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Fighting Climate Change With Flood Resistant Rice

It is a well-known fact that rice is a staple for billions of people across the globe, 3.5 billion to be exact (CGIAR, 2019). Rice, or Oryza sativa in scientific terms, is responsible for 19% of human energy, in association with caloric intake (CGIAR, 2019). Though our dependence on rice has been well examined, the problems with how our current rice production operates needs further exploration. If we are going to move forward with sustainable agricultural practices, we have to reconsider how we grow our most basic crop.

There are many types of rice production, paddy fields - or wet farms- being one of the most common throughout southeast Asia (Climate and Clean Air Coalition, 2018). In China, however, rice terracing is most common because of its ability to take advantage of land on hills and mountains that would otherwise be used for grazing or residence. The Asian continent grows over 90% of the world's rice, with 25% of that from India, second only to China's 31% (CGIAR, 2019). And the most common variety of rice grown in the Indian subcontinent is Swarna, which is useful for scientists because of its ability to be genetically modified and easily cross-bred (Asia Society, 2021).

One of the biggest issues with rice production is the total loss of crop yields due to unpredictable weather and flooding. Although rice is a semi-aquatic plant, it will die if submerged in water for more than 2-3 days (Johnson, 2015). Because of the recent changes in our climate, an estimated 4 million tons of rice are lost every year (Ornstein, 2019). For reference, that is enough rice to feed 30 million people annually (IRIN News, 2009). The challenge of reversing changing weather patterns on a global scale is not a realistic option to solve this problem. Scientists must look instead to alter the genetic makeup of our crops to help challenge the limitations of their environment.

Dr. David Mackill, a scientist studying biotechnology and plant breeding, is currently working at the International Rice Research Institute (IRRI) to address this issue. According to a recent interview with Mackill, the IRRI has been able to isolate what they called the "*Sub1*" gene, which is now responsible for Swarna's ability to survive underwater (Asia Society, 2021). Specifically, the *Sub1* gene is able to prolong the survival of rice underwater by tampering with the quiescence scheme that takes place on a cellular level. The naturally occurring process allows plant cells to rest for a relatively long period of time in which they do not replicate, giving them time to stall before re-entering the cell cycle (Oladosu, 2020). This builds underwater endurance that can keep cells alive, allowing plants to last up to an additional 10 days fully submerged. Some other mechanics include changes in the architecture of leaves, and enhances in the plants ability to escape stress-inducing environments by rapid elongation of the central stem -- pulling the plant up to a higher elevation (Oladosu, 2020).

The *Sub1* gene is naturally found in smaller rice varieties in Sri Lanka and Orissa, and was able to be transferred to Swarna. An experimental study was conducted where the newly modified Swarna crop was grown in close proximity to a control group, and the results were astonishing. The genetically altered rice survived over 17 days fully submerged in water, 21 in some areas, with no visible effects on the health of the plant (Ornstein, 2019). However, the IRRI is still pushing to get the new variety approved for commercial use, and several complaints have been made about the taste of the variant.

This new wave of research has only just begun. Pamila Ronald, a University of California-Davis professor and geneticist, lead a similar project involving Precision Breeding (Johnson, 2015). Also known as SMART breeding, this technique is done by selectively reproducing a particular species to obtain a certain desired trait. Her team was also able to use this technology to introduce *Sub1* gene into commercial rice varieties, without genetic modification. The precisioned breed was grown in a semi-controlled environment in India and Bangladesh (Johnson, 2015). The results found no difference in taste or texture of the rice, and not only was the breed water-resistant, it also produced 3 to 5 times more seed than the original variant. This new flood-tolerant rice is available to farmers throughout Asia. Because Ronald was able to take advantage of smart breeding, the wait time for commercial approval was much shorter than it would have been if she had taken the standard GMO route when experimenting with the *Sub1* gene (Johnson, 2015).

This case is just one of many upcoming flood-resistant strains to take over the market. However, my proposal is that every country, with the available resources and funding, should invest in hydroponic farms that are dedicated to the production of rice. With the incorporation of selective breeding, rice will potentially be able to survive entire seasons in nutrient-rich water with little to no maintenance or pest-upkeep. Capitalizing on hydroponic farms is a necessary step when transitioning to 100% sustainable agricultural practices. This will allow us to grow a considerably large amount of rice in controlled temperatures with a fraction of the amount of water required in comparison to paddy and terracing fields. Vertical agriculture is one of the few reasonable solutions to our food crisis. Not only will this cut costs in the long-term, but it will ensure that limited amounts of rice will be lost due to climate or harsh weather, and will expand the geographical area in which rice production can be located.

Although there is significant pushback against the use of plant breeding, without the technology we have today we would not be able to sustain our growing population. Malnutrition and hunger are very real and serious issues that millions of kids and adults face across the globe. Over 8.9 percent of the world's population right now has little or no access to food, that is 1 in 11 people (World Hunger: Key Facts and Statistics, 2021). Furthermore, a disproportionate number of those are women and children. Being able to successfully grow large amounts of rice and smaller plots of land will save lives and help protect the future of this planet.

Taking advantage of our land and prioritizing its uses is the only way to sustainably produce enough food to fight the hunger crisis. The amount of crop lost per year costs farmers and the agricultural community over 1 billion dollars, and the loss is directly linked to flooding (IRIN News, 2009). That is why the key to this solution is an investment in flood-resistant rice. Using our resources to advance our agricultural practices will support the ever-growing demand of our society. The world population is expected to rise over 9.7 billion by 2050 (Watts, 2019). We are not prepared. It is necessary for the nations of the world to unite and ensure that our methods of farming, both in fields and in greenhouses, will support us as the climate becomes more vicious and unpredictable.

Rice is not only a source of calories, but also a way of life for tens of millions of people. Seventy percent of India's rural households still heavily depend on agriculture as a main source of income (Rice Production in India, 2021). And with rice being their second largest export, the quality and variety of harvests are a top priority. Therefore, particular strands of rice have been cultivated in specific regions of India for hundreds, mere thousands, of years. Just in the 2019-2020 harvest alone, over 120 million tonnes of rice were produced in India. And since 1950 there has been a 45.959% increase in total farmland dedicated to rice, measured per million hectares. In addition, a 334.791% increase in yield was recorded, measured per million tonnes (Rice Production in India, 2021).

The international rice research institute has been in the process of breeding and testing several variants of rice for about 40 years now, however they have not been widely adopted in the larger commercial centers due to certain undesirable traits that come as side effects of the genetic modification. Reported side effects include grain quality reduction, and alterations in size and/or texture (Emerick, 2019). Farmers who were made aware of these traits reasonably turned down offers to switch variants. They rightfully feel as though it is too big a burden to switch to flood-resistant strains, and are confident in their specific crop to adapt to the frequent weather conditions recorded in the past semicentennial. However, the continuation of an experiment conducted in 2010 revealed that the *Swarna-Sub1* gene resulted in a 10% higher crop yield than the original Sawarna variant in dry conditions (Emerick, 2019). Therefore, the variant has been proven to increase yields in both droughts and floods, overall resulting in a higher profit.

So why is this strand not receiving attention in the most rural of villages that suffer the most from increased rainfall, record-high salinity levels, and prolonged dry seasons? The answer lies in the economic structure of India and its means of trade. The majority of farmers obtain packages of Swarna seeds for the season from government supply centers in order to profit off of the “buying-in-bulk” method, conserving a significant amount of rupees per kilogram. However, it is common for smaller farms to buy seeds through an informal sector composed of local farmers in the surrounding areas (Emerick, 2019). With the average cost of one kilogram of rice now at ₹24.50 ($1 = ₹74.29), farmers often look for better deals within their local markets, which can offer kilograms around half the average price. This makes it difficult for the *Swarna-Sub1* gene to be diffused to more rural fields that are prone to flooding, extreme weather patterns, and that often have little access to resources.

International organizations such as the Food and Agricultural Organization of the United Nations can help this dilemma by ensuring the spread of information concerning the modification of rice. If farmers are informed on the benefits of the *Sub1* gene and are given a reasonable ability to access such variants, then perhaps more rural areas will begin to adapt flood tolerant rice as a primary crop (FAO, 2000).

The IRRI is currently working with individual state governments to help encourage the diffusion of *Sub1* to farmers who wouldn't normally have access (Emerick, 2019). The best way to do this is to introduce the variant as a permanent product sold at various local markets. However, there is a lack of funding to support this investment.

Due to historic circumstances and religious beliefs, India can still be classified under a caste system, in which it is very difficult for individuals of lower status or finance to reach a higher caste level. The average rural household in India is approximately five people. And oftentimes, the parents work for/rely on the agriculture industry (India, Hce). Due to the lack of resources or access to quality education, the children follow in their parents footsteps - once they reach a certain age (India, Hce). Because such a high population depends on rice farming, foreign institutions often try to respect the intricacy of the system. However, due to the pressing issues - involving the gradual severity of weather patterns - the progressive wing of the Indian government is beginning to encourage the research and production of alternative crops and variants that will be able to sustain their growing population.

The investment in hydroponic technology will serve as the backbone of rice's economic viability in the future. Certain crops, including rice, have to be completely submerged in water to enhance the uptake of nutrients in the soil and to prevent weed growth, therefore increasing yield (5 Most Water Intensive Crops, 2017). And producing enough seed per season is necessary to maintain its economic status. However, rice is one of the world's top 5 most water intensive crops. On average, farms need 3,000 to 5,000 liters of water to grow just one kilogram of rice (5 Most Water Intensive Crops, 2017). As an alternative, hydroponics allows plant roots to absorb nutrients and water from designated reservoirs, recycling the solutions in the process. Oftentimes, artificially made nutrient solutions consist of a series of minerals and salts, depending on the desired crop. The most common solution mostly contains nitrogen, with trace amounts of potassium and phosphorus in dissolvable form. This results in a minimal amount of evaporation, saving a significant amount of water annually. On the other hand, there is a downside to this advantage. In 1999-2000, there were approximately 44.97 million hectares designated to rice production in India, with 19.9 kg of seed harvested per acre (Rice Production in India, 2021) In order to meet the growing demands within the food industry, the hydroponic alternative must produce more crops within a smaller surface area. In addition, the time period it takes for rice to fully mature can last as long as 180 days (5 Most Water Intensive Crops, 2017). This limits farmers to the equivalent of 2 harvest per year.

In the near future, as conditions worsen and the population increases globally, it is necessary to invest in alternative farming practices. Methods that require minimum upkeep, low water usage, and take up less square mileage than current techniques -- while still producing the same (if not more) crops -- must be adapted to the highest degree. However, the economic investment in vertical hydroponic agriculture can come with a hefty price. The amount of time, energy, and money that will be needed to construct the necessary infrastructure must be supported by various international organizations and national governments. So for the time being, flood-resistant rice grown through hydroponics can ensure that a minimal amount of crop will be lost due to over-submergence -- maximizing profits and establishing a sustainable method of rice production.

In conclusion, investigating the methods that naturally occurring plant species use to survive underwater, and integrating those mechanisms to common rice crops in India and around the world, can significantly reduce the amount of harvest lost to submergence -- benefiting farmers and ensuring food security on a global scale.

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