SOIL CONSERVATION MANUAL

TEA RESEARCH FOUNDATION OF KENYA (TRFK)

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FOREWORD

The Tea Research Foundation of Kenya in its day to day operations and in pursuit of its mandate, is guided a set of core values; environmental consciousness being one of them. The Foundation is therefore committed to ensuring that tea production is done in a sustainable manner.

One of the major aspects contributing to sustainable tea production is soil conservation. Reductions in crop yields on degraded soils have been attributed to the resulting poor physical and chemical properties and decreased nutrient content in both the soil and the plant.

The soil conservation measures as presented in this manual are derived previous tea research studies on soil conservation among other empirical studies referred and are in use at the Foundation and the entire tea industry in Kenya. Proper implementation of these measures coupled with other Good Agricultural Practices will foster sustainable tea production.

The tea industry stands to benefit in reference to the manual on soil conservation measures. The manual will be updated from time to time to incorporate emerging issues.

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Managing Director, TRFK

PREAMBLE

The principal objectives of Tea Research Foundation of Kenya is to promote research and investigate problems related to tea and such other crops and systems of husbandry as are associated with tea throughout Kenya including the productivity (yield), quality and sustainability of land in relation to tea planting.

Sustainable farming practices carry on soil conservation as a routine in securing sustainable farming land for posterity. Loss of top soil has been demonstrated to have a depressive effect on crop growth, tea included although much of this reduction is currently masked by improved technology and soil management. It has also have been identified as one of the main causes of land degradation and one of the main environmental management concerns.

The soil conservation manual outlines factors contributing to soil loss in the first part and highlights appropriate soil conservation measures on the other part. We believe that this will form an important reference on soil conservation measures in Kenya's tea industry.

The contribution of staff of Crop Environment Department of the Tea Research Foundation of Kenya in the compilation of this manual is acknowledged.

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1.0 Introduction

Soil conservation is a set of management strategies for prevention of soil being eroded from the earth surface. Soil erosion is therefore the physical removal of topsoil by various agents, including falling raindrops, water flowing over and through the soil profile, wind, and gravitational pull. Erosion is a two-phase process consisting of the detachment of individual particles from the soil mass and then their transport by erosive agents.

Soil loss is the quantitative amount of soil lost from a given area, (water and/or wind being the agent of that loss) over a specified period of time and expressed in standardized units mostly in tonnes/acre/year or tonnes/ha/year. Loss of top soil has been demonstrated to have a depressive effect on crop growth hence, food production. Although the effect of erosion on crop growth may be difficult to assess due to other external factors, a number of studies show that erosion reduces crop yields, and much of this reduction is currently masked by improved technology and soil management. Reductions in crop yields on eroded soils have been attributed to the resulting poor physical and

chemical properties and decreased nutrient content in the plant.

Factors contributing to soil erosion

There are five major factors that contribute to soil erosion, namely: rainfall, soil type, slope length and gradient, ground cover and land management practices and land use/land cover.

Tea Farming

In most tea areas 150 mm of rain each month ensures continuous crop production, that is an annual total of 1800 mm, but tea cannot normally be grown in areas where the rainfall is below 1150 mm, unless irrigation is available.

When the soil moisture content in the root zone is at field capacity, excess rainfall will either runoff on the surface, or percolate through the soil from the surface before appearing as outcrops of water table in streams and rivers. Until the ground cover has reached at least 60%, there is always a risk that runoff will occur in young tea fields if no precautions are taken, such as mulches, intercropping or tied ridges.

Soil conservation measures

Soil conservation measures are designed to intercept surface flows before soil erosion reach destruction depths and velocity and to lead this excess water at predetermined safe to suitable areas. There are always strong links between measures for soil conservation and measures for water conservation. Land management practices such as tillage and cropping practices (systems), directly affect the overall soil erosion problem and solutions on a farm.

1. Agronomic measures

Crop rotation: Crop rotation is planned sequence of cropping. Rotation of crop is an important method for checking erosion and maintaining productivity of soil. A good rotation should include densely planted small grain crops, spreading legume crop etc. which may check soil erosion. Although this is not applicable to perennial crops like tea, it could be intercropped in young tea during establishment without causing detrimental effects.

Strip Cropping (inter-cropping): It consists of growing erosion permitting crops in alternate strips with erosion checking close growing crops (e.g. grasses, pulses etc.).

Strip cropping employs several good farming practices including crop rotation, contour cultivation, proper tillage, stubbles mulching, cover cropping etc. It is very effective and practical means for controlling soil erosion, especially in gently sloping land particularly in young tea farms. One of the factors detrimental to the establishment of young tea is soil erosion, which is more severe the sloppier the area planted to tea. The danger from erosion in tea areas is greatest on land prior to and just after planting and even if the land is terraced there will be movement of soil between terraces during heavy storms. Planting with oats, beans, millet and/or cabbages is recommended to reduce this soil movement.

Tea bush management which encourages the early spread of the canopy, such as pegging, is a better method of reducing the amount of soil erosion than frequent pruning. In areas of high rainfall (therefore high erosion hazards), tea clones which spreads easily and quickly following planting should be preferred to those which spread slowly. Closer spacing at planting can also produce early closure of canopy.

Types of Strip Cropping

Contour strip Cropping: Contour strip cropping is the growing of erosion permitting and erosion resisting crops alternately in strips across the slope and on the contour line. This practice is useful because it checks the fast flow of run-off water increases the infiltration of water in the soil and prevents soil erosion.

Field Strip Cropping: Strips of crop are planted parallel to the general slope of the land.

Wind Strip Cropping: Strips of crop are across the direction of wind regardless of contour.

Buffer Strip Cropping: In this, the severally eroded portion of land is permanently kept under grass and contour strip cropping is practices.

Minimum tillage and no tillage conservation: To be practiced on land deemed to have a high erosion hazard or by compulsory, legally enforced requirement for the construction of conservation.

Hand or manual hoeing to control weeds: these create a loose soil cap at the surface to serve as an energy absorbing agent thereby reducing the erosivity of the raindrops although it damages tea feeder roots.

When agronomic practices are not enough to control erosion in a field, a combination of measures might be necessary e.g. contour plowing, strip cropping, or terracing may be considered

2. Vegetative measures

Cover crops: Crops and vegetables which cover the ground surface well and have extensive root system reduce soil erosion. Plant canopy protect the soil from the adverse effect of rainfall. The grasses and legumes produce dense sod which helps in reducing soil erosion. The vegetation also provides organic matter to the soil. As a result, the fertility of soil increases and the physical condition of soil is improved. Oats and *Crotalaria sp.* are usually planted between rows of tea as cover crops.

Plate 1: *Oats planted as cover crop in a young tea farm*

When a delay between clearing and planting is inevitable, the land should normally be planted to oats *(Avena sativa)* or Guatemala grass *(Tripsacum laxum)*. The recommended oats variety is Suregrain. The seeds can be sown at the rate of about 170 kg per hectare; at the same time, single superphosphate (or triple superphosphate) should be mixed with the top 5 cm of soil at the rate of about 56 kg per hectare (or 26 kg per hectare TSP).

Should it be desired to grow a food crop, either beans or Irish potatoes are suitable. Maize, sunflower or sweet potatoes should not be grown on land intended for the cultivation of tea because these are heavy feeders and thus would remove a lot of nutrients from the soil. They also attract mole rats which could destroy young tea. If the period before planting tea will be a few months, then the land must be planted with a cover crop as soon as possible.

Organic manure: Organic manures improve the soil structure. The crumb and granular structure increases the infiltration and permeability in the soil and conserve the soil water. Consequently soil erosion decreases.

Mulching: Mulches of different kinds such as leaves, straws, paper, stubbles, etc. minimize evaporation and increase the absorption of moisture. It also protects the surface of the land against the beating action of rain drops. Later on, mulch decays to form humus which improves the physical condition of soil. Natural mulching also helps in the infiltration of water and reduction of evaporation.

Mulching is recommended to reduce soil erosion in tea farms and since the use of herbicides has become

prevalent, the trash due to dead weeds also helps in reducing soil erosion. Young tea is vulnerable to erosion because it has not formed an appreciable ground cover, and for this reason prunings should never be removed. Results from erosion experiment to quantify surface run-off and soil erosion on a sloppy (10% slope) field of tea showed that grass mulching gave the best control of soil erosion.

The following materials have been found to be suitable for application as mulch.

a. Prunings and leaf fall of tea
b. Guatemala grass *(Tripsacum laxum)*
c. Napier grass *(Pennisetum purpureum)*
d. Weeping grass *(Eragrostis curvula)*
e. Oats *(Avena sativa)*

The list is not exhaustive but, while mulching tea; care should be taken not to introduce weeds in tea gardens. Guatemala grass has proved to be the most effective of all the mulching materials. However, it was noted that most feeder roots of mulched tea concentrated on the top 10 cm below the soil.

3. Mechanical measures

Mechanical measures include various engineering techniques and structures that helps in mitigating soil erosion. These practices aim:

i. To divide a long slope of land into a series of shorter ones in order to reduce the velocity of run-off water.
ii. To retain the water in the land for long period so as to allow maximum water infiltration and reduce water flows down the slope of the land at non-erosive velocity.
iii. To protect the soil against erosion by water.

The important mechanical soil conservation measures are as follows:

Contour bunds: Contour bunds consist of building earthen embankment at intervals across the slope and along the contour line of the field. A series of such bund divide the area into strips and act as barriers to the flow of water. As a result, the amount and velocity of run-off are reduced, resulting in reduced the soil erosion. Contour bund is made on land where the slope is not very steep and the soil is

fairly permeable. Contour bunds are also called level terraces, absorption type terraces or ridge type terraces.

Tea planted on or near a bund of soil immediately below a terrace trench show remarkable tolerance to extended drought. These bunds (or micro-catchments) are capable of intercepting run-off water and eroded soil if properly constructed and maintained. This can be particularly beneficial in young tea plant in sloppy areas.

Terracing: A terrace is an embankment of ridge of earth constructed across the slope to control run off and to minimize soil erosion. A terrace reduces the length of the hill side slope, thereby reducing sheet and rill erosion and prevents formation of gullies.

Types of terraces

Bench terracing: It consists of transforming relatively steep land into a series of level or nearly level strips or steeps running across the slope. The soil materials that are excavated from the upper part of the terrace is used in filling the lower part and a small bund is also raised along the

outer edge of the terrace to check the downward flow of rainwater and also soil erosion.

Channel terrace: It consists of making wide shallow channels across the slope of the land either exactly on contour line or with a slight gradient (0.1 to 0.2 per cent). In this process, the excavated soil is placed along the lower edge of the channel in the form of low ridge.

Narrow based terrace: It consists of making a number of narrow based ridges or bunds at a distance of 1m to 2m across the slope of the land at suitable intervals in high rainfall areas.

Gabions: Should be done along the road edges to protect banks and road edges. Materials used include large stones and gabions mattress, if not available boxes of galvanized wire mesh may be used.

Ridging: Making cross-tie walls of the micro-catchments to lower the velocity from field without causing damage.

Water ways or drainage: Construction of natural runoff drains e.g. road culverts etc. field layout should be taken into consideration and should be wide and shallow with

channels below the ground to allow water entry from each row.

Field drainage in low-lying areas: Terraces and cut-off drains are adequate for sloping land (see plates 1 & 2). Low-lying areas need a system of parallel channels leading into the main drain or channels laid out in a herring-bone pattern. Whichever method suits the conditions, the main drain must be in the lowest part of the area, with a fall of at least 1 per cent to ensure disposal of water and channels leading into it must also have their fall.

Should the area have a high water table and be liable to water-logging, then drains must be adequate to lower the water table sufficiently to prevent water-logging. This may entail quite deep drains and a problem of subsoil disposal.

Plate 2: *Main drain prepared before grassing but with the field staked ready for planting*

Grass verges: These are recommended on roadside banks and along the sides of drains, as they prevent the bank from eroding and exposing the roots of tea bushes. A single, thin line of grass planted between the metaled road surface and the edge of the adjacent drain is useful in preventing the loss of murram and gravel by washing into the drain. It is necessary, however, to have a good camber on the road and periodically to clear the debris away from the grass and back to the middle of the road so that water can pass freely

through the grass into the drain and not form rivulets down the road.

Love grass *(Eragrostis curvula)* and Dallis grass *(Paspalum sp.)* are recommended for these purposes. Kikuyu grass *(Pennisetum clandestinum)* is effective but needs constant attention to keep it from spreading into tea and road, and is therefore not recommended. *Eragrostis curvula* is easy to establish as it is a prolific seed producer and germination from seed is very high. Unless turfs of this grass are available for splitting and planting, seed should be planted in a nursery five or six months beforehand.

For planting, turfs are dug up and split into small pieces, trimmed and dibbled in, the closer the better as this will give quicker cover. Two or three grains of superphosphate in each hole into which grass is to be planted will improve establishment. The area planted should be hand weeded after planting to delay weed germination until the grass is established. The grass chosen must never be planted nearer to tea than 60 cm or it will adversely affect the growth of tea.

Khus Khus *(Vetivera zizanioides)* grass is sometimes used to reduce erosion because of its dense mated root system. It tends to grow in clumps, forming gaps in the row through which erosion channels form, and also competes severely for soil water with adjacent tea rows in dry weather.

Road drainage: The run-off from murramed roads is proportionately greater than that from fields. Drains must discharge into existing or intended cut-off drains, and not into planted areas. The directions of flow of a roadside drain to the nearest culvert should be at an even fall. Should the fall at any place become less, silting will occur at this point and water may cross the road and spill into the clearing.

Culverts should slope from the upper to the lower side of the road and should have a trap at the upper end to collect silt and trash. This trap should not be less than 1 metre square and its floor 30 cm below the culvert; the trap should be cleared out from time to time.

Cut-off drains must be of sufficient capacity to deal with the discharge from road drains and culverts should not be less than 40 cm diameter. The best type of cut-off drain is that

made of precast concrete sections or stone and cement. Grass drains silt up and requires careful maintenance.

Water from roads must be kept out of tea areas and confined to drains. Run-off from roads may be quite high and can cause serious erosion by forming gulleys which will tend to get progressively deeper, resulting in washing off young tea or causing serious root exposure in old tea.

4. Windbreaks

In the areas where strong winds occur during the dry weather, the effect on the young tea plants can be reduced by allowing a light stand of the cover crop to remain during the dry weather.

Dry air takes up water from any soil and vegetation over which it passes and the stronger the wind, the faster will the water be removed from the soil by evaporation and from the vegetation by transpiration. In dry weather, this process can cause a reduction in tea yields.

In severe cases, not only may the soil dry out to such an extent that the plants suffer from drought, but even when a plentiful supply of water remains in the soil, the transpiration

rate may be so high that the roots cannot supply water to the leaves fast enough. Eventually the leaves wilt and may suffer permanent damage.

The object of a windbreak is to reduce the speed of damaging winds over the tea plants. The best kind of windbreak is formed by a belt of growing trees which are taller than the tea. The beneficial effect of a windbreak decreases as the distance from that windbreak increase, so it is necessary to have a series of windbreaks across the direction of the prevailing and most damaging wind. It has been found that on level ground, the distance between adjacent belts should be ten times the effective height of the trees in the belts. The effective height is defined as the height of the tree above the tea. The effective height of trees which are 10m tall which will protect tea plants about 1.5 m tall at most, is therefore 8.5 m so the belts of trees should be 85 m apart.

On sloping ground, the distance between adjacent belts should be less than this, but if the belts become too close the yields will be reduced by shading and by competition with the shelter trees.

Turbulence is greatest over and around hills, up valleys and beside any obstacle in the path of the wind such as buildings, woods etc. The windbreaks should be sited so that they interrupt the wind across exposed hills and across narrowing valleys. The windbreaks should then be sited at right angles to the wind, especially on windward slopes, over the top of the hills and across the valleys. Because wind goes round the edges of windbreaks, the belts of trees should extend at least 20 m beyond the limits of the area which is to be protected.

Hakea saligna has proved to be the best tree for windbreaks in tea. It grows faster than tea in the first few years and eventually reaches a maximum height of about 6 m. Although all plants growing in tea will compete with the tea to some extent for soil water and nutrients, *Hakea* appears to compete less than most other species and, moreover its leaves do not taint the tea.

The shelter belts are best planted before the tea is established, but if *Hakea* is to be planted in standing tea, care should be taken to ensure that the *Hakea* plants are not shaded by the tea as they will not grow well under

shade. The belts should be about 75 m apart; the trees 2 m apart in each belt.

Tea itself may be used to form windbreaks especially in established tea fields. The tea plant should be allowed to run up, being trimmed to form fan-shaped trees with fans of adjacent plants in the belts touching each other forming a continuous windbreak at right angles to the wind. Adjacent belts should not be more than 100 m apart and normally 75 m apart.

Grevillea robusta may also be used as a windbreak. In the application of these trees or tea as shelter belts in tea, it should be borne in mind that the shelter trees should not constitute a complete barrier to wind flow through them. The rows of trees should only reduce the speed of strong winds thus creating an environment for good tea growth.