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Egypt, Sustainable Agriculture

Egypt: Aiding Malnutrition with Arbuscular Mycorrhizal Inoculants

Egyptian Economy

Egypt has a mixed economy, with agriculture, manufacturing, and services playing significant roles. The Gross Domestic Product (GDP) has shown moderate growth in recent years of 6.6% in 2022 according to the Food and Agriculture Organization of the United Nations (FAO), supported by economic reforms and infrastructure development, including subsidy reductions and currency devaluation, to address fiscal imbalances and attract foreign investment. The International Monetary Fund (IMF) provided financial assistance in the form of a loan to support these reforms. Egypt has been working to attract foreign investment, especially in sectors like energy, infrastructure, and telecommunications. Government initiatives and policy reforms aim to create a more favorable business environment. Due to Egypt's debt burden from recent wars the government has been seeking out foreign investors in order to increase their money supply.

Agriculture is a crucial sector, contributing to employment and food production. Key crops include wheat, rice, and corn. The government has been working on improving irrigation systems and enhancing agricultural productivity. Manufacturing and industry are vital contributors to the economy, with sectors such as textiles, chemicals, and construction playing significant roles. Egypt has been encouraging industrialization through investment incentives and infrastructure development. Egypt has historically been a popular tourist destination due to its rich cultural heritage and historical sites, including the pyramids and temples. The tourism sector faced challenges, particularly security concerns due to the recent military coup in 2011, but efforts have been made to revitalize and promote tourism.

Climate and Geography in Egypt

Egypt is bordered by the Mediterranean Sea to the north, the Gaza Strip and Israel to the northeast, the Red Sea to the east, Sudan to the south, and Libya to the west with a total land area of about 1,010,408 square kilometers. Due to its location Egypt has been surrounded by war and conflict throughout most of history. The competition for land and scarce resources near the Nile has been fierce due to the limitations of a desert climate. The climate in Egypt can be broken down into three broad regions, the desert, the Mediterranean, and the Sinai Peninsula. The majority of Egypt has a desert climate with extremely high temperatures during the day and cooler temperatures at night. Rainfall is minimal, and these areas are characterized by arid landscapes. The northern coastal areas, including the Nile Delta, have a Mediterranean climate with mild, wet winters and hot, dry summers. Rainfall is more frequent in this region compared to the rest of the country. Finally, the Sinai Peninsula experiences a desert climate, similar to the rest of Egypt, with hot temperatures and minimal rainfall. However, the high mountain ranges in the peninsula can lead to cooler temperatures in elevated areas. Only 4% of Egypt's land is used for agriculture according to the FAO. The Nile River plays a crucial role in shaping Egypt's climate, providing a water source for agriculture and influencing the temperature along its course. Seasonal winds, such as the khamsin, can bring hot and dusty conditions, especially in the spring. Overall, Egypt's geography and climate have had a profound impact on its historical development, with the Nile River serving as a lifeblood for agriculture and settlements in an otherwise arid landscape.

Family in Egypt

Family life in Egypt is often characterized by strong family bonds, traditional values, and a collective sense of responsibility towards family members. Extended families often live in close proximity or even in the same household so grandparents, uncles, aunts, and cousins can all play significant roles in family life. It is common for multiple generations to live together, fostering a sense of intergenerational support. Families in Egypt serve as a crucial social support system. In times of need or crisis, family members come together to offer assistance, both emotional and practical. Marriage is highly esteemed in Egyptian society, and families often play a significant role in the matchmaking process, but in recent times, there's a growing trend of individuals choosing their own partners. Parenthood is highly valued, and having children is seen as a blessing. Families are typically close-knit, and grandparents often play an active role in raising grandchildren. However, in urban areas, especially among the younger generation, there is a trend toward smaller nuclear families due to factors such as modernization, education, and career opportunities.

Education is considered essential, and families generally encourage their children to pursue higher education. According to United Nations International Children's Emergency Fund (UNICEF) 91% of the population complete primary school and 70% of the population attends upper secondary school at some point. In recent years, there has been an increase in the number of women pursuing higher education and joining the workforce. UNICEF reports that 38% of students enrolled in higher education are female. Men are typically expected to provide for their families, and career choices are often influenced by the need to secure stable employment. Traditional gender roles are often observed, with distinct responsibilities for men and women. While there have been changes over time, especially in urban areas, certain traditional expectations may persist, such as women taking care of domestic duties and men being the primary breadwinners. It's important to note that family life can vary across different socio-economic backgrounds, urban and rural settings, and individual preferences. While traditional values persist, societal changes and globalization have also influenced family dynamics in contemporary Egypt.

Malnutrition in Egypt

Malnutrition has been a persistent issue in Egypt, affecting various segments of the population. Malnutrition encompasses both undernutrition and overnutrition, and it is influenced by factors such as economic conditions, food security, and healthcare access. Malnutrition in the form of stunting (low height for age) and wasting (low weight for height) has been observed, particularly among children. According to the FAO, as of 2022 22.3% of children experience stunting and 6.8% of children experience wasting. As reported by the FAO 5% of Egypt's population experience undernourishment. According to UNICEF poor access to a balanced diet among the poorest sections of society, as well as poor dietary habits, lifestyle and lack of nutritional awareness across the population contribute to malnutrition. Furthermore, the limited access to food is extrapolated due to Egypt's dependence on imported food due to the lack of arable land as discussed previously.

Economic challenges and poverty contribute to food insecurity, limiting access to nutritious food for some segments of the population, especially rural populations. These vulnerable groups may experience deficiencies in essential micronutrients such as iron, iodine, and vitamin A which can lead to various health problems, particularly among children and pregnant women. Traditional dietary patterns in Egypt may not always align with modern nutritional guidelines, affecting the overall health and nutritional status of the population. Furthermore, limited access to healthcare services, especially in rural areas, can contribute to the prevalence of malnutrition. Regular check-ups, nutritional counseling, and interventions are crucial in addressing and preventing malnutrition. The Egyptian government has implemented various initiatives and programs to address malnutrition, with a focus on improving access to nutritious food, enhancing healthcare services, and promoting public awareness about proper nutrition. Addressing

malnutrition requires a comprehensive and multi-sectoral approach, involving not only the healthcare system but also education, agriculture, and social support systems.

Solution Research

Saltwater intrusion is the inward movement of seawater. Saltwater intrusion dramatically changes the chemistry of tidal freshwater wetlands. Soil salinization can occur slowly over time or rapidly. The slow processes include groundwater exchange, surface water mixing, and tidal pumping (Tully et al, 2019). Sea levels rising and periods of prolonged drought can increase the speed of these processes. Rapid soil salinization occurs during events like tsunamis or hurricanes. An anthropogenic source of rapid salinization is man-made canals through saltwater marshes that provide an unnatural flow of saltwater into areas that have never been affected by salinity.

Mohamed Hemida Abd-Alla et al. conducted an experiment in Egypt to assess how *Vicia Faba*, also known as fava bean, growing in alkaline soil was affected by both arbuscular mycorrhizae (AMF) and rhizobium because they found a need for agricultural solutions to fix land unable to support plant life. Fava beans are an important native legume that Egyptians have survived on for centuries and the study was an effort to increase crop yield, sustainably, in a country with an ever-increasing population. The results indicate that the plants under salt stress were aided in their growth by AMF and plant fitness was improved (Abd-Allah, 2014). Abd-Alla et al. suggest that the inoculant-infected roots' ability to absorb the mineral from the available soil was increased. This idea can be introduced to other areas with salt-stressed soil that can potentially be used for repairing soil and increasing crop yields.

I conducted a study to test the viability of a solution that can be introduced to Egyptian farmers, AMF inoculants. I chose to grow *Lactuca sativa var capitata* and I tested the salinity levels 0 dS/m, 1.35 dS/m, and 2.7 dS/m because the average salt tolerance of *Lactuca sativa var capitata* is 1.35 dS/m. Each salinity level had two groups: a control and an experimental inoculated group with two plants in each group. Germinated seeds were transplanted into the pots and experimental group plants were inoculated in the new pots with one tablespoon of AMF inoculant. The inoculant is a powder that is spread onto the roots of the seedling or directly on the seed. Inoculation is a very simple process that can easily be taught to people of any educational background.

I gathered data by measuring the fresh and dry mass of the plants that were grown. I also collected data weekly by testing the salinity level of the potted soil where the plants were grown. This gave me insight into how the AMF and the plants affected the molecular makeup of the soil that they inhabited. Testing salinity over the course of the plant growth allowed me to look at the timeline of how long it takes for the plants to take up the salt present in the soil at the time of planting.

Through my research, I determined that *Lactuca sativa var capitata* has greater fresh mass and water uptake when inoculated with AMF at all salinity levels I tested. My hypothesis was supported by the results of the experiment as all of the inoculated groups had greater masses than the control groups. At the 1.35 dS/m and 2.7 dS/m levels of salinity, the *Lactuca sativa var capitata* control group plants' growth was inhibited by the salt stress while the inoculated plants were not. The mycorrhizal symbiosis helped the plants reach more nutrients in the soil and increased plant yield. Mycorrhizal inoculants are an excellent alternative to using expensive fertilizers to replace depleted soil in farms in Egypt. From the data collected, it can be concluded that the AMF led to better growth and vitality in salt-stressed *Lactuca sativa var capitata*. In the future researchers may want to test more crops that are grown in areas affected by saltwater intrusion such as Egypt in order to properly assess its usefulness in these regions.

Implementation of Research

AMF inoculants are a sustainable method of increasing crop yields for plants in many adverse growing conditions. The inoculant should be introduced to smallholder farmers with access to modern farming techniques, technology, and financial resources. This can enhance their productivity and income while continuing to promote sustainable agriculture as the inoculants are naturally found globally and have not shown to have any lasting negative effects on the environment. In order to introduce the inoculant to farmers, Baden Aniline and Soda Factory (BASF) could be a knowledgeable and trusted resource. BASF currently provides training and technology to smallholder farms in many countries including Egypt (BASF, 2024). Farmers may be willing to introduce AMF to their farms if BASF is the group to introduce it to them due to their longstanding relationship with the farmers in the region. The Food and Agriculture Organization (FAO) may also be a good resource for introducing AMF to smallholder farmers because they are a globally trusted organization that can potentially be trusted by the farmers. Currently the FAO has an office in Egypt that has worked with the government of Egypt since 1978 with a focus on creating policies and national strategies to guide the sustainable development of agriculture and food security (FAOSTAT Egypt, 2024). With a focus on how the inoculant can increase yield and land use the farmers are likely to be receptive to the introduction.

To start with, BASF and the FAO can gather a group of farmers in a region that have been very receptive to their help and introduce them to AMF inoculants. Educational resources such as posters with pictograms depicting the increased nutrient uptake that AMF allows may be needed as farmers with limited education or literacy will easily understand them. Then, due to the resources available to them it may be best to assure the farmers by covering the costs of farming for the year if they implement AMF so that the farmers don't have to risk losing a season's worth of crops. If the inoculation is successful and increases crop yield then they can use these farms as examples for when they introduce the inoculants to other farms in Egypt. Starting with a small group and expanding outward to allow word of mouth and results of the AMF treatment to persuade other farmers to implement the solution to their lowering crop yields as the effects of saltwater intrusion continue to plague the regions closest to the Nile River.

AMF inoculants are readily available commercially and with financial aid, many farmers should have no issue with gaining access to it. The inoculant does not need to be reintroduced to the soil very regularly so it will not be a long term expense to the farmers. This is a large concern as farmers and those living in the rural regions of Egypt tend to be the poorest sections of society. The Borgen Project can step in to influence the Egyptian government to invest in the education and supply of AMF inoculants in order to achieve their mission of addressing global poverty. According to Martha V. T. Cely et al., the inoculants can increase the crop yield of cotton and soybean plants (Martha, 2016). Cotton growth, as one of the major crop exports in Egypt, has a huge impact on the economy in Egypt. The Egyptian government is likely to be receptive to this initiative because if crop yields in Egypt increase, foreign investment is likely to increase as well due to greater financial incentives. This is conducive with the Egyptian government's recent fiscal and monetary policy actions.

Conclusion

Egypt has a desert climate that makes most of its land unable to support agriculture but with sea levels rising the small portion of arable land that they have is being salinized. Salt intrusion of farmland is especially harmful to the poorest sections of Egyptian society who don't have access to imported food. AMF inoculants are a cost-effective and sustainable alternative to artificial fertilizers for giving Egyptian farmers access to more arable land. AMF has proven to increase crop yields which may create an economic incentive for the Egyptian government as well as foreign businesses to invest. Overall, AMF inoculants are an environmentally and economically beneficial solution to food insecurity in Egypt.

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