a rate of 10 kg per hectare in 200 litres of water can be used. In younger tea plants that have shown symptoms of zinc deficiency and have not attained plucking age, the same rates can be adopted but because of the small total leaf surface, an attempt should be made to cover each leaf with droplets.

4.0 Organic manures, composts and mulches

Definitions
Organic materials as applied to fertilizers refer to materials, which retain obvious signs of their plant or animal origin. Organic materials, which have undergone manufacture, may not fit organic definition.

Manure
Manure is a term applied to animal, rather than plant residues, or mixture of the two, as regards fertilizer material.
Compost
This refers mainly to plant residues that have undergone decomposition process.

Mulch
Mulches are organic as well as inorganic materials put on the soil surface around the plants.

SPECIFIC FERTILIZER RECOMMENDATIONS FOR VARIOUS TYPES AND AGES OF TEA

5.0 Fertilizers for mother bushes

These are bushes used as regular sources of supply of cuttings (leaf propagules). They are usually pruned at five to seven months intervals, and prunings removed to the nursery to be used for cuttings. Removal of nutrients from plots of mother bushes is at a much higher rate than from similar areas of plucked tea. It is recommended that mother bushes should be given twice as much fertilizer of the same kind in split application to keep them in a state of vigorous shoot production, e.g. two doses of 150 kgN/ha as NPK 25:5:5 applied after each prune when moist.

6.0 Fertilizer for nurseries

Seedling nurseries
Tea raised from seed (seedlings) does not respond to fertilizers which have been mixed with the nursery soil in experiments, and therefore fertilizer placement in seedling nurseries is not recommended. The nursery soils should not have a pH value greater than 5.8. The seedling should have fertilizer applied every four months starting as soon as the seedlings are 15cm tall. Every second application should be with sulphate of ammonia at the rate of 16g/cm^2.

With the introduction of the much versatile cutting nurseries, the seedling type of nursery is not common and is mainly useful for research purposes.

Cutting nurseries

Cuttings should be planted into a layer of subsoil, 7.5cm thick, which contain single super phosphate mixed with soil at the rate of 600 g/m^3 or 300 g/m^3 of triple super phosphate.

The following fertilizers are suggested for mixing with the lower part for the rooting medium:

Forest soils	SSP	600 g/m^3
	Sulphate of potash (SOP)	300 g/m^3
Grassland soils	SSP	600 g/m^3
	Sulphate of potash (SOP)	300 g/m^3
	Sulphate of ammonia (SOA)	300 g/m^3
Exhausted soils	DAP	600 g/m^3
	Sulphate of potash (SOP)	300 g/m^3

Fertilizer placement in planting holes

Single super phosphate is preferable to double super phosphate because it contains sulphur, and should be mixed with the soil at rates which vary according to the size of the holes, as follows:

Table 3.6: *Fertilizer in planting holes*

Size of planting hole (Depth x Width)	Amount of single / triple (super phosphate) per hole
45cm x 22.5cm	30g
50cm x 25cm	40g
60cm x 30cm	54g

7.0 Fertilizer for young tea

These are tea plants from transplanting to the age of first prune cycle, inclusive of three to four years' plucking. Compound fertilizer providing N,P,K in the proportions 5:1:1 or formulations with more P and K, as for mature tea is recommended for young tea. NPK+S fertilizer formulation can also be used.

As a rule, fertilizer should only be applied when there is adequate moisture in the soil, otherwise there is danger of damaging the plant roots.

First year tea
Fertilizer application should be done six months after transplanting and subsequently once at about eight-week intervals and at the rate of 2g N/plant (or 8g of NPK 25:5:5 fertilizer per plant). Application during drought should be avoided.

Sleeved plants
Apply as little as 12g of NPK 25:5:5 fertilizer at the rate of 1.5g N per plant, six weeks after planting and subsequently once at eight-week intervals during remainder of the year to give a total of 9g N per plant.

Second year tea
Apply a total of 120kg N/ha/year (or 480kg/ha/year NPK 25:5:5 fertilizer) split into three applications of 40 kg N/ha (or 160 kg/ha

NPK 25:5:5 fertilizer) or four applications of 30 kg N/ha (or 120 kg/ha NPK 25:5:5 fertilizer) in areas with wet seasons.

Tea in its third, fourth and fifth years
In areas with a single rainy season, the fertilizer can be applied once, preferably at start of the rains. In areas with two distinct rainy seasons, it is recommended that two half-applications, one at the start of each rainy season be made. The fertilizer should provide a total of 150 kg N/ha (600 kg/ha NPK 25:5:5 fertilizer) in the third year and a total of about 180 kg N/ha (720 kg/ha NPK 25:5:5) at the fourth year after planting.

Table 4.7: *Amounts of nitrogen to apply in young tea*

Year from	**Seedling plants**		**Clonal plants**	
planting	**1 wet season**	**2 wet seasons**	**1 wet season**	**2 wet seasons**
1^{st} (stumped)	4 x 2 g/plant	4 x 2 g/plant	4 x 2 g/plant	4 x 2 g/plant
(sleeved)	6 x 1.5 g/plant	6x1.5 g/plant	6 x 1.5 g/plant	6 x 1.5 g/plant
2^{nd} (all plants)	3 x 40 kg/ha	4 x 30 kg/ha	3 x 40 kg/ha	4 x 30 kg/ha
3^{rd}(all plants)	1 x 150 kg/ha	2 x 75 kg/ha	1 x 150 kg/ha	2 x 75 kg/ha
4^{th}(all plants)	1 x 150 kg/ha	2 x 75 kg/ha	1 x 180 kg/ha	2 x 90 kg/ha
5^{th}(all plants)	1 x 150 kg/ha	2 x 75 kg/ha	1 x 180 kg/ha	2 x 90 kg/ha

8.0 Fertilizer for mature tea

Type of fertilizer
Over the years the development of a standard fertilizer nutrient composition led to the adoption of a single-formula compound fertilizer, 25:5:5:5 referring to the percentage of N, P_2O_5, K_2O and S, respectively. This formulation was used, especially by the smallholder sector beginning in the 1970's to 2000. However, research and development (R&D) activities showed that soils in most

tea growing areas contained adequate levels of S, leading to a change in fertilizer policy to the use of NPK 25:5:5 or NPK 26:5:5.

Rate of use of fertilizer

The Foundation (TRFK) continues to research on the optimum fertilizer rate by field trials on the yield/fertilizer relation under different ecological zones. For high yielding tea, growers are advised to test application of fertilizer rates at levels of 100, 150, and 200 kg N/ha/year.

Time of application of fertilizer

Tea under severe nutritional stress should receive a curative fertilizer application as soon as practicable. Normal fertilizer application should avoid prolonged cold or wet season, and if they are made during dry weather they should be delayed until it is evident rain is certain to come.

The first consideration should always be given to planning a fertilizer programme that allows efficient and even distribution of the fertilizer.

Split fertilizer application

No evidence exists to support a recommendation to split an annual fertilizer application for mature tea. Splitting the annual fertilizer programme may be adopted in order to lessen the risk of increasing already excessive crop in certain seasons and to enhance efficiency of spread when applying fertilizer.

Role of other nutrients other than NPKS

Apart from zinc and copper, no other nutrients have shown great necessity as additives to the general fertilizer programme at present to warrant application.

Soil acidity in relation to fertilizer use

The conventional way of denoting acidity by the pH scale is that the greater the acidity the lower the pH number, i.e. acidity increases from a value of 6.9 to a value of 1.0 or less, and the pH is said to decrease in the same order. Tea is known to thrive in soils with pH values as low as 3.2.

The Foundation's fertilizer recommendations are not adjusted to take account of soils acidity. Special cases where soil is not sufficiently acid for tea to grow properly are dealt with separately.

9.0 Fertilizers for seed bearers

Currently, seed bearers are mainly useful for research purposes although they may become useful to farmers as a seed source as long as there is a market for the tea seeds. On top of the normal compound fertilizer used in other tea plants, seed bearers require low amounts of boron for fruit production. The area of application should form a circle round the seed bearer.

10.0 Treatment of hut sites and soils of pH higher than optimum

Tea establishment

Tea thrives best in soils of pH between 4.5 and 5.6. Tea is difficult to manage in soils of higher pH. Many clones have been found to grow poorly in soils of high pH. Soil pH can be reduced in a number of ways, if it is necessary to do so, as follows:-

- Leaching
- Cropping
- Sulphur treatment
- Sulphate of ammonia
- Aluminium sulphate
- Brimstone90®

Treatment of tea established on hut sites

Where tea is growing but not thriving on hut sites, the best treatment is to apply Brimstone90® or aluminium sulphate at the rate of 100g per square metre or 450g per square metre, respectively placed on the ground every three months for up to two years. There should be adequate moisture in the soil during application for the treatments to be effective.

Nurseries on high pH soils

The nursery should always be established in an area with suitable soil pH (pH 4.0 - 5.8) since it is uneconomical to use soil acidifying amendment compound to try to lower the soil pH.

11.0 Symptoms of nutrient deficiency and excess

Nitrogen deficiency

Deficiency of nitrogen in a tea bush first shows as a lighter than normal green colour in the young flush leaves, and which progressively becomes quite yellow (see Plates 1 and 2). The auxiliary buds do not develop, resulting in fewer and fewer new shoots and ultimately the yield declines. Gross nitrogen deficiency is clearer in unshaded tea than on shaded tea. Some clones are more yellow in colour than others and it should not be confused for lack of nitrogen. The young flush leaves in a deficient field are normally harder compared to the normal succulent leaves in a well-nourished tea plant.

Phosphorus deficiency

Symptoms show on the mature leaves as an absence of gloss on the surface. The affected leaves appear dull and matt in comparison with normal leaves that look shiny and polished (see Plate 3). This glossiness however washes off in heavy rain. The bush frame shows excessive die-back of the young and old woody stems and can easily be confused with “sun-scorch”. In gross phosphate deficiency, the smaller branches die back from the ends that have been cut when pruning.

Potassium deficiency

In mature tea, symptoms include severe defoliation of the maintenance layer and large quantities of fallen leaves are seen under the bushes (see Plates 4, 5 and 6). The branches especially in younger plants are thin and weak and if shaken makes the leaves fall off while still green and fresh.

Sulphur deficiency

It is known as "tea yellows" in many tea growing regions. At first the leaves become yellow between the veins, which remain green. The leaves of new growth become smaller and internodal distance becomes shorter. Leaves turn more yellow, scorch and then fall off while the new shoots are stunted and ultimately the stems die back from the tip.

Magnesium deficiency

First symptoms appear on the lower leaves which are bright yellow with a conspicuous inverted dark green "V" down the midrib, and sometimes extending along individual veins (see Plate 7). In Kenya this symptom normally appears during extended periods of drought but will disappear after the onset of rains.

Zinc deficiency

Under deficiency conditions, the youngest tissues in tea fail to develop normally. This is shown by three main patterns of malformation, which are commonly seen at the tip of a dormant shoot. If the shoot recovers without any application of zinc, the foliage of normal size, shape and positioning develops above the permanently damaged leaves. However, if zinc is applied and stimulates the deficient shoots into growth, such severely distorted leaves show little improvement if any (see Plate 8).

Copper deficiency

Tea plants deficient in copper have slightly darker foliage than normal, but in most cases it is difficult to detect the symptoms in the field. However sever deficiency may inhibit “fermentation” or “auto oxidation” and such leaf develops a bright orange colour during fermentation and changes colour very slowly through dark green to dark brown. Such cases of copper deficiency are rare in Kenya.

Manganese excess

Tea with excess manganese often due to very acid soils, appear normal. However, mature leaves are brittle and when crushed in the hands crack easily with a rustling noise and the leaf surface may develop a cracked appearance.

Calcium excess

The tea plant is known to be *“calcifuge”* i.e. a plant species that grows poorly on soils with high levels of calcium and prefers acid soils, hence the calcium excess symptoms. Calcium is also known to have antagonistic effects on the uptake of potassium, magnesium, phosphorus, manganese, zinc, and boron. Often, the young shoots and leaves are affected with the leaves remaining small with a bright yellow colour and curl backwards. The stems show stunted growth and young stems may begin to defoliate.

12.0 Common identifiable photographs of nutrient deficiencies

Plates 1 and 2: *Nitrogen deficiency*

Plate 3: *Phosphorus deficiency*

Plates 4, 5 and 6: *Potassium deficiency*

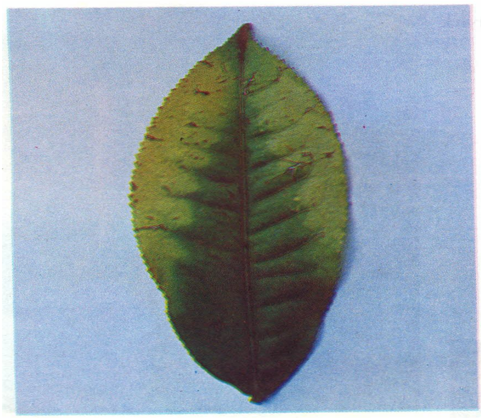

Plate 7: *Magnesium deficiency*


Plates 8: *Zinc deficiency*


Plate 9: *Combined potassium and nitrogen deficiency*

13.0 Recording and calculating fertilizer use

Estate records

Grower's records should contain enough detail on nutrient application in the past, to enable the Foundation (TRFK) staff advice accordingly.

Make sure that it is clear whether weight recorded refers to the fertilizer as a whole or to one of the nutrients. For example:-

600 kg/ha of compound NPKS 25:5:5:5 or
150 kg/ha of N, as NPKS 25:5:5:5

Remember to record exact date of application and whether the quantity is applied per ha or to the whole plot.

Examples of common calculations

Example 1: How much triple super phosphate, with a quoted P_2O_5 content of 46%, is required to supply 23 kg of P_2O_5?
Solution:

$$\frac{100 \times \text{weight of nutrient required}}{\%\text{ of nutrient}} = \text{Weight of fertilizer}$$

thus, 100 x 23 / 46 = <u>50 kg of triple super phosphate</u>.

The general form of the calculation can be used for similar conversions for other fertilizers.

Example 2: How much sulphate of ammonia, quoted at 20% N, would be required to give the same weight of N as 400 kg of a 26:5:5 fertilizer?

Solution:

400 x 26 / 20 = <u>520 kg of sulphate of ammonia</u>

Example 3: To make a mixture with an N: P_2O_5: K_2O ratio of 25:5:5:5, from straight fertilizers, and to apply at 150 kg /ha of N, using sulphate of ammonia (20% N), single super phosphate (20% P_2O_5) and muriate of potash (50%).

Solution:

Calculate the quantity of sulphate of ammonia as in example 1:-

$$= \frac{100}{21} \times 120 \text{ kg/ha of fertilizer}$$

= 570 kg/ha of sulphate of ammonia

Example 4: Concentration of solutions:

For all practical purposes, a 2% solution of fertilizer, for example, means:-

2 kg of fertilizer in 100 litres of water, or
2 kg of fertilizer in 22 gallons of water, or
2 Ib of fertilizer in 10 gallons of water.

14.0 Appendices

14.1 Leaf and soil sampling sheet / Farm Evaluation Questionnaire.

Form to be completed for each sampled field/farm or area

Name & address of Estate or Farm ....………………..…
Field number …........ Planting date …........ Sampling date ....…..................
Seedling/Clonal. If Clonal which is most common? ....…..............
Month/Year of last pruning............... Next prune date...........……………
Last fertilizer application date (Month/Year) ……………………………...
Date of application …....…....... .....……...... ....……......................
Type of fertilizer(s) .....….....….. ...……….…..... .....…….......…..................
Quantity in kg/ha ....……..... ..………......... ....……...……....................
Fertilizer Nitrogen rate (KgN/ha): 2005,....… 2004,....... 2003,..................
Past three years yield (kg MT/ha): ....……………
Type of weeding: Herbicide, Jembe, uprooting, other (specify)..................
Are prunings left in the field?...
Mulch or organic manures applied, Type/Quantity.....................................
Weather conditions in 3 months before sampling (tick the applicable):
Rainfall; about normal, above normal, below normal
Temperatures; about normal, above normal, below normal
Hail damage in last 6 months? Yes/No. If yes how severe?..............………………………………………………………
Area represented by leaf or soil sample(s) in Ha or No. of bushes.....……………………………………………………………...
If no sampling, indicate N/A....…...
Slope of land: level/moderate/steep……………………………………
Other relevant information, e.g. history, pests, diseases, etc...………………………...
Analysis required: soil pH / complete soil nutrients / leaf nutrients / any additional nutrient, e.g. trace elements / soil physical analysis, etc.
…………………………………………………………..………………

Date:....…..........…. Name & Sign: ....…………….

Table 5.14: *Tea plant spacing and population density*

Spacing		No of plants per hectare	
Feet	Metres	Rectangular & Contour	Triangular
2 x 2	0.61 x 0.61	26,896	27,792
$3_{1/2}$ x $2_{1/2}$	1.07 x 0.76	12,299	-
3 x 3	0.91 x 0.91	11,970	13,810
$3_{1/2}$ x $3_{1/2}$	1.07 x 1.07	8,784	10,146
4 x 2	1.22 x 0.61	13,448	13,896
4 x $2_{1/2}$	1.22 x 0.76	10,766	11,331
4 x 3	1.22 x 0.91	8,975	9,676
4 x 4	1.22 x 1.22	6,730	7,768
$5_{1/2}$ x $2_{1/2}$	1.52 x 0.76	8,611	-
5 x 3	1.52 x 0.91	7,179	-
5 x 4	1.52 x 1.22	5,383	-
5 x 5	1.52 x 1.52	4,306	4,972
6 x 6	1.83 x 1.83	2,989	3,453

Double hedgerow

4 x 2 x 2	1.22 x 0.61 x 0.61	18,150	-
4 x 2 x $2_{1/2}$	1.22 x 0.61 x 0.76	16,754	-
4 x $2_{1/2}$ x $2_{1/2}$	1.22 x 0.76 x 0.76	14,892	-

Table 6.14: *Fertilizer measurements for different N-rates and tea plant spacing's.*

(a) 5x2.5 ft

Fertilizer type /	***Spacing: 5x2.5 ft or 8611 plants/ha***			
Rates (kgN/ha)	***75***	***100***	***150***	***200***
NPK 26:5:5	30	22	15	11
NPKS 25:5:5:5	29	22	14	11
NPKS 22:6:12:5	25	19	13	9
SOA (21%N)	24	18	12	9
NPK 20:10:10	23	17	11	9
Urea (46%N)	53	40	26	20

(b) 4x2.5 ft

Fertilizer type /	***Spacing: 4x2.5 ft or 10766 plants/ha***			
Rates (kgN/ha)	***75***	***100***	***150***	***200***
NPK 26:5:5	37	28	19	14
NPKS 25:5:5:5	36	27	18	13
NPKS 22:6:12:5	32	24	16	12
SOA (21%N)	30	23	15	11
NPK 20:10:10	29	22	14	11
Urea (46%N)	66	50	33	25

(c) 4x2 ft

Fertilizer type /	***Spacing: 4x2 ft or 13448 plants/ha***			
Rates (kgN/ha)	***75***	***100***	***150***	***200***
NPK 26:5:5	47	35	23	17
NPKS 25:5:5:5	45	34	22	17
NPKS 22:6:12:5	39	30	20	15
SOA (21%N)	38	28	19	14
NPK 20:10:10	36	27	18	13
Urea (46%N)	82	62	41	31

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