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GEOG 1410

The Whole World Has Bean Waiting

Throughout the 1960s and 1970s, concern about rapid population growth and increased famine and poverty around the world prompted the Green Revolution. At its core, the Green Revolution aimed to eliminate hunger and to introduce agricultural innovations from the developed to the developing world. These technological innovations aimed specifically at increased production of wheat, rice, and maize. Despite producing significantly higher yields and avoiding the Malthusian crisis of a food shortage, the Green Revolution led to countless environmental problems. As the global population continues to grow each year, in combination with rising global temperatures, and environmentally unsustainable practices following the Green Revolution, it is still necessary to increase food production. It is essential to increase crop yields without liberal application of pesticides, fertilizers, and wasteful irrigation. Instead, food production must switch to incorporate more sustainable forms of agriculture. Implementation of leguminous crops in agricultural systems provides a sustainable solution for increasing soil productivity, decreasing use of chemicals, and providing a much-needed source of protein for many people in rapidly-growing populations around the world.

Legumes include a staggering 13,000 varieties of beans, peas, soybeans, peanuts, clover, alfalfa and lentils. Nearly all legumes are an important source of complex carbohydrates, protein, fiber, and vitamins, and provide an inexpensive source of quality plant protein as compared with meat substitutes ("The Health Benefits of Legumes"). In increasing food production for the ever-expanding population during the Green Revolution, the focus on wheat, maize, and rice led to dietary deficiencies in many diets in the developing world. In 2012 in Malawi, maize occupied

about 80% of the land area under cultivation and accounted for more than 80% of the population's caloric intake (Ngwira 149). Although valued as a "staple crop," maize contains more starch and sugar than protein- and nutrient-rich legumes. Because the first Green Revolution focused on principle cereal crops, "dietary diversity decreased for many poor people, and micronutrient malnutrition persisted" and led to an increasing price of legumes (Pingali 12304). Although the Green Revolution made maize, rice, and wheat more economical for low-income countries, this led to a decrease in crop production for other crops, thus resulting in a decreased supply of diverse nutrients for farmers and people in developing countries as a whole. An article from the "Society for Science & the Public" published in 1973 already began to recognize the drawbacks of focusing on such a limited range of crops. During the Green Revolution in India, farmers decreased legume production in favor of wheat, likely depleting the nutritional supply of protein because "legumes contain more protein than wheat" (Arehart-Treichel 42). In "Roots of the Second Green Revolution," Lynch highlights the importance of legumes for human nutrition and their high market value compared with staple crops (Lynch 506). In addition to their environmental pay-off, the increased value of legumes could make them a more economically-valuable export for developing countries. Boosting the production of legumes will provide more substantial sources of protein and vitamins in developing countries that lack these essential dietary elements, and give them an increased potential to become competitive food producers in the global economy.

Many plants introduced during the Green Revolution required integrative use of fertilizers and irrigation in order to produce massive yields. The first Green Revolution led to "Unintended consequences in water use, soil degradation, and chemical runoff" (Pingali 12304). Due to the increasing global population, it was essential to increase food production during the

Green Revolution and this remains necessary today. However, producing monocultures of "staple crops" like maize deplete soil nutrients and require artificial chemicals in order to produce substantial yields. When significant amounts of fertilizer are artificially added to soil, which is often necessary to produce high yields of crops, "the excess nitrogen runs off soil and pollutes the environment" (Arehart-Treichel 43). The increased global population requires an ever-increasing food supply, but artificial fertilizers are not a realistic solution on a large scale because of their environmental consequences. The global carrying capacity will decrease significantly if increasing crop yields come at the cost of depleting ecosystems which humans are dependent on. Planting more leguminous crops can boost Nitrogen fixation from the atmosphere and Carbon sequestration in agriculture (Snapp, 20840). Through the process of Nitrogen fixation, legumes can convert atmospheric Nitrogen into Nitrogen that can be used by other plants, thus adding valuable nutrients back into nutrient-depleted soil. These nutrient-efficient crops could be beneficial in wealthy nations by "reducing the cost of production and environmental impacts of intensive fertilization" (Lynch 506). Because they have the ability to add nutrients back to the soil, and do not require the addition of nitrogen fertilizer, legumes are able to support "efficient, sustainable use of fertilizer" (Snapp 20842). Leguminous crops have the ability to increase soil productivity through nitrogen fixation and reduce the amount of environmentally-harmful chemical fertilizers needed to grow large yields of other crops.

Despite increasing crop yields worldwide, the benefits of the Green Revolutions excluded many developing countries, which continue to struggle with food security and crop diversity still today. Although innovations extended to Asia and South America, "Sub-Saharan Africa continues to be the exception to the global trend" (Pingali 12302). Beginning in the 1970s, scientists began recognizing Africa's exclusion from the benefits of the Green Revolution. The

article, “Biodiversity can support a greener revolution in Africa,” identifies the need for introducing sustainable principles in Africa, “where ecosystems are degrading and crop yields have stagnated” (Snapp 20840). According to Jonathan Lynch, a distinguished professor at Penn State, states that the technologically-rich methods of the first Green Revolution were not available to many of the neediest people because “many third-world agroecosystems rely on crops other than wheat and rice” (Lynch 493). Furthermore, Lynch believes a second Green Revolution could improve the yield of crops grown in infertile soils by farmers with little access to fertilizer (Lynch 493). Although largely excluded from the yield increases of the first Green Revolution, developing countries, with some of the highest rates of population growth around the world, could experience an enormous potential to increase food production. Considering the benefits to soil by planting legumes, this increased production would come without the environmentally detrimental practices that were implemented in the first Green Revolution.

As a testament to their potential, legumes have already been used in a variety of agricultural systems including cover-cropping and intercropping systems. A study conducted in 2010 revealed that legumes could be used to maintain growth and produce grain late in the season, after a cereal crop is harvested (Snapp 20841). This same study revealed the potential for vegetative cover of legumes to “support complex trophic soil food webs and conserve soil” because of their ability to provide an additional two to six months of cover (Snapp 20843). The extended growing season of many leguminous plants, like clover and alfalfa, can be used as a cover crop to prevent topsoil erosion when soil would otherwise be exposed to the elements. A project launched in Benin tested the use of Mucuna or “Velvetbeans” as a maize covercrop. Mucuna is an edible and extremely vigorous vine that grows well in moderately poor soil, is drought resistant, and has bacteria-rich roots that store nitrogen (“Mucuna”). When used as a

covercrop, it has been shown to add biomass to the soil, retain moisture, prevent erosion, and reduce weeds, while producing higher maize yields according to research conducted by The Oakland Institute. In addition, leguminous use as a covercrop, particularly shrubby legumes, "performed reliably across diverse soil types and precipitation patterns," exemplifying their ability to be used in various climates across Africa and in other third-world regions (Snapp 20843). The combination of traditional high-yielding varieties (Maize) and environmentally beneficial legumes (Mucuna) in covercropping systems prove the ability to increase yields while also providing environmental benefits.

In addition to its use as a covercrop, using leguminous plants in intercropping systems provides potential benefits for consumers, farmers, and the environment. One particular case study examines the effects of intercropping legumes with maize in Malawi, a low-income country in Africa that is largely dependent on agriculture. According to the CIA World Factbook, Agriculture accounts for about one-third of Gross Domestic Product and 90% of export revenues ("The World Factbook"). As of 2016, Malawi also had a fertility rate of 5.54 children born/woman ("The World Factbook"). The rapid population growth modeled in many African countries necessitates increased sustainable food production. Like many other developing countries, Malawi's extreme dependence on a single crop makes it vulnerable to changes in weather and the possibility for a disease to wipe out their entire supply of a single crop. Intercropping maize with a particular legume called "pigeonpea" resulted in "more than double gross margin compared to conventional tillage systems" (Ngwira 154). Not only does this system produce an additional crop that farmers can sell for profit, but it can increase the productivity of current valuable exports as well. In transitioning into polycultural production through the introduction of leguminous crops in intercropping systems, many developing countries can

increase food production and diversify sources of nutrition. According to the study in Malawi, intercropping maize with leguminous crops may also be critical in enhancing productivity, increasing farmers' incomes, sustaining and improving soil fertility, and reducing labor shortages" (Ngwira 150). Unlike the short-vision goals of the first Green Revolution, using legumes for intercropping can play an instrumental role in combining enrichment of the soil with the health of local agricultural productions. These benefits can provide larger implications for Africa's economy while providing an environmentally sustainable model for the rest of the world.

As a result of population and environmental stress on human, plant, and animal populations around the world, alternative methods of sustainable agriculture are required to prevent a global crisis. The first Green Revolution provides us with valuable lessons regarding the sustainability of food production and the potential benefits and downfalls of producing only a few crops in huge quantities. Maize, rice, and grain produce high yields and remain "staple crops" for countries around the world. However, the use of these crops alone deplete the soil of valuable nutrients and lack in their nutritional value to consumers. As our world continues to increase food production, it is important to be conscious of the environmental, nutritional, and sustainable impacts of agricultural production. Implementing leguminous agricultural techniques provides innumerable environmental, social, and economic potential due to their ability to fix nitrogen in the soil, provide nutrients to famished consumers, and their potential to be used with cover-crop and intercropping systems. In the coming years, it will be impossible to experience true global prosperity without implementing leguminous agricultural techniques.

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