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Innovative agricultural intensification of sandy desert soils using organic and inorganic amendments

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Earth's total land mass is about 148,939,063 km^2 which is about 29.2 per cent of its total surface. Water covers approximately 70.8 per cent of the Earth's surface, mostly in the form of oceans and ice formations. Earth is the only planet known to have an atmosphere containing free oxygen, oceans of water on its surface, and life. Thus, if it provides sustainable ecosystem services we can call it a living land. If, however, its capacity is diminishing due to diversified threats then we have to think of its sustainable management for long-term services for human beings, maintaining biodiversity and environmental services.

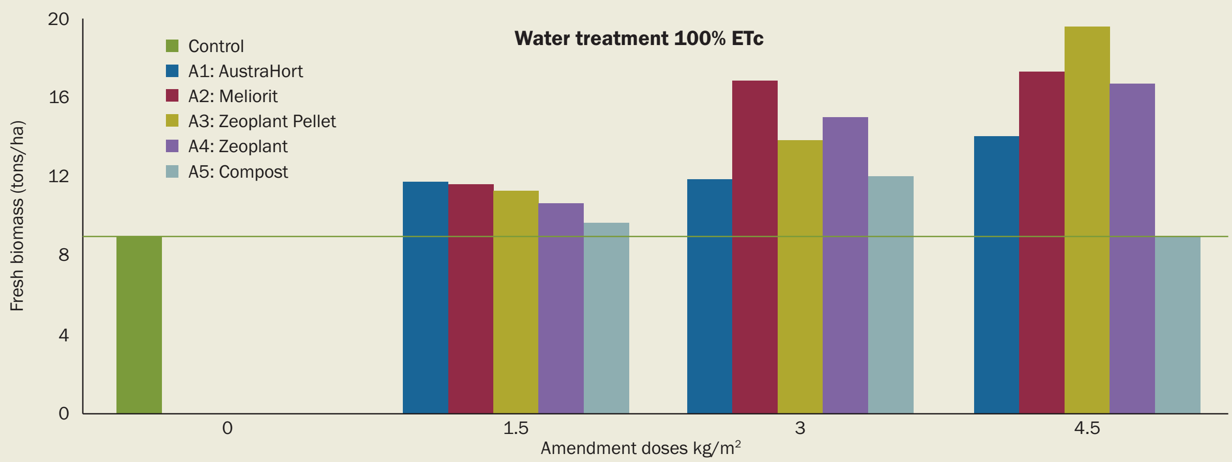
'Land' is a broad term, which includes diversified features, mountains, rivers, forests, agricultural farms, buildings and so on. However, 'soil' is narrower in meaning and exclusively means a medium for plant growth. Overexploitation of soil resources, for quick benefits without appreciating soil health, has shrunk soil resources to an unprecedented level and there is growing concern that over years it may not be able to provide sufficient food to meet human demand. Therefore it is essential to maintain soil health for long-term benefits; this is only possible when we manage the soil through scientific diagnostics and innovative ways including diversified organic and inorganic soil amendments.

Trials on soil amendments for forage production at the International Center for Biosaline Agriculture (ICBA) have revealed a general increase, and in some cases a doubling, of fresh biomass over the control treatment where amendments were not added. Results from greenhouse and field

Image: ICBA

Land degradation is a serious environmental problem, especially in the drylands that occupy one-third of the Earth's surface

Sandy soil amended for agriculture intensification



A field trial was conducted on sandy soil (*Typic torripsamment*) at an ICBA station for barley forage production. Sandy soil is dominant in the United Arab Emirates (UAE) and other Gulf Cooperation Council countries and is used for agricultural and landscaping activities. The sandy soil was amended with four inorganic amendments (AustraHort: A1, Meliorit: A2, Zeoplant pellet: A3 and Zeoplant: A4) and one organic amendment (Compost: A5) applied at the rates of 0, 1.5, 3 and 4.5 kg/m^2. Standard fertilizer rates were used to offset nutrient requirements of barley crop. Treatments were triplicated in Randomized Complete Block Design. The plot size was 2.25 m^2 (1.5m x 1.5m).

Soil amendments can boost soil resource capacity, improving the cost-effectiveness of agricultural production.

The standard agronomic parameters were recorded and biomass determined. The trial was irrigated at two irrigation levels (75 per cent ETc and 100 per cent ETc). The results have shown positive effects of amendments addition to soil on biomass production. At both irrigation levels the addition of amendments has shown promising results in terms of fresh biomass increase (more than double) over control treatment. At 75 per cent ETc and 100 per cent ETc (control) biomass was recorded as 6.5 and 9 tons/ha, whereas with the addition of amendments variable increase of biomass was recorded, the maximum being 15.5 tons/ha with the application of 4.5kg/m^2 meliorit at 75 per cent ETc (138 per cent increase) and 19.5 tons/ha with the application of 4.5 kg/m^2 zeoplant pellet at 100 per cent ETc (117 per cent increase). This preliminary investigation provides hope for the intensification of agriculture in sandy soils which are inherently low in crop productivity.

Source: ICBA

trials give us hope for the intensification of agriculture in desert sandy soils through organic and inorganic amendments and boosting forage production.

Soil is made up of sand, silt and clay and has many thousands of soil taxa, depending upon where you are on the world soil globe. Plants and crops depend on soil for the supply of water and nutrients, anchorage of plants and as a medium in which to grow. Soil is a fundamental component for food production and in providing other soil functions such as climate regulation, nutrient cycling, habitat for organisms, flood regulation, a source of pharmaceuticals and genetic resources, foundations for human infrastructure, provision of construction materials, cultural heritage, provision of food, fibre and fuel, carbon sequestration and water purification and soil contamination reduction. Thus we are justified in saying that soils deliver ecosystem services that enable life on Earth.

Over many years humans have used soils to gain great economic rewards. However, many of the methods used to gain those benefits are now seen as unsustainable, because in many cases they lead to degraded land. Hence land degradation (loss or reduction of land functions or land uses) becomes a serious worldwide environmental problem, especially in the drylands that occupy one-third of the Earth's land surface. Land degradation is induced through natural and human activities, and accelerated due to persistent droughts in many developing arid countries.

Irrational use of soil resources has been carried out by powerful competing economic and social forces that have little knowledge about the potential of soil resources and little or no regard for the long-term care of soils. Therefore, there is a lot riding on our capacity to understand, conserve and manage soil resources efficiently and sustainably. The unsustainable use of soil resource is ultimately diminishing its capacity for long-term services especially producing food. Sustainable soil management could produce up to 58 per cent more food through agricultural intensification, so that 95 per cent of our food is directly or indirectly produced on our soils.[1] This provides hope for meeting the future food demand of an increasing population.

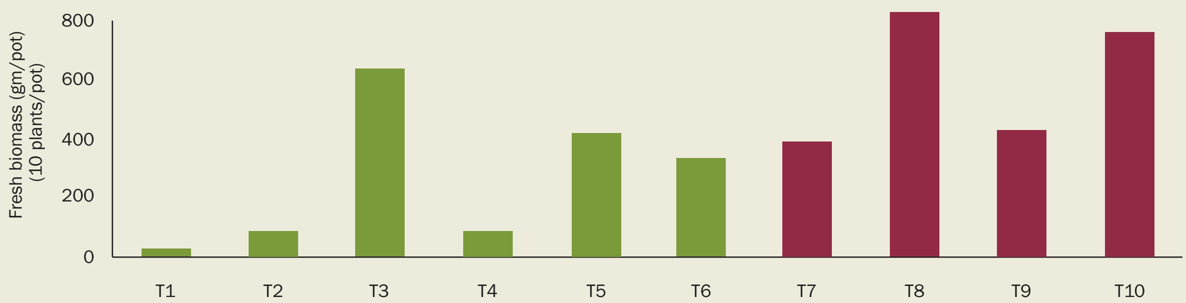
Global data shows that 33 per cent of soils are degraded due to diverse ailments. Among the natural forces of land degradation, under desert conditions wind has a major role in soil erosion. Globally over 24 billion tons of fertile soil was lost due to erosion in 2011, that is 3.4 tons per person per year, costing US$70 per inhabitant, or US$419 billion worldwide. Without fertile soils, food security, poverty alleviation and climate change mitigation and adaptation will not be achieved. In addition to affecting agricultural farms through nutrient mining, drifting soil also causes environmental issues.

ICBA has experience in managing marginal lands with sandy, salt-affected soils through scientific and site-specific diagnostics

Due to increasing population growth and unsustainable land uses, arable lands are shrinking. Currently, each human has only 0.22 hectares at their disposal; in 1960, that figure was 0.5 hectares. The other major constraint to food production is the development of soil salinity in irrigated agricultural farms which is great concern as 40 per cent of world food is produced from irrigated agriculture and 60 per cent from rain-fed agriculture. Currently, an estimated 20 per cent of irrigated lands is salinized to various degrees and the global annual cost of salt-induced land degradation in irrigated areas could be US$27.3 billion because of lost crop production.[2] Globally about 1.6 million hectares are lost annually due to salinization. With this pace of loss, the irrigated area that is now contributing to agricultural foods will be out of production in nearly 140 years — an alarming situation since by 2050 we have to produce 70 per cent more food to feed 2 billion extra mouths in addition to current 7.3 billion. The impact of climate change is another constraint to achieve sustainability in food security. An Intergovernmental Panel on Climate Change (IPCC) synthesis report[3] has recognized the major impacts of climate change as food and water shortages, increased displacement of people, increased poverty and coastal flooding.

Overexploitation has shrunk arable lands for food production and it may not be able to provide sufficient food to meet human demand. Globally there are 1,500 million ha cropland including 250 million ha (17 per cent) irrigated producing 40 per cent of world food, and 1,250 million ha (83 per cent) rain-fed agriculture contributing 60 per cent of world food production.[4] Under a business-as-usual scenario, by 2050 agricultural production must increase by 60 per cent globally — and almost 100 per cent in developing countries —to meet food demand alone for 9 billion.[1] To achieve such targets it is essential to understand soil health constraints and develop problem-solving, innovative ways which have long-term effects. This requires the development and implementation of new agricultural and food policies, and water, environmental and soil protection plans. The concept of climate-Smart Agriculture (CSA) could be a step in the right direction. The CSA being promoted by FAO[5] is not a single specific agricultural technology or practice that can be universally applied. It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices. With this understanding, using innovative ways to improve soil health, intensification in both irrigated and rain-fed agriculture may be possible. However, increasing agriculture lands may not be a viable option in many countries due to various factors including unfavourable terrains, such as in African countries.

Integrated plant nutrient management for sandy soil



One of the best ways to improve soil properties and prevent nutrient losses is to improve soil health through innovative ways using organic amendments and minimizing the use of fertilizers. In order to achieve this we have conducted a greenhouse experiment to test the integrated effects of chemical fertilizer (CF), compost (C), biofertilizer (BF) and biochar (BC) on maize crop productivity and improvements in nutrient availability.

A pot experiment was conducted in the greenhouse using the following treatments with three replication:

T1 — Control
T2 — Compost @ 5 tons/ha
T3 — Compost @ 5 tons/ha + 100 per cent conventional fertilizer
T4 — Compost @ 5 tons/ha + 5.5 L/ha biofertilizer
T5 — Compost @ 5 tons/ha + 50 per cent fertilizer + 5.5 L/ha biofertilizer
T6 — Compost @ 5 tons/ha + 25 per cent fertilizer + 5.5 L/ha biofertilizer
T7 — Compost @ 5 tons/ha + 5 tons biochar/ha
T8 — Compost @ 5 tons/ha + 100 per cent conventional fertilizer + 5 tons biochar/ha
T9 — Compost @ 5 tons/ha + 5.5 L/ha biofertilizer + 5 tons Biochar/ha
T10 — Compost @ 5 tons/ha + 50 per cent fertilizer + 5.5 L/ha biofertilizer + 5 tons biochar/ha.

The results are presented as grams per pot (each pot contains 10 plants). They show that agricultural intensification in desert sandy soils can be achieved through appropriate combinations of organic and inorganic soil amendments

General observations revealed the maximum biomass production was found when biochar was applied in combination with 100 per cent conventional fertilizer (T8), which is 29 per cent more compared to where chemical fertilizer was applied alone (T3). All treatment combinations increased fresh biomass over the control treatment (T1) in various ranges. It was also found that when half of the chemical fertilizer was applied in combination with biofertilizer and biochar (T10), an increase of 19.7 per cent fresh biomass was recorded compared to where 100 per cent conventional fertilizer was applied (T3). The application of various amendments has increased cation-exchange-capacity (9-15 per cent) and organic carbon (48-52 per cent) compared to T3.

Source: ICBA

ICBA has vast experience in managing marginal lands (sandy, salt-affected soils) through scientific and site-specific diagnostics. The marginality has been mainly in two forms: desert sandy soils and salt-affected lands. The former is confined to desert environments where loose sand forms the major landscape and basis for agricultural farms.[6] The salt-affected lands can be found both on sandy deserts and other arid region soils of various soil textures. ICBA scientists believe that it may be possible to keep the soils healthy and productive for a long time when a soil health programme goes simultaneously with agricultural activities.

Sandy desert soils (hot arid climate) are plagued with very low water and nutrient holding capacities, which results in frequent irrigation and nutrient application, high leaching and nutrient losses. Such harsh conditions call for new ways to conserve water, improve soil properties and prevent nutrient losses. One of the best ways is to modify sandy soils with organic and inorganic amendments to improve soil tilth and ultimately improve moisture and nutrient retention, leading to efficient use of water resources and preventing groundwater pollution. At ICBA we have proved through greenhouse and field trials that the addition of suitable quantities of organic and inorganic amendments improved soil qualities, leading to significant water saving and doubling fresh biomass production.

Image: ICBA

Desert soils are loose and fragile — a view of degraded land in UAE deserts