The First National Potash Symposium

28-29th July 2015

Protea Hotel Court yard,
Dar es Salaam

The role of Potash for sustainable crop production:

The case of flue-cured tobacco

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Introduction

- Tobacco research in Tanzania started in 1954 with the main objective to improve tobacco yield.

- New technologies developed mostly at Kutsaga Research Station in Zimbabwe where tobacco research was more advanced were tested.

- Tobacco research on fertilizers in Tanzania has mainly concentrated on the rates of Nitrogen. The other macronutrients varied with Nitrogen depending on the NPK formulation being used.

Because:

- Nitrogen was considered to be the most critical nutrient for tobacco production.
- Phosphorus and Potassium were considered to be needed only as replenishment to the amounts taken up by plants.
- It was thought that soils had enough potassium for many crops, including tobacco.

- However, analysis of soils from the major tobacco growing areas of Tanzania show that potassium levels are low to medium (Table 1).

- The soils are primarily sandy and sandy loams, which are relatively low in inherent fertility

- Thus farmers need to apply large quantities of fertilizer to get high yields.

Table 1. Number of soil samples in relation to Potassium levels of some sites growing Flue cured Tobacco

Area	Very low	Low	Medium	High	Very high
Kahama	0	3	92	15	0
Tabora South	1	11	40	3	1
Tabora	0	38	84	15	0
Urambo	3	22	88	6	0
Chunya	0	3	27	1	0
Mpanda	0	12	21	0	1
Total	4	89	352	40	2
Contribution (%)	0.82	18.28	72.28	8.21	0.41

Importance of Potassium

Potassium:

- is one of the plant nutrients required by plants, including tobacco, in big quantities (macro nutrients) and is removed from the soil in larger quantities as well.

- is essential for the vigorous growth of the plant and cannot be entirely replaced by any other element. It is also more important than any other element in producing good combustion of the dried leaf and is necessary for choice aroma.

- plays an important role in the photosynthesis and food production processes within the plant.

- is necessary for photosynthesis, and green plants could not exist in the absence of the simple carbon-containing foods (products of photo- synthesis), which all the organs of the plant require.
- increases resistance to lodging and increases disease resistant mechanisms of the plant.
- is more closely connected with the quality of the crop.
- application in adequate amounts is necessary for profitable tobacco production.

- has an influence on leaf content of reducing sugars and nicotine, which are known to influence its value for cigarette purposes.
- deficiency causes yield loss and reduction of leaf quality.
- has a catalytic function in the synthesis of proteins. Cell division, or mitosis, does not occur in the absence of Potassium
- serves as a carrier in the absorption of nitrates and other anions through the root hairs and in their translocation throughout the plant.

- The major physiological functions disrupted by lack of K are the osmotic regulation of the plant and the ionic balance of cells (pH) and therefore the opening of stomata, activation of many enzymes, and decrease in layer thickness as well as disease and stress resistance.

- Furthermore both K and P play a key role in controlling important quality parameters such as leaf colour, texture, hygroscopic properties and combustibility, sugar and alkaloid contents

Potassium content in Tobacco growing soils

- Tobacco requires a large amount of potassium to reach a healthy and mature plant.
- When Potassium levels are not adequate the plant will develop cankers of dead tissue forming on the plant body, and the tips of the leaves will turn a brownish colour.
- When a surplus of Potassium is present, the tobacco plant will use this in order to protect itself against desiccation.

- Soils vary in their supply of available Potassium, depending upon the parent material, previous fertilization, and cropping history.
- In agricultural practice, Potassium deficiency is common worldwide and leads to crop growth inhibition and output reduction.
- Potassium is leachable, especially in deep, sandy soils
- Sub soils in tobacco fields may contain substantial amounts of Potassium and other leachable nutrients that are seldom measured by soil tests because only top soils are usually sampled.

- It was once assumed that K occurs in sufficient quantities for many crops grown in the soils of Tanzania.
- This assumption is not supported by recent soil sample analyses.
- The levels of extractable Potassium in most soils in the flue-cured tobacco growing areas of Tanzania are low to medium (Tables 1 and 3).
- When considering what an appropriate K rate is for a specific field consider the residual soil K content, soil texture, and depth to clay layer

- Approximately 112 to 196 $kgha^{-1}$ of Potash (K_2O) are adequate for most soil conditions.
- Therefore the recommended rate for optimum tobacco production of 90-110 kg K_2Oha^{-1} per growing cycle is within range.
- At Tumbi, tobacco is grown in two main soil types, known as Isenga and Kikungu.
- Kikungu, the local name for Ferralic cambisol, is the major soil type in Tabora.
- Kikungu soils are well drained and medium-textured.

- Isenga soils are mainly arenosols, whose texture is sandy loam or coarser within 100 cm of the surface.
- The average nutrient contents of the top soils (0-30cm) for the two soil types are shown in Table 3.
- The nutrient differences in the two soils were not spectacular, but there was a considerable difference in the tobacco leaf yields from control plots (unfertilized plots).
- The levels of K and N were very low where yields were lower (Isenga soil) and low where yields were a bit higher (Kikungu soil).

Table 3. Average nutrient contents of the top 30 cm of Isenga and Kikungu soil types

Soil type	Texture	Total N (%)	Bray-1 P (ppm)	K (meq/100g) Soil	Ca (meq/100g) Soil	Mg (meq/100g) Soil	Leaf yield ($kgha^{-1}$)
Isenga	Sandy Loam	0.10 VL	4.5 L	0.09 VL	1.83 L	0.33 L	297
Kikungu	Sand Clay Loam	0.11 L	3.5 L	0.17 L	1.96 L	0.34 L	408

L = Low, VL = Very Low

- The difference in total N was almost negligible (0.10% vs 0.11%).
- It would be interesting to investigate whether exchangeable K had any contribution to the observed higher yield on Kikungu soil.

Potassium fertilizer trials on Tobacco

Tobacco fertilization is affected by:

- the richness and balance of soil nutrients (soil tests are essential)
- type of tobacco grown and the variety chosen
- planting density
- and other factors interfering with plant growth, including rainfall ;
  amount
  intensity
  and distribution.

- To determine the effects of potassium in a fertilizer trial, one would have to keep constant other factors, particularly the levels of the other major nutrients, and vary only the potassium levels.
- There is no record available of such trial in Tanzania.
- Fertilizer trials on tobacco in Tanzania have always considered compound NPK fertilizers or mixtures of NPK straight fertilizers.
- The treatments variations depended mostly on variations of N, considered to be the most limiting nutrient in tobacco production.

- In such trials it is not simple to separate the individual effects of the different nutrients contained in the compound or mixture.
- Results from a trial to test different NPK formulations showed no evidence that reducing K content in the formulations from 24% to 20% K_2O affected yield in any way.
- The formulations were: 10:18:24; 12:20:20; and 10:24:20

Flue-cured tobacco Leaf quality

Levels of Leaf nicotine and reducing sugars

- In cigarette manufacturing quality of tobacco leaves is judged according to their nicotine content and the content of reducing sugars.
- The preferred nicotine content is 2%.
- Nicotine concentration is closely correlated with the amount of nitrogen (N) supplied, since N is 17.3% of the molecular weight of nicotine.

The role of K on leaf nicotine content is related to its function as a carrier in the absorption of nitrates.

- The amount of nicotine in different tobacco plant parts can be reduced by the application of Potassium fertilizer at different times of growth.
- Higher content of reducing sugars in flue cured tobacco is undesirable as it imparts to the smoke an acidic character.
- Lower content imparts alkalinity to smoke due to high nitrogenous constituents.
- The optimal value is 22.09 %

Grade indices

Leaf grade indices serve as a measure of leaf quality. In an on-farm trial at Mtanila in Chunya to compare two formulations [N:P:K 10:18:24 and N:P:K 12:20:20], there was an increase in the average grade index from 1.25 $USDkg^{-1}$ to 1.85 $USDkg^{-1}$ for the formulation with reduced Potassium but increased Nitrogen and Phosphorus contents [N:P:K 12:20:20]. This shows that appropriate nutrient ratios for optimum leaf quality need to be determined.

Conclusion

- Tanzania's environment in terms of soils and climate differs from many other countries where potash research on Flue-cured tobacco has been undertaken.
- The behavior of different nutrients and the response of tobacco plants to the nutrients may differ as well.
- **It is evident that we need to undertake detailed studies on the role of potassium and other nutrients in tobacco production with respect to the Tanzanian environment**.
- One particular aspect would be how to reduce the large amounts of chemical fertilizers used while maintaining high yield and quality levels.