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FOREWORD

Bio-fencing or boundary planting is a practice of raising perennial shrubs and trees on boundaries of agricultural farms to form a fence, which prevents entry of humans and stray animals. In semi-arid rainfed agro-ecosystem, due to sparse vegetative cover during most part of the year, the animals are let loose to graze, resulting in damages to the standing crops with losses varying from 20% to as high as 80%. In the Vertisols of semi-arid regions, high intensity rains coupled with low water intake rate of soils produce large amount of runoff and associated loss of nutrient rich topsoil. Unrestricted cattle grazing further aggravates soil degradation and disturbs the agro-ecosystem, which adversely affects the crop yields. These problems can be effectively tackled by vegetative barriers in the form of live fences on boundaries of cultivated fields and also across the slope in the cropped area.

The investment for either constructing a long cement wall surrounding a piece of land or barbed wire fencing is quite high. Small and marginal farmers cannot afford huge investments on such measures. Instead, the farmers can grow perennial shrubs and trees around their cultivated fields as a live fence or bio-fence. Scientific planting of trees, shrubs and bushes of economic value on the boundary of agricultural fields enhances crop diversification and also serves as a source of food, fodder and fuel, especially during prolonged drought periods. "People who go for natural way of farming prefer to have a live fence."

This brochure presents the relevant information on bio-fencing technology in Vertisols of semi-arid region. I am confident that this brochure will prove to be very useful for the farmers, scientists, state agriculture departments and extension workers in successfully implementing the technology for enhanced productivity.

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Bio-fencing in Vertisols of Semi-arid Region

Introduction

Bio-fencing or boundary planting is an age-old practice being adopted by the farmers of semi-arid rainfed agro-ecosystem to protect their cultivated agricultural fields from human and animal encroachment. Due to sparse vegetative cover animals are let loose to graze, causing damage to the standing crops, with the losses in crop yield varying from 20 to 80%. The poor, small and marginal farmers constitute a majority of the farmers in the dryland regions and their economic compulsions do not allow them to invest on high cost barbed wire fencing, hence, bio-fencing is an important practice to be followed in agricultural fields in the rainfed region.

In the traditional bio-fence practice, both living and freshly pruned materials of thorny bushes, shrubs and trees are available at or near the site, are used as fence on the boundaries of cultivated fields. This kind of fencing is not economically beneficial to the farmers. Hence, bio-fencing with trees and bushes of economical importance not only protects the field crops from encroachment by human and cattle but also conserves the natural resources i.e. rainwater and fertile top soils, fetches additional income through their by-products i.e food, fodder and fuel wood.

Technology Implementation

Planting techniques

- During summer, the bunds may be cleaned and kept free from weeds with a trench (20cm width x 30 cm depth) on outer side. If field bunds do not exist, the soil excavated from the trench may be used to form ridge or small bund.

- After the onset of monsoon rains, either during June or September, bio-fence species may be planted.
- Bio-fence species may be planted on the ridge or field bunds at a spacing of 50 cm x 50 cm in two staggered rows (Fig.1).
- Select bio-fence species depending upon the farmers preference, economic use and availability of planting material.
- Apply 1kg FYM and 200g DAP per running meter around the bio-fence plants at the time of establishment for better growth.

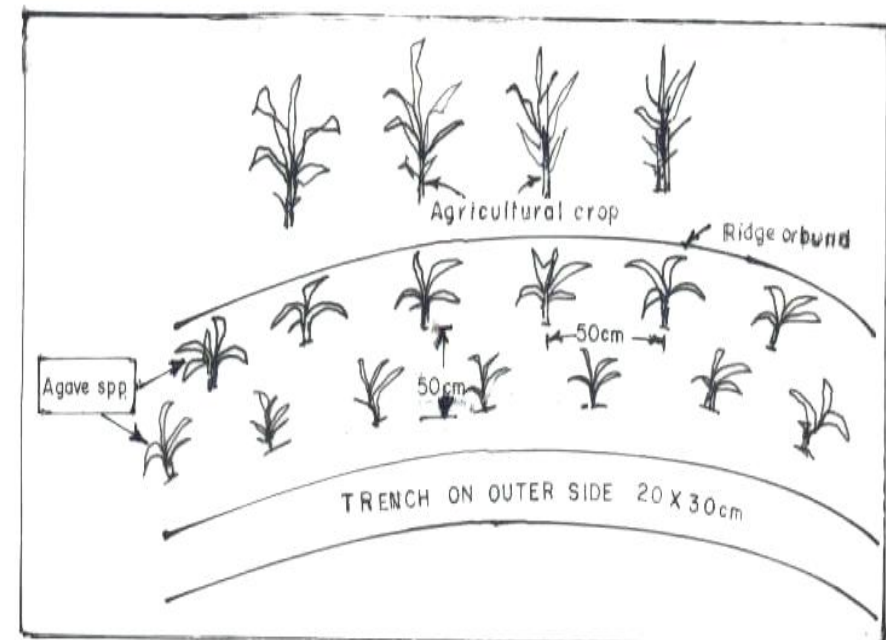


Fig.1 Bio-fence planted on ridge

Planting material

For *Agave*, root suckers are commonly used as planting material; stem cuttings are used for *Euphorbia tirucalli*. Root suckers of *Agave sisilana* can be obtained from Forest Department nursery or nearby fields where *Agave sisilana* plantation exists, and stem cuttings of *Euphorbia tirucallis* from nearby fields where *Euphorbia tirucalli* plantation exists.

Cost of bio-fencing is given in Table 1

Table 1. Cost of bio-fencing (Rs / running meter)

Species	Cost of establishment	Cost of maintenance	Total
<i>Agave sisilana</i>	15.50	4.50	20.00
<i>Euphorbia tirucalli</i>	10.50	3.50	14.00

Maintenance / Management

- During the first year of bio-fence planting, it is essential to provide life saving irrigation for better establishment of planting material.
- Depending upon the survival of bio-fence species, it is required to replant the bio-fence in the gaps during second year in the rainy season.
- Weeding in between bio-fence plants may be done at regular intervals for better growth of plants.
- Cultivate the agricultural crops as usual in the farm fields.

- In about 3 to 4 years, bio-fence species attain good growth and are fully established as a live fence (Photo 1).
- Mature leaves of *Agave sisilana* are harvested and used for fibre extraction. The yield of fibre is 5 kg per running metre with an additional annual income of Rs.10 per running metre in addition to the protection of crops from stray animals.
- Pruning of plants of *E. tirucalli* (Photo 2) is carried out after the plants attain a minimum height of 1.5 m in agricultural crop fields, otherwise it affects crop growth and crop yields are reduced by 20 to 30%.
- The pruned plant materials can be incorporated into the soil after cutting them into small pieces to improve soil fertility. The pruned materials can also be placed in the compost pit where it will form good manure. Through this activity, a farmer can realize an additional income of Rs. 3 to 5 per running metre of bio-fence.



Photo 1. A well established bio-fence of *Agave spp.*

Advantages

- Protection from livestock damage
- Demarcation of field boundary
- Stabilization of bunds and reduces bunds breaching
- Reduction in soil erosion
- Incorporation of bio-fence species pruned biomass into the soil improves the soil fertility and increases crop yields
- Additional income is obtained through sale of their by-products.
- Bio-fence all along the road protects the crops from dust especially in the mining area and reduces the crop yield loss from 5 to 10%.

Disadvantages

- Competition for nutrients and soil water
- Acts as host for insects and pests
- Obstruction in field operations
- Decrease in production of adjacent crop cultivated (up to 2 m from fence)



Photo 2. Bio-fence of *Euphorbia tirucalli*

Production / Output

- The tangible or direct benefits from bio-fencing are of two types, i.e. protection of crops from animal damage and yield of bio-products from the fence which can be used by the farmer and has market value.
- Pruning of *Euphorbia tirucalli* of 1.5 m height can be done and pruned biomass incorporated into the soil, which improves soil fertility.
- Direct benefits from *Agave sisilana* are from the sale of fibre that can be extracted from the leaves. The fibre is used for making ropes. The yield of fibre is 5 kg per running metre that fetches an additional annual income of Rs.10 per metre.

- Grain yield of sorghum at 2-4 m away from bio-fence was higher by 6% (11.5 q ha⁻¹) as compared to near (<2 m) the bio-fence (10.9 q ha⁻¹) indicating that bio-fence and crop compete for soil water and nutrients. However, this loss is compensated by increased production at 2-4 m away from the bio-fence and prevention of loss due to animal grazing.

Economics

Tables 2 and 3 reflect the comparative advantage of bio-fence species under the real field situation.

Table 2. Comparison of different bio-fence species

Bio-fence species	Time taken for Establishment and function as a bio-fence (Years)	Additional income from bio-fence (Rs/running metre)
<i>Agave sisilana</i>	3	10
<i>Euphorbia tirucalli</i>	4	4

Table 3. Net Returns (Rs./ha/year)

Plot details	Bio-fence species	
	<i>Agave sisilana</i>	<i>Euphorbia tirucalli</i>
Bio-fence	1168	603
Sorghum crop in bio-fence plot	5625	5580
Bio-fence + sorghum crop	6793	6183
Sorghum crop without bio-fence	4500	4500

Case Studies

The studies on bio-fence species conducted both at Central Soil and Water Conservation Research and Training Institute, Research Centre Farm and in the Farmers' fields in Joladarasi and Chellagurki watersheds of Bellary district in Karnataka indicated that:

Performance of Bio-Fence Species

- The survival, plant height, collar diameter and canopy of bio-fence species in ridge method of planting are higher than under flat method of planting.
- Among the bio-fence species, higher survival (75%) is observed in *Agave sisilana* followed by *Euphorbia tirucalli* (65%).
- Canopy spread is higher in *Euphorbia tirucalli* (126 cm) in the field.

Yield Advantage

- The yield of sorghum was higher by 26% and 20% when planted with *Agave sisilana* and *Euphorbia tirucalli*, respectively over control (without bio-fence).
- The grain yield of Bengalgram was higher by 27% and 20% when planted with *Agave sisilana* and *Euphorbia tirucalli*, respectively over control (without bio-fence).

Moisture Storage

- Ridge planting of bio-fence recorded 7% higher soil moisture as compared to flat planting. Soil moisture was higher by 6% in the cropped area at 2-4 m distance away from bio-fence as compared to within 2 m.
- The soil moisture was higher by 17% and 12% when planted with *Agave sisilana* and *Euphorbia tirucalli*, respectively.

Runoff and Soil Loss

- *Agave sisilana* and *Euphorbia tirucalli* reduced the runoff by 56% and 58%, and soil loss by 73% and 75%, respectively over control (without bio-fence).

Farmers' Opinion

- Among the bio-fence species in black soil of semi-arid (<750mm rainfall) region, and red soil regions of Sandur and Kudligi taluks (Bellary district, Karnataka State) farmers prefer both *Agave sisilana* and *Euphorbia tirucalli* for planting on their field boundaries.
- The incorporation of pruned material of *Euphorbia tirucalli* in the soil is not acceptable by the farmers as it involves labour for making pieces of pruned material. The farmers are ready to put it into the compost pit to get good manure.

Scope of Application

Bio-fencing in the semiarid regions has scope for preventing the trespass of human and animals of both domestic and wild kind and for soil and water conservation, value addition and sustainability of the ecosystem.

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