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Innovative Farming
-An International Journal of Agriculture

BIODRAINAGE

Popular Article

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KEY WORDS
Biodrainage,
Drainage,
Agroforestry,
Water logging

ARTICLE INFO

Received on:
28.03.2016
Revised on:
21.04.2016
Accepted on:
23.04.2016

ABSTRACT

Biodrainage may be defined as "pumping of excess soil water using bio-energy through deep-rooted vegetation with high rate of transpiration". The biodrainage system consists of fast growing tree species, which absorb water from the capillary fringe located above the ground water table. The absorbed water is translocated to different parts of plants and finally more than 98% of the absorbed water is transpired into the atmosphere mainly through the stomata. This combined process of absorption, translocation and transpiration of excess ground water into the atmosphere by the deep rooted vegetation conceptualizes bio-drainage. Fast growing Eucalyptus species like known for luxurious water consumption under excess soil moisture condition are suitable for biodrainage. These species can be planted in blocks in the form of farm forestry or along the field boundary in the form of agroforestry. Other suitable species for block plantations are *Casuarina glauca*, *Terminalia arjuna*, *Pongamia pinnata* and *Syzygium cuminii* etc.

Introduction

Shallow groundwater tables and associated salinity problems have become dominant features in agricultural areas around the world. These problems have been caused by increasing pressures on land resources caused by rising populations, especially in irrigation areas. Increasingly, large areas of land having historically deep groundwater tables are now in need of some form of water table control. In many places management strategies have been developed to address this problem. These often focus on engineering approaches such as deep open ditches, vertical drainage (groundwater pumping) or horizontal subsurface drainage.

Conventional physical drainage works require expensive capital investment, operation and maintenance. Physical drainage measures also generate drainage effluent. Disposal to rivers of the often saline and sometimes chemically contaminated effluent is increasingly considered unacceptable because downstream users in the catchment rely on these river systems for their water supplies. Greenhouse emissions caused by energy-hungry pumps may also be disapproved of in a world that is becoming more aware of issues related to global warming. Any positive alternative, preferably cheaper, addition to our arsenal of drainage techniques would be extremely welcome in our fight to keep groundwater tables in our agricultural areas under control. Biodrainage, i.e. the use of vegetation to manage water fluxes in the landscape, is one such technique that has recently attracted interest in drainage and environmental management circles.

Water table control

Shallow water table levels pose a threat to agricultural crops as they often result in salinization of the plant rootzone. The management of irrigation areas often aims to keep water tables below the *critical depth*, which is defined as the depth at which capillary salinization is negligible.

Sustainability of irrigation is determined by the *leaching capability* of soils. To avoid salinity problems, the salts present in the irrigation water will have to be removed from the rootzone by *leaching* them either laterally to adjoining non-irrigated areas or streams or vertically down to levels below the vegetation rootzone.

Plants can remove water from the soil either (1) directly from the saturated zone below the water table, (2) from the unsaturated capillary fringe above the water table or (3) from unsaturated topsoil layers after rainfall or irrigation. Scenarios (1) and (2) result in *water table control*; scenario (3) *recharge control*. In scenario (3) leaching is unimpeded; when water application exceeds plant water demand, leaching will take place. In scenarios (1) and (2) leaching becomes restricted and salt accumulation processes begin to occur. This happens especially where water tables are shallow, as is often the case in irrigation areas. A final equilibrium salinity level will establish, depending on applied water salinity, soil hydraulic conductivity, hydraulic gradients (vertical and lateral) and vegetation type (salt tolerance).

Channel seepage interception

Channel seepage can be a major contributor to water table accessions in irrigation areas. High seepage rates will result in groundwater mounds beneath channels, causing waterlogging and salinity problems in the adjoining land. Water quality in supply channels is normally good and the seepage water, if not left to evaporate and increase in salinity, can be productively used by vegetation and commercial crops. The issue of salt balance, although less critical than for more saline groundwater situations, is still a matter of long-term concern.

Principles of planning and design

The aim of biodrainage is to remove excess groundwater through the process of transpiration by vegetation. This is achieved by enhancing the transpiration capacity of the landscape by introducing high-water use vegetation types in large enough areas to balance recharge/discharge processes to maintain groundwater balances below the rootzone of the agriculture crops. The following issues should be considered in the development of biodrainage systems:

Water balance: Biodrainage plantations should be able to extract groundwater volumes equal to the net recharge. The water balance is to be maintained such that the water table is kept below the rootzone.

Plantation area: The biodrainage plantation area should be kept as small as possible. Agriculture (particularly irrigated agriculture) is practised primarily to produce high-value crops. Conversion of high-value cropping land to relatively low-return forestry may be difficult. Often good quality water is in short supply while land is not a limited resource. Particularly in arid and semi-arid regions, dryland areas surrounded by irrigated land could be earmarked for tree plantations without loss of productive resources.

Salt tolerance: Biodrainage crops need to be salt tolerant. Groundwater qualities can vary greatly spatially, normally they have a higher salinity than irrigation supplies. The water use capacity of trees and other crops decreases with increase in water salinity. In the case of Eucalypt species, it reduces to about one-half of potential when the water salinity increases to about 8 dS/m (Oster *et al.,* 1999).

Drawdown of water table: Crops, including trees, act as biopumps; they depress the water table directly underneath plantation areas and consequently lower the water table in the surrounding area. The drawdown effect under trees/crops depends on the tree/crop's water use, the rate of recharge in the surrounding area, the hydraulic conductivity of substrata and the depth to deeper barrier layers. Biodrainage plantings should be established in blocks or strips and spaced to keep water table levels in the irrigated farmland in between the plantings below the rootzone. The harvesting of the biodrainage plantations would need to be planned in such a manner that the "drainage" function is not lost (thinning regimes).

Salt balance: The introduction of irrigation always upsets the salt balance. Although irriga-tion supplies often have relatively low salinities, the large volumes of water that are introduced in the landscape increase salt imports signi-ficantly. Drainage of effluent to export these salts is therefore generally considered a necessity. To achieve salt balance without conventional drainage, the irrigated crops, along with interspersed biodrainage plantings, would have to accumulate the salts introduced by irrigation, and would subsequently have to be harvested and removed from the region. This is only (potentially) achievable in situations where very low-salinity water is available to the plants.

Economic aspects: The growing of biodrainage trees and crops requires a different operational management approach than the growing of agricultural crops. Up-front costs associated with planting and maintenance precedes the income from harvesting by many years. Some form of contract growing, based on annual payments might have to be considered to make the system acceptable to landholders.

Social acceptance: The introduction of new crops such as tree plantations affects rural social societies. New markets might have to be developed, security arrangements differ from those for normal crops (illegal pruning or cutting for fuelwood) and fires could destroy the results of many years of labour in a single day. Active participation of local communities in the deve-lopment of tree plantation-based biodrainage systems is extremely important to overcome problems and ascertain that the benefits of the biodrainage systems are reaped to the maximum extent.

Scientific Basis of Biodrainage

Experiments were conducted in Haryana state. Plantations were raised in water logged areas of Haryana state. To measure the ground water table observation wells were installed in between the tree plantations. Carbon content of oven dried timber, fuel wood, twigs/leaves and roots samples were determined by dichromate oxidation method. The transpiration rate was measured using dissipation probes. The basic dissipation probe has two thermocouple needles inserted in the sapwood, the upper one containing an electric heater. The probe needles measure the temperature difference (dT) between the heated needle and the sapwood ambient temperature below. The dT variable and the maximum dTm at zero flow provide a direct conversion to sap velocity. Girth of all trees was measured at the breast height with the help of a measuring tape.

Four parallel strip plantations worked as bio-pumps and lowered the water table by 0.85 m in 3 years in canal-irrigated, agricultural, waterlogged fields located in a semi-arid region with alluvial sandy-loam soil. The annual rate of transpiration by these plantations was 268 mm against the mean annual rainfall of 212 mm. Lowering of water table and associated improvement by *Eucalyptus* plantations increased by 3.4 times than the adjacent fields. There was no net increase in ground water table salinity underneath the plantation. The fluctuations in g.w.t. caused fluctuations in g.w.t. salinity underneath the plantation as well as in the adjacent fields. Tree species vary in their "biodrainage potential" as evidenced by the extent of lowering of water table immediately beneath the plantations. Eucalyptus species has a higher biodrainage potential as compared to relatively slow biodariners like T. Aphylla and P.pinnata.

Conclusion

Tree species vary in their "biodrainage potential" as evidenced by the extent of lowering of water table immediately beneath the plantations.Eucalyptus species has a higher biodrainage potential as compared to relatively slow biodariners like T. Aphylla and P.pinnata.

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How to cite this article?

Apparao Ch. and G. Rakesh. 2016. Biodrainage. *Innovative Farming*, **1**(2): 38-41.