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Soil Fertility Management in Dry Lands

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Introduction

Drylands are characterized by the scarcity of water where the precipitation is counterbalanced by evaporation from the soil surfaces and transpiration by plants. Dryland contribute surplus food production to fulfill the dietary needs of world population. However, water scarcity, extreme weather variability, nutrient losses due to soil erosion, leaching, nutrient mining, runoff, and lack of integrated nutrient management approaches trigger the full crop production potential of dryland soils. Fertilizer use in dryland soils is less than irrigated lands in the world. Crop residue input into the soil is also low due to strong crop-livestock interaction in dryland areas. Application of chemical fertilizers on the basis of soil analysis, together with use of organic manures, compost and crop residues is a useful option to harvest potential crop yields in dryland regions. Inclusion of legumes in crop rotation, and cultivating the legume crops during fallow periods in dryland regions may enhance the soil nutrient supply to upcoming crops.

1. Nutrient Cycles in Dryland Areas: Nutrient cycling in drylands is affected by low and erratic rainfall, wide temperature extremes, alkalinity and/or salinity, and occasionally by relatively high rates of dry deposition of nutrient-enriched soil particles from wind erosion. In extremely dry areas where vascular plants are absent, nutrient cycling through microbial organisms predominates. For example, micro biotic crusts, composed of nitrogen-fixing cyanobacteria, are often found on desert surfaces. These organisms can survive long periods of desiccation with very rapid responses to rehydration. These organisms conserve and cycle water as well as nutrients, increasing water infiltration, slowing evapotranspiration, and reducing wind erosion. Some of the nitrogen they contribute to the soil can be lost, however, through denitrification from underlying anaerobic microsites, which limits nitrogen build-up.

2. Conservation Agriculture and Tillage: Conservation agriculture aims to conserve and improve the natural resource base while using the resources available for agricultural production more efficiently. Conservation agriculture avoids or minimizes soil tillage, maintains a permanent soil cover of crops and/or residues, and utilizes efficient crop rotations. Stewart and Koohafkan (2004) suggest, however, that even small amounts of crop residues can reduce wind erosion considerably and increase soil water storage. Since significant quantities of soil and nutrients are lost by wind and water erosion under dry conditions where the soil remains bare for most part of the year.

3. Legume Rotations and Crop Mixtures In recent years there has been an encouraging trend away from mainly cereal-based systems in drylands toward cereal–legume and cereal–legume–livestock systems that not only bring economic benefits but also improve soil fertility. Biological nitrogen fixation is the cheapest and most effective management tool for maintaining sustainable yields in low-input agriculture. An alternative to the widely practiced cereal–fallow or cereal monoculture systems is the introduction of nitrogen-fixing legume crops into a rotation with cereals.

4. Nitrogen-Fixing Trees: Leguminous trees can survive with dry soils low levels of nitrogen due to their nitrogen fixing capacity. According to Dakora and Keya (1997), legume trees can fix 43–581 kg N ha-1 year-1, compared to about 15–210 kg N ha-1 year-1 from grain legumes. This is why they can be characterized as "fertilizer trees". Nitrogen-fixing trees such as Acacia and Prosopis are some of the best sources of this fertilization in dry regions, which is inexpensive and already in situ. In addition, most of these species are sources of highly nutritious fodder, fuel, food, charcoal, gums, fiber, and timber. Acacias are also well adapted to low rainfall and extreme temperatures due to their extremely deep root systems. They include about 1250 species of deciduous or evergreen trees and shrubs widely distributed in the tropics and warmer temperate areas. These species are planted to provide windbreaks, afforest mining and salt-affected areas, stabilize sand dunes, and reduce erosion. In addition to their nitrogen-fixing capacity, such species in agroforestry systems are beneficial for maintaining soil fertility due to their efficient nutrient cycling of tree biomass and their uptake of nutrients from deep soil layers, report that Acacia holosericia trees are capable of fixing 36–108 kg N ha-1. Leguminous trees, which can be grown in hedgerows or intercropped with annual crops, improve soil water conditions as well as enhance soil nitrogen supplies. These trees obtain most of their water from deep soil layers whereas annual field crops take water from the upper layers.

5. Horticultural and Agroforestry Systems: According to Olivares et al. (1988), the plants best able to take advantage of dryland soil and climate conditions are trees, by making better use of limited water and nutrient resources through their deep root systems. Furthermore, many trees, shrubs, and drought tolerant plants, such as cactus, play an important role in sand stabilization and land protection, in addition to their economic uses for food, fuel, wood, fodder, and other purposes.

Conclusions

As external inputs are scarce and costly in dryland areas, management systems that require few external inputs, relying on nutrient cycling and the more efficient use of water and nutrients, are more likely to gain acceptance. These should be more resilient and generate higher-value products than the mainly cereal-based, crop–livestock systems dominant in dryland areas. Promising management options for improving soil fertility in the drylands include conservation agriculture and tillage; crop rotations; low-cost soil and water conservation technologies developed with farmers; higher-value food, medicinal, cosmetic and herb crops; and new tree and livestock options.

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