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Nigeria, Factor 1: Plant Science

Nigeria: Halophytes as Cover Crops to Remediate Soil in Nigeria

Nestled in the crook of the West African coastline lies the country of Nigeria, one of the wealthiest and most populated superpowers of the African continent. Residing in a geographically diverse region rich in natural resources, Nigeria sits on one of the largest oil reserves in the world and relies heavily on exporting petroleum, cotton, and peanuts to satisfy foreign consumers and support nearly 170 million people. Despite having one of greatest gross domestic products of Africa, about 120 million Nigerians, most of whom live in rural areas, remain below the poverty line without access to healthcare, education, or food (“Nigeria Population") The deep-rooted problem of poverty stems from a corrupt government absorbing the wealth of the poor ("Poverty in Nigeria: Rich Country, Poor People.”), leaving them to starve beneath the rigid and inflexible poverty line. However, despite the enormity of the problem, a solution to this persistent poverty may lie in a small adjustment to rural farming methods. For a country heavily reliant on agriculture as a source of food, jobs, and money, Nigeria overlooks a vital component of crop production: soil quality. Soil quality affects the quantity and quality of crops; therefore, the revenue of the Nigerian population invested in agriculture. Being a tropical, coastal country, Nigeria naturally suffers from high soil salinity and risk of topsoil erosion; in addition to its natural disadvantages, the unsustainable agricultural practices of Nigerian farmers also magnify soil degradation and accelerate desertification, threatening the livelihood of the entire country. Rather than intensifying soil degradation by refusing to deviate from cheap, harmful agricultural shortcuts, we must address the problem in order to alleviate poverty in Nigeria. The use of halophytes, salt-loving plants, as cover crops in Nigeria has the potential to mitigate and remediate soil degradation by preventing salinization and erosion, two incremental steps which will trigger a natural reclamation of the soil. Though the precarious balance between nutrients, moisture content, and particle size of a healthy soil is as delicate and precarious as the ratio of ingredients in a cake recipe, a small shift in how we farm our domesticated land could be the force that gives Nigerians enough momentum to escape from the poverty trap and begin anew.

Though most foreign attention is consumed by terrorism and toxic political conflict, Nigeria suffers from the silent, omnipresent crisis that is food insecurity. Malnutrition, a direct result of food insecurity, is defined as the “condition that occurs when people consistently do not consume or absorb the right amounts and types of food and essential nutrients;” (Malnutrition: Nigeria's Silent Crisis) it acts like a thick and stifling blanket suffocating Nigerians trapped beneath the poverty line. Parents, never having received any sexual or economic education, assume that the solution to their own hunger is to have a large number of children who can work and earn money. However, malnourished mothers produce stunted children who are more vulnerable to disease and malnutrition and function as more of an economic burden than a catalyst. Because of their developing bodies and immune systems, children are acutely vulnerable to the threat of malnutrition, forcing themselves and their parents to spend their earnings on the immediate necessity of food rather than saving for an education or investing in entrepreneurism. To alleviate their own misfortune, these children take on the responsibility of a large family early and trap themselves in the same unforgiving cycle their parents circulate in. As of 2015, Nigeria has one of the highest percentages of underweight children below five years old in the world, with approximately half a million Nigerian children dying from malnutrition before their 5th birthday because their parents have to scavenge and scrape barrel bottoms just to feed their families (Adesina). Well-nourished children are proven to do better in school than their hunger-distracted peers and have more future job opportunities; in addition to having a greater personal income, well-nourished children grow into healthier and more productive workers in the labor force, boosting the country’s GDP growth.

Food insecurity is undoubtedly the root of many of the problems that plague Nigeria, malnutrition included, but what is the root of food insecurity? Though it is often a result of a parent's poor choices stunting their children's opportunities, food insecurity can be traced back to the unsustainable agriculture practices that deplete and degrade the arable land. Nigerians rely heavily on agriculture as a source of income and food; around 60% of the Nigerian population is part of the agricultural industry, but many citizens farm for subsistence rather than profit (Aregheore). Therefore, soil quality dictates the quality of life in Nigeria. The economic and environmental positive feedback loops of Nigerian agriculture are closely intertwined with the poverty cycle; unsustainable farming practices starve the land, the economy, and the people. The unsustainable, antiquated farming methods currently practiced reduce the quality of soil, the quantity and quality of crops, and the income of farmers; consequently, farmers are left with barren fields and empty stomachs. As farmers become more desperate with less patience, time, and money to spare, they rely more and more on the cheap and harmful agricultural shortcuts which further exhaust the soil. The precarious balance of soil can easily be upset, and altering one constituent of the soil can cause a ripple effect. Because of this fickle temperament, unsustainable agriculture practices not only drain the soil of nutrients and decrease water capacity, but also simultaneously magnify the effects of salinization and erosion.

Though the majority of the land consists of plains and savannas, Nigeria's geographically diverse landscape encompasses a variety different biomes such as tropical rainforests, mountainous regions, and deserts, but for the sake of clarity, Nigeria can be divided into highlands and lowlands ("The World Factbook: Nigeria."). Nigerian soils reflect their specific climate and can be divided into four primary zones: the northern zone of sandy soils, the interior zone of laterite soils, the southern belt of forest soils, and the zone of alluvial soils. Because of the varying moisture content around the country, the fertility of Nigerian soils ranges from extremely low to good productivity grade. Unfortunately, almost half of the soil in Nigeria is classified as dry, low grade soil consisting of mainly vertisols, alisols, acrisols, ferrasols and arensol (Aregheore). Because of insufficient moisture retention and nutrients from decomposing organic matter, low grade soils are unproductive and infertile, making them more difficult to farm. The majority of staple crops are grown in the tropical forest zone of the south, a vital agro-ecological zone because of its long rainy season. Even without anthropogenic influence, the most productive agro-ecological zones naturally suffer from leaching, erosion, nutrient loss, salinization, and high soil acidity. Nigerian soils undergo frequent flooding, wind erosion from northern desert sands, and naturally low levels of essential trace elements like bioavailable nitrogen and phosphorous (Powell).

Because of a lack of education and technological advancement in rural farming communities of Nigeria, farmers primarily practice simple but inefficient farming practices to produce both subsidence and surplus crops. Farmers most commonly practice intercropping, or crop polyculture, of two to three crops interrupted by brief fallowing periods, or periods in which soil restoratively idles. Government subsidized fertilizer is applied to the crops with little to no attention to the particular needs of each different plant species. Seeding, maintenance, and cultivation are typically done manually by family or hired workers using basic tools like hoes (Powell). This reliance on manual labor stresses the false need for sizable and unsustainable families, further dragging farmers into the poverty trap. The inefficiency of the common farmer has immense repercussions in the form of degraded soil, lost money, and wasted time. As farming communities become more desperate to produce crops, they typically either reduce allotted fallow time or resort a nomadic lifestyle, utilizing slash and burn tactics to get the most they can out of a plot of land before moving on, leaving the area desolate and wasted. The farming practices currently implemented exacerbate the already naturally deficient state of the soil and neglect to remediate environmental damage; if continued, this toxic agriculture industry will result in the eventual desertification of all arable land in Nigeria.

Because population pressure, environmental adversity, natural calamities, and climate change are all slowly encroaching upon Earth's arable land, many have already begun exploring possible solutions to alleviating soil degradation with creative mechanical, chemical, and biological innovations. World Food

Prize laureate Daniel Hillel pioneered the agricultural remediation revolution with his invention of micro-irrigation, a water distribution system designed to "maximize efficient water usage in agriculture, increase crop yields, and minimize environmental degradation"(Hillel). Hillel's attention to the economic and environmental significance of soil sparked interest in soil reclamation, an often overlooked and ignored aspect of agriculture. In arid and semi-arid countries like Nigeria, soil salinity is a limiting factor in crop production caused by weathering of parent material, deposition of sea salt carried in wind and rain, inundation of coastal land by tidal water, rise of water table due to excessive irrigation by underground water, irrigation with salt containing water, and poor drainage (Powell). Plants living in highly saline soils are put under extreme environmental stress; the salt levels interrupt germination, growth, reproduction, and physiological processes, a series of interruptions which eventually result in the organism's death. Approximately 831 million hectares of land on Earth are salt-affected (Focus on the Issues), and contrary to similar snags in the agriculture system, salinization cannot be solved by fallow or fertilizer; the solution requires active human involvement. A cost-effective solution to the global predicament of salinization and Nigeria's food insecurity could lie in halophytes, more specifically the use of halophytes as cover crops in salt-affected soils.

The majority of plants experience "salt stress" in high concentrations of sodium and chlorine ions which inhibits their growth, regeneration, and germination. Some plants are tolerant to saline soils, but, generally, as the salinity of soil increases, the number of species able to survive decreases. However, an exception to the limiting factor of soil salinity are halophytes, plants that have adapted to not only tolerate saline soil, but to also lower the salt concentration of the soil through a process called salt excretion. High concentrations of salt ions are toxic to most plant life because when a plant uptakes saline water through its roots, the salt ions accumulate in the cytosol of cells and essentially choke the organism. Halophytes developed an improved transport system which minimizes salt uptake, preventing excessive salt accumulation in photosynthetic tissues. The excess salt that is fostered by the plant is transpired through the stomata, or sweat glands of the leaf, thus removing it from the soil (Sopory). The concept of cover crops first evolved from the idea of "green manure," or a natural fertilizer substitute from derived from decomposing biomass, but since then it has evolved to have multiple purposes catered to each the modern farmer's need. Cover crops are generally deep-rooted plants with large, sturdy leaves that prevent topsoil erosion by slowing the velocity of rainfall before it infiltrates the soil, slowing percolation rate, and subsequently preventing flooding. As cover crops decompose, they return the vital bioavailable nitrogen and phosphorous stored in their tissues to the soil for other plants to assimilate, essentially adding a layer of natural fertilizer to the soil. Some cover crops, primarily legumes, are implemented specifically to fix nitrogen, an essential trace element necessary for amino acid, protein, and DNA production, through their root nodules forming a symbiotic relationship with the nitrogen fixing bacteria in the soil ("Cover Crops). In summary, cover crops are multipurpose biological tools traditionally used to maintain soil health, but hypothetically could be used as phytoremediators. Though this proposed phytoremediation has become a sexy buzzword in the environmental community, simply implementing halophytes will take precious years to restore degraded soil back to an arable state. However, if halophytes were to be implemented as cover crops, strategically planted crops maintain soil health, the combination of desalinization and prevention of erosion and leaching could accelerate the reclamation process enough to help the impoverished farmers who have been farming the same exhausted soil for generations.

Recruiting halophytes as cover crops has exciting potential as a clean, cost-effective method of alleviating soil degradation and poverty in agrarian societies like Nigeria. The optimal plant for this proposed phytoremediation is the species Atriplex halimus L., a deep-rooted Mediterranean saltbush capable of phytodesalinization and erosion prevention (Walker). If integrated into the country's agricultural blueprint, the proposed salt shrub would directly desalinate the soil and combat erosion. As the system stabilizes, the developed roots of the halophytes would prevent leaching and slow the percolation rate of precipitation, therefore increasing water retention. As the plant sheds organic matter, the decomposing biomass would act as a natural fertilizer to recycle nutrients back into the soil. With the passage of time, the soil

would slowly remediate and acquire a healthy balance between nutrients, moisture content, and particle size; therefore, reversing the environmental positive feedback loop that holds farmers beneath the poverty line. As the rejuvenated soil produces a sufficient crop yield, the farmer's wages and the availability of food increases, alleviating economic and food insecurity. To live independent of the threat of food insecurity is to live freely; it is to live with opportunities and luxuries considered necessities in wealthy nations like education, health care, family planning. Once relieved from the burden of food insecurity, people who were once concerned with filling their stomachs and nothing more become innovators and economic stimulators, capable of breaking from the cycle of poverty to live a meaningful and satisfying life.

By redesigning Nigeria's agricultural blueprint to be environmentally conscious and sustainable, we can lift the weight of food insecurity off the backs of the impoverished and help them escape from poverty. Healing is a slow and arduous process; like any scratch or bruise it will take time and patience to remediate the mistreated soil and people of Nigeria. However, with the healing of a generation comes the success of their children and their children's children. If we can learn to cycle through land in a sustainable and conscientious manner, we can transform the abusive relationship between people and our planet into a symbiotic relationship. Earth that was once scorched can be farmed, and the thirteen million hungry people ("Feed Yourself") who survive on scraps can live with full stomachs, clear eyes, and loud voices; all that's left to do is start planting.

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