NeWold Times

a 3rd Millennium R&D Publication

Volume 3, Issue 1

February, 2016

Inside this issue

A Long Long Time Ago…

By: Raechel Baumgartner

A long, long time ago, hunter-gatherer societies transitioned into farming societies when they realized that planting and tending seeds of wild species was a more secure way of assuring a food source than pursuing herds of animals across the landscape. Fast-forward many generations and we have the domestication of species caused by repeated planting, harvesting, and replanting by the people in these farming societies who knowingly or unknowingly (but my money is on knowingly) replanted the seeds from the "best" plants, the ones that produced the most harvestable food. Fast-forward again to the beginning of the 20th century in the US and the situation had not changed much: the farming families were still planting, harvesting, and replanting the seeds from the "best" plants, those that produced the most harvestable yield.

If you look at our situation today, the main practice still has not changed: farmers still plant, harvest, and replant seeds of the varieties that produced the most harvestable yield, the "best" varieties. The part that has changed is who is doing the selection, and most of that change occurred in the last 100 years or so after the rediscovery of the work of Gregor Mendel in 1900. As scientists grasped hold of the concepts of segregation (which were hotly debated!) in the early 1900s, variety development became more scientist-dominated than farmer-driven, first through an explanation of what was being seen in segregating varieties and later by targeted crossing and breeding efforts, in turn leading to the dawn of plant breeding as a profession.

The 20th Century brought about some really fascinating and impactful developments in plant breeding, including but not limited to the development of single-cross hybrid corn and the development of dwarf wheat varieties. Single cross hybrid corn revolutionized corn production in the United States and has spread around the world. Semi-dwarf wheat varieties are now so widespread that unless they have read about it, people my age have no idea that wheat used to be much taller than anything we see nowadays. Horticulture crops have not been untouched by the advent of plant breeding either, with two key items being hybrid tomatoes and seedless watermelon. For a northern dweller, the abundance of new cold-hardy varieties of fruit trees is also very exciting.

Somewhere along the lines in the development of the plant breeding profession, the divide between farmers and scientists grew, and an "elitist" attitude regarding plant breeding developed. Not having been around at the dawn of plant breeding as we know it in the 20th century, I can only comment on what I have seen at the beginning of the 21st: most plant breeders, especially the new ones, seem to have forgotten the origin of crop development and how it was started by people with no formal education, just an awareness of their surroundings and the drive to survive. A lot of the groundwork for hybrid corn was developed before the rediscovery of Mendel's work with peas, including cross-pollination of different varieties and detasseling. Yields were improved in landraces before anyone knew the science behind what they were doing. And Norman Borlaug, the father of the Green Revolution, did not have a degree in plant breeding.

Plant breeding is an interdisciplinary field that encompasses a variety of other fields (Figure 1), including agronomy, horticulture, biology, chemistry, business management, pathology, plant physiology, genetics….the list goes on. An understanding of genetics is arguably one of the key components of being a successful plant breeder in today's world. However, understanding genetics is not the only important component, which is not evidenced by the genetics-heavy course load that current plant breeding students face (Figure 2). This kind of narrow focus is like using a magnifying glass to look at a fine painting: you can see the brushstrokes, but you lose sight of the big picture and what the artist is trying to convey. In plant breeding, we are becoming bogged down in one small component and losing sight of our overall goal: boosting production and sustainability on a global scale across all types of acres to help all kinds of people.

While I disagree with Harry Stine that "It takes a minute and a half to learn what there is to learn about plant breeding [3]," I firmly believe that you do not need a Ph.D. to be a successful plant breeder. Learning plant breeding fundamentals does not take a lifetime, maybe a few months with good instruction in both the field and the classroom (or classroom theory in the field). You then spend a lifetime fine-tuning everything and learning your germplasm. In the field, boots on the ground is where theory is tested and proven right, wrong, or too impractical for use. In the field, talking with other people in agriculture is where you really learn what you need to be doing as a plant breeder to meet the needs of those who are farming. Too many current breeders and breeders-in-training are not tracking enough dirt into their offices. This creates a disconnect between them and what is really going on in the fields of the world. The disconnect between plant-breeding and variety development and the farmers who ultimately grow the crops is something that makes me sad. The elitist society of plant breeders frustrates me and occasionally makes me angry. We need to work together again, with the plant breeders in the role of service providers to the farmers.

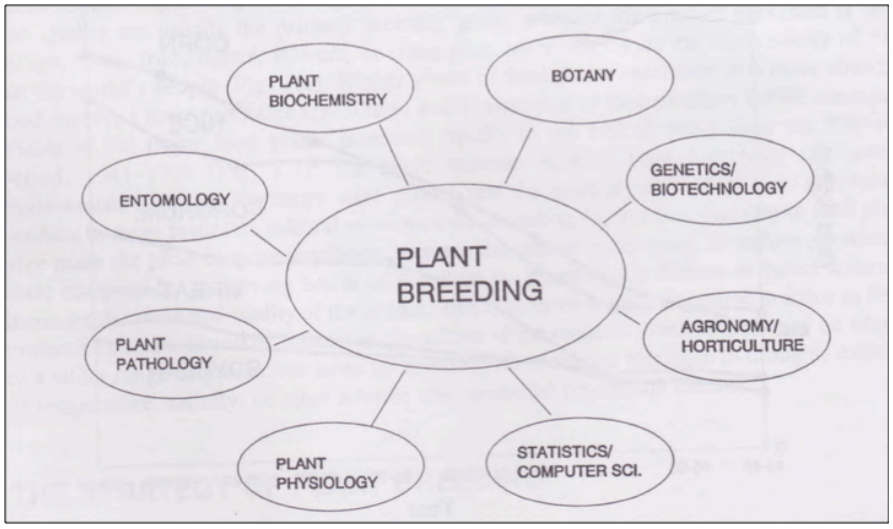


Figure 1. The interdisciplinary nature of plant breeding [1]

Although no courses are actually mandatory, virtually all plant breeding students take those listed below.

- For Master of Science
  - Agron 521 (3 cr) Principles of Cultivar Development
  - Agron 522 (2 cr) Field Methods in Plant Breeding
  - Agron 523 (3 cr) Molecular Plant Breeding
  - Agron 524 (3 cr) Applied Molecular Genetics & Biotechnology
  - Agron 528 (3 cr) Introduction to Quantitative Genetics for Plant Breeding
  - Agron 600A (1 cr) Plant Breeding Seminar
  - Agron 698 (2 cr) Agronomy Teaching Practicum
  - Agron 699 (variable cr) Research-related activities each semester
  - Agron/AnSci 561 (4 cr) Population and Quantitative Genetics for Breeding
  - Gen 510 (3 cr) Transmission Genetics
  - Stat 401 (4 cr) Statistical Methods for Research Workers
  - Stat 402 (3 cr) Statistical Design and the Analysis of Experiments / Agron 526 (3 cr) Field Plot Technique
- Distance Master of Science in Plant Breeding:
  - See the distance program site.
- Additional courses for Ph.D.
  - Agron 621 (3 cr)-Advanced Plant Breeding
  - Agron 625 (3 cr)-Genetic Strategies in Plant Breeding

Figure 2. Graduate coursework in plant breeding [2]

"Hybrid corn arrived through two complementary sets of skills: the field-based passion and intuition of the farmer who understands their crop and the abstract intellect of the scientist."

– Noel Kingsbury, *Hybrid: the History and Science of Plant Breeding* [4]

That statement of fact is something we need to keep in mind. The goal of the plant breeder is to bridge that gap between farmer and scientist, not add to it.

---

[1] Poehlman, John Milton and David Allen Sleper. Breeding Field Crops. 4th ed. Iowa: Iowa State University Press, 1995. 6.

[2] Plant Breeding. 2013. Department of Agronomy, Iowa State University. 3 February 2016. https://www.agron.iastate.edu/academic/graduate/plantbreeding.aspx

[3] Morrel, Alex. "Can This Man Feed the World? Billionaire Harry Stine's Quest to Reinvent Agriculture – Again." Forbes. 14 April 2014. http://www.forbes.com/sites/alexmorrell/2014/03/26/can-this-man-feed-the-world-billionaire-harry-stines-quest-to-reinvent-agriculture-again/2/#249fbdb6b689

[4] Kingsbury, Noel. Hybrid: The History of Science and Plant Breeding. Illinois: University of Chicago Press, 2011.

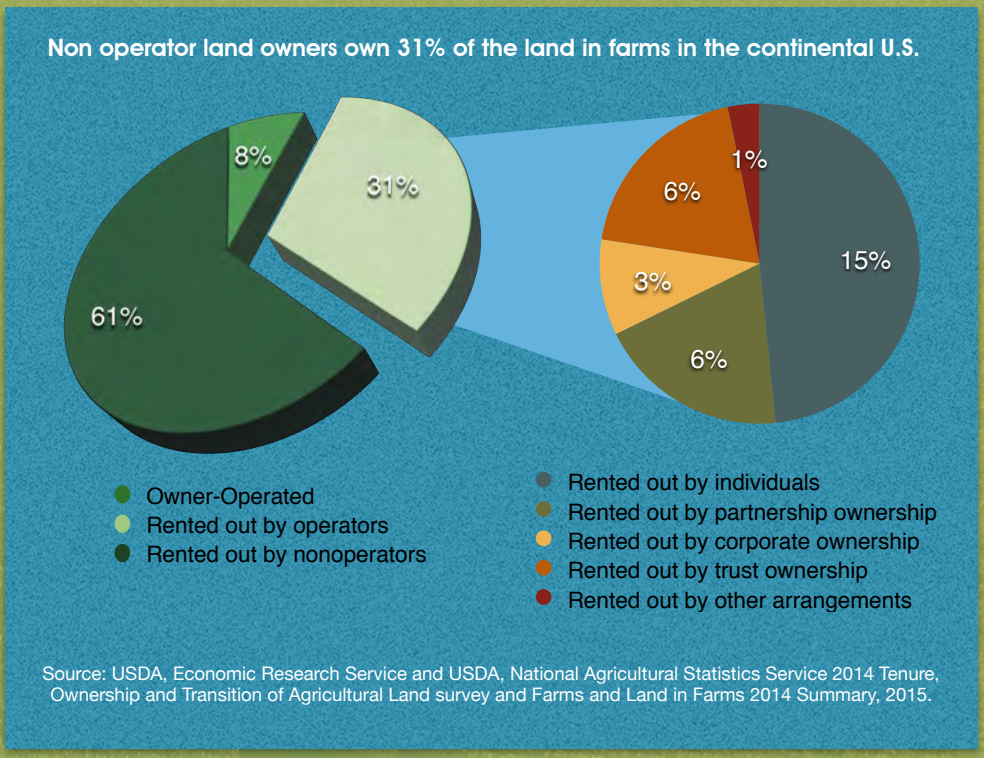
Land Ownership

by Erin Rodríguez

Land ownership is an integral part of modern day life in a profit driven society. Long gone are the days of feudalism that defined the agrarian era in Europe. Access to land was one of the cornerstones of the Agricultural Revolution and its success. However, there are also social components to land ownership. There was a time in this country that even the ability to vote was dependent upon owning land. Certainly, the times have changed but the importance and effects of land ownership have not. In regards to farming, this paradigm is even more engrained and farther reaching than the family home. The American narrative is one that tells us that the family farm is an integral part of our story- the idea that generations of the same offspring work toward the common goal of farming is primordial in our history. Little by little the family farm is becoming less prevalent. There has been much talk in the media lately about the diminishing numbers of American farms and the increase in the average farm size. How does land ownership and farming affect the social fabric of the communities in which they live? How will this change affect agriculture? In the final analysis, access and ownership of land is more than just an agricultural issue: it is a social issue.

There have been several significant changes in farming demographics in the last decade. According to US Agriculture census data between 2007 and 2012, the number of farms in the US dropped by 4.3% - making it a statistically significant decline. Likewise, the average farm size increased during this same period. There was also an increase in the number of farms that are run by non-owners. The number of farms with sales and government payments greater than $1 million doubled between 2007 and 2012. There seems to a correlative relationship between the growth of farm size and the decline of owner operations. *(http://www.agcensus.usda.gov/Publications/2012/Preliminary_Report/Highlights.pdf)*

While smaller farms have been on the decline, larger Ag companies have been steadily increasing their land holdings or land use through rental agreements and acquisition. This shift has many far reaching effects, some positive and others negative. It would be naive to think that one operation or the other is the sole hope for the future. A more realistic approach acknowledges that both of these types of farms have a place in our society. On one hand people want and need access to affordable food products. The large Ag operations that now dominate the global food market have been successful in that they have been able to streamline and mechanize the agricultural processes to ensure greater food production. Simultaneously they have been successful in minimizing



the risks associated with farming. However, with this industrialization of food production have come social consequences. For example, the labor force has been reduced as machines have been created that can do the work of ten laborers. Large farms have also become somewhat insulated from the rest of society and have suffered from a lack of understanding by the consumer, hence the cultural backlash many of these companies are receiving now. People fear what they do not understand.

In ever increasing numbers consumers are calling for organic or locally grown products. Customers want to know where and how their food is being produced. If you visit any major US city you are sure to find restaurants that provide farm to table fare. This is an area that the smaller farms are more adept to serve than their larger counterparts.

When a farmer owns the land on which he or she works, there are various advantages. Landowners have more access to capital and financing; they have the final say in how the land is used, and they can build more wealth for their family through inheritance. Studies also show that owner operators are more inclined to engage in conservation programs and practices. There are also some drawbacks to being an owner-operator: they carry most (if not all) the risks associated with farming. Farmers who rent land are subjected to the restrictions placed on them by the land owners. Furthermore, the renters are less inclined to engage in conservation practices- and who can blame them? These practices are expensive, time consuming and can quickly eat through a small profit margin. It is unrealistic to expect these farmers to foot the entire investment of land conservation for land that they do not even own. It is also true that without conservation and sustainability practices farmable land will become increasingly scarce. We learned this lesson the hard way in the US when the dustbowl devastated the Midwest in the 1930's. This phenomenon was not just a natural disaster, but rather a natural reaction to the ethos of agriculture at the time. This phenomenon caused a historical shift from the small family farm to the large corporate monoculture farm. This shift began with the dustbowl exodus from the Midwest. Small family farms and sharecroppers did not have the financial resources to bounce back from the disaster, and this was a major factor in the economic depression that defined the times. Consequently, American culture and farming were changed forever.

The correlation between land ownership and sustainable farming are not particular to the United States. Furthermore, the social consequences of private farmland ownership can be seen in communities the world over. A Peruvian economist, Hernando Soto poses the theory that land ownership is one of the biggest factors in combating poverty and hunger. He theorizes that because in capitalist systems the ability to sell, trade or invest in land creates capital which in turn maximizes productivity. *http://ecologic.eu/sites/files/project/2013/lot5_13_land_grabbing_en.pdf*

Throughout history eligibility to own land has been one of the consistent factors in the struggle for equality. For centuries one group or another has been denied land rights, whether it was women, black people, or poor people. On a global scale this struggle continues. In the US this struggle manifests itself in the class struggle. The gap between the haves and the have nots widens as land holdings continue to be concentrated in the upper echelon of the socio-economic scale. How can we as a nation -and furthermore as an industry- provide venues for small farmers to obtain, keep, and farm their land? I do not know the answer to this, but my hope is that we can work collectively to decrease this gap.

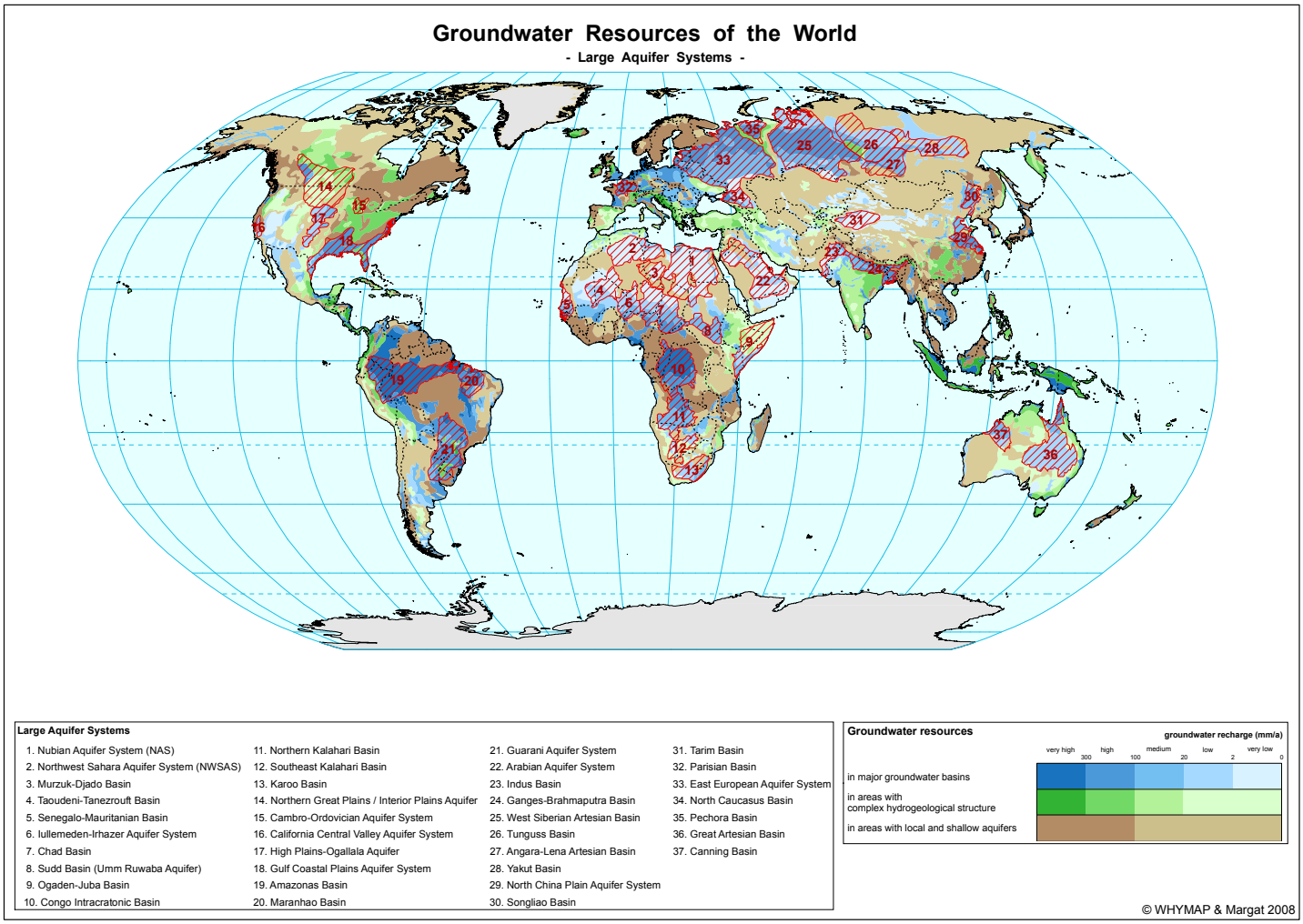
In the end, balance is what is most important. We need both ends of the spectrum. Without the larger Ag companies we would not have affordable food for the masses nor would we have a lot of the scientific advancements that have been made in the last decades. Without the smaller farms we would not be able to serve the rising niche markets such as organics and farm to table produce. The hope is that each of these sectors will take on some of the characteristics of the other. We need to create viable ways for non-owner operators to engage in more conservation practices, and likewise we need to ensure that the smaller farms have access to markets and scientific advances. Most importantly it is imperative that farmers of all sizes have access to land while using it in a socially and environmentally responsible way. I am an idealist- that is true, but I believe we can work together as an industry to be just in our business practices.

World's Water Supply

by Ed Baumgartner

There is a lot of discussion in our industry and agriculture as a whole regarding water use and efficient use of that water. We need irrigation water for our Puerto operations or we have no business, so this topic is very near to us too. Our local aquifer and surface water sources in Puerto Rico are under pressure from many different interests, including agriculture, industry, tourism, and urban needs. Agriculture is a big user of water and must become more efficient, or it will lose out in the water competition.

Aquifers are basically underground water storage areas that are generally recharged from surface water by percolation. As long as we do not remove more water than is added, we will have plenty of water to use. Globally, 37 large aquifers are monitored by many different agencies to try to understand our global water usage[1].



When the word "stressed" is used regarding an aquifer it means that we are using more water than what is being replenished. Recently the 37 large aquifers were re-assessed using groundwater storage levels calculated from satellite data [2] as opposed to solely using nationally reported groundwater withdrawal statistics[3]. The aquifers were classified based on their groundwater use and availability and divided into four stress regimes: Overstressed, Variable Stress, Human-dominated Stress, and Unstressed. Overstressed aquifers are actively being depleted and may potentially see a future decrease in aquifer storage capacity. Eight aquifers currently fall into this category, mostly located beneath Saudi Arabia and Yemen, in India, Pakistan and Northern Africa. Thirteen aquifers are considered "unstressed" in terms of water quantity, as storage levels are increasing. Most of these aquifers are located in areas of heavy rainfall and lots of surface water (such as along the Amazon River), sparsely populated areas (parts of Australia and Siberia), and also areas where

the typical rainfall meets population needs, such as the upper Midwest and south central Canada. That leaves the remaining 18 aquifers in the two variably stressed categories, which have stress levels categorized by the United Nations as Low, Moderate, High, and Extreme. Many of the stressed aquifers are located in—you guessed it—areas with high levels of cropland. The most notable for the USA is the California Central Valley aquifer, which is classified as highly stressed [3]. Our aquifer in Puerto Rico is stressed. We have a US Geological Survey well on our office property for monitoring.

What is not well understood is how water flows through aquifers. The Ogallala aquifer is very intriguing because it has declining water levels southern portion of it, covering parts of Texas, Oklahoma and Kansas, while areas of the northern part of the aquifer in Nebraska actually have rising water levels [5]. Why doesn't the water flow from the north to the south in the Ogallala aquifer? We are learning more through the volunteer monitoring programs in place in the USA, one of which is the High Plains Water-Level Monitoring Study [6], which tracks water quality and movement at various depths across the different states served by the aquifer.

While agriculture is a huge user of groundwater resources, it has not been completely reckless with its water use. Like anything new, you do take advantage of it until you realize that this is a precious resource (which gets expensive) and need to make changes to prolong the use of your precious asset. Perhaps even make it sustainable. Irrigation equipment manufacturers continuously develop products with more efficient application methods, reducing the total amount of water needed to grow a crop. Farmers adopt these products as they become affordable or necessary to stay in business. They change their farming practices to conserve water with no-till and cover crops. Each party is doing, and needs to continue to do, their part to help alleviate the situation. On our farm, we use drip tape for irrigation, which reduces the amount of water needed to grow a corn crop by 2/3 verses flood irrigation. We are only watering the row itself, not the total 30" space between rows, and we irrigate at a rate slower than the rate at which our soil can absorb the water, which in turn reduces the evaporation of water from the field. Today drip tape is too costly to be an economical solution for commercial commodity crop farms, but it is economical in high value crops like research work, orchards and vegetables. However, being made of plastic, the drip tape has a large environmental impact, as it is a petroleum-based plastic single-use disposable item rather than a biodegradable product. Finding someone willing to recycle the used drip tape is challenging also.

We intend to continue to work on developing corn (and someday other crops) that is more productive with less water than the current hybrids available to day. Our target is to find hybrids that can produce a reasonable, economic yield with 50% of the water used today. Is that possible? I am not sure, but we need to try. We are seeing nice gains from breeding cycle to breeding cycle with our no-spray/limited irrigation work, better known as Durayield. We had a group of people touring the farm during the last week of January, some of whom were on a similar tour in 2012. The repeat visitors brought up pictures of the 2012 Durayield nursery they saw to compare against what they were looking at in 2016. The group could not believe the difference (honestly, it surprised me, too), and now they recognize the power of breeding that we have been discussing since the beginning. The new families in development are much better than I hoped to see, and this gets me even more excited for the future. We want to make sure that farmers can make at least one less pass (even fewer, if we reach our goal) with the irrigator per crop to get that high yield while conserving our resources to recharge aquifer levels. This is a joint effort between all parties involved: farmers, corn breeders and equipment manufacturers.

Agriculture ultimately is about sustainability of all resources for the future generations, and yet we have some very real needs that must be met now as well. We need to ask ourselves very honestly and everyday, what are we doing that will negatively affect our children and grandchildren? What are we doing that will positively affect them? Then we need to work towards the solutions and make the necessary changes so that the gifts we were given are sustained—or improved—during our lifetimes by what we do each day. This takes courage, fortitude and persistence to make it happen. Godspeed.

---

[1] WHYMAP – Looking at Groundwater from a Global Perspective. http://www.whymap.org/whymap/EN/About/whymap_looking_at_gw_pdf.pdf?__blob=publicationFile&v=2

[2] Grace Mission. NASA. http://www.nasa.gov/mission_pages/Grace/index.html#.VrPDt8cshpo.

[3] Richey, A. S., B. F. Thomas, M.-H. Lo, J. T. Reager, J. S. Famiglietti, K. Voss, S. Swenson, and M. Rodell (2015), Quantifying renewable groundwater stress with GRACE, Water Resour. Res., 51, 5217–5238, doi:10.1002/2015WR017349

[4] Water-Level and Storage changes in the High Plains Aquifer,

[5] Predevelopment to 2013 and 2011–13. Groundwater Resources Program, US Geological Survey. http://ne.water.usgs.gov/ogw/hpwlms/files/HPAq_WLC_pd_2013_SIR_2014_5218_pubs_brief.pdf

[6] High Plains Water-Level Monitoring Study. United States Geological Survey, Department of the Interior. http://ne.water.usgs.gov/ogw/hpwlms/

Contributors

Ed Baumgartner
President

Erin Rodríguez
Editor, Assistant Marketing Manager

Raechel Baumgartner
Assistant Editor

Alexis González
Creative Design

We thank our staff at all our locations for providing us with support as well as many of the photographs used on our articles. Keep on contributing!

NeWold Times

3MG R&D

PO Box 818 • Santa Isabel, PR 00757

www.3mgpr.com

787-845-4600

Founded in 2012, 3MG R&D has been involved in the creation of innovative products that we hope will be in the forefront of the seed market. Guided by our principle that we can develop food crops that combat environmental pressures naturally and economically, we continuously research new solutions using a mix of millennia-old breeding techniques with high-end modern genetic technologies.