

# The Future of Peanut Agronomic Research - The Sky is Not the Limit

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## ABSTRACT

Many guidelines for agronomic management of peanut (*Arachis hypogaea* L.) are well-established when considered individually. However, crop productivity is typically driven by more than one variable and the interactions of multiple practices are not as easily derived. With an ever-changing availability of new cultivars with greater disease resistance, improved yield and/or grade potential, and varying growth characteristics, there is a steady need for agronomic research in both the immediate and distant futures. In some cases, traditional agronomic experimentation on variables such as rotations, tillage and land management, timing of planting, row pattern and spacing, seeding rate, irrigation, plant growth regulators, inoculant/biological products and fertilization need to be revisited every several years when a new cultivar becomes commercially relevant. This is especially true with differing climates and soil types in various growing regions. The effects of climate and weather along with pest pressure, pest management programs, and maturity characteristics of cultivars are also drawing the attention of peanut agronomists to improve predictability of optimum maturity. Yet, peanut agronomists are also attempting to adapt new ideas to assist with management decisions and increase revenue potential for growers to stay competitive in a very volatile commodity market domestically and with fluctuating export opportunities. The adoption of technologies such as GPS guidance, seed monitors, aerial imagery, and variable rate planting or spraying equipment are becoming more common to assist growers with better precision in planting and digging practices, ensuring proper seed placement, and assessing problematic areas in the field for site-specific in-season management decisions. So many excellent achievements have been made through the collaborations of scientists of the American Peanut Research and Education Society over the last 50 years, and there is no doubt that similar collaborations remain strong throughout the current membership to lead us into the future.

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One of the greatest challenges of talking about the future is risking a foolish comment that could be repeated for generations to come. There have been countless examples where a person's many positive contributions become overshadowed by one statement that defines them in history. At the outset of the American Peanut Research and Education Society (APRES) (otherwise known as the American Peanut Research and Education Association at the time), Mr. Kenneth Frick (Administrator of the Agricultural Stabilization and Conservation Service of USDA) stated his confidence that researchers would continue to find ways to increase yields, and that a doubling of present yields may occur (Frick, 1969). It was also referenced that peanut production had doubled in the previous 15 years despite the fact that harvested acreage in the U.S. had slightly declined. The 1969 national average yield for peanut was 1,953 kg/ha (USDA-NASS, 2018). It took more than an additional 15 years to prove Mr. Frick correct, although his bold prediction was realized in 2012. This was the first time in U.S. history that the national average peanut yield went above 3,906 kg/ha, shattering the national yield record with 4,720 kg/ha, a record that still holds today. Yet, the national yield average for peanut has remained above 4,000 kg/ha every year since 2012.

After 50 years of successful peanut research and education, agronomists are still questioned about the importance of what we do. There are comments such as "surely you have figured out what is the best seeding rate by now" and "why are agronomists still so amazed by the fact that the addition of N fertilizer causes plants to grow taller and greener?" To some extent, there is relevance to these questions and the nature of good science is to advance the discipline rather than repetitively conduct research with the same objectives over again. There is no need to "reinvent the wheel", yet at the same time there are usually applicable reasons for conducting similar research as the past. The advances in technology in other disciplines warrants validation in a wide range of production practices to ensure that certain management decisions will not cause a catastrophic interaction, or which practices might unlock an even greater benefit in some situations.

One of the most exceptional examples of using agronomic practices in combination with improved technology to enhance (and protect) its utility was following the rapid development of tomato spotted wilt of peanut [transmitted as *Tomato spot wilt virus (Orthotospovirus)*]. The pathogen was introduced as an immediate major threat to the U.S. peanut industry in the mid-1990's which could have devastated production for years to come causing shifts in infrastructure, altering growing regions and cropping systems, and causing multi-billions of dollars of damage to growers and businesses that rely on peanuts. If it were not for cv. Georgia Green (Branch, 1996) and the quick action of peanut scientists throughout the southeastern U.S. coming together to create the Tomato Spotted Wilt Risk Index (Brown et al. 1999), there may not be peanuts grown in Georgia, Alabama, and Florida (and parts of other states as well) today. Considering those three states produce over 70% of U.S. peanuts each year (USDA-NASS, 2018), that would have been a considerable upheaval. The Risk Index has evolved and expanded to the current Peanut Rx Prescription Fungicide Programs (Kemerait et al. 2017) and continues to be a model of a cross-disciplinary team approach to solving complex problems. Although designed to resolve pathological issues, it is still heavily influenced by agronomy. Of the ten risk categories in the current Peanut Rx, six are based on agronomic research and management decisions.

From 1969 through 1975, there was a steady increase in peanut yield (roughly 225 kg/ha/yr in GA). Much of this can be attributed to the release of the cv. Florunner (Norden et al. 1969) which would be the commercial standard variety for roughly the next 25 years, and for improvements in scientific research, collaboration, and exchange of information as prompted by the formation of the American Peanut Research and Education Association. U.S. peanut production saw a similar period of consistent and rapidly increasing yields from 2006 to 2012 when yields increased by around 280 kg/ha/yr in GA. This can also be heavily credited to superior genetics with the release of cv. Georgia-06G (Branch, 2007) and supporting research on how to improve its yield potential. Georgia-06G is not the most disease-resistant peanut available to growers, however supporting research has demonstrated additional methods to reduce the risk of disease through chemical and cultural practices for reducing the spread of multiple pathogens affecting this cultivar. The availability of new fungicide products for peanuts has also aided growers in the preventative and curative management of diseases during this timeframe.

Yield increases in peanut are not unique to the state of Georgia in recent years however, as there has been stair step progression in most of the top seven peanut producing states in the U.S. over the last 20 years. From 1997 through 2004, no state had ever topped 4,000 kg/ha as an annual state average, with only occasional years when a state jumped above the 3,500 kg/ha threshold. Since 2005, no state has dropped below 2,750 kg/ha in any year, and 3,250 to 4,000 kg/ha was commonplace. Yet, from 2012 to present there have only been three states that have dropped below the 3,900 kg/ha mark in a year, and most states have eclipsed the 4,400 kg/ha point at least once, with Georgia having achieved 5,100+ kg/ha in the record-setting year of 2012. Although, increased yield potential in peanuts raises a number of issues affecting long-term management decisions. Therefore, relying on extension recommendations that were based on older cultivars with lower overall yield potential and less disease resistance than currently available cultivars would be a disservice to growers. Hence, there is a great need for additional research, even on previously studied topics if this upward trend in yield potential is going to continue.

One growing trend in agricultural research is the utilization of unmanned aerial vehicles (UAVs) for a multitude of useful applications. A symposium at the 49<sup>th</sup> APRES meeting in 2017 highlighted the use of UAVs (or "drones" as many people refer to them), primarily for the imagery they can provide, but also for a number of beneficial activities. There is research already underway to determine the effectiveness of using UAVs in assessing poor plant stands to potentially give a quick decision on whether a field or portion of a field should be replanted. Also in identifying early season weed escapes, insect damage, or disease incidence over a larger area than a scout can identify in a more timely manner for earlier control measures to be deployed. Timeliness in application is one of the most important factors in addressing problems before they can become uncontrollable. Some UAVs are being equipped with small volume spray tanks and nozzles giving the ability to spot spray a hot spot or origin of a pest issue before it can spread. Use of multi-spectral cameras may also assist with other decisions like early identification of drought stress, inoculant failures or other fertility issues, and more. But even the sky is not the limit to the information tools that are starting to be used with more regularity in agriculture. Satellite imagery is a method of remote sensing that has functionality to help track crop growth and correspond to problems in the field as well as assist with harvest scheduling and storage decisions

(Robson and Wright, 2013). This type of data has many future avenues of utility in potentially identifying correlations of rotations, management decisions, weather patterns, irrigation timing, etc. on the spread of disease, crop stress due to drought, and many others.

Looking further into the future, one topic that has sparked interest but has not proceeded much past the idea stage so far is the potential of planting only the peanut embryo in place of the current method of planting the entire kernel (Hollis, 2011). Dr. Marshall Lamb (USDA-ARS) proposed the idea, which would drastically reduce the cost of seed for planting and return a large quantity of peanut to the edible market each year. Peanut seed is currently the most expensive input cost to a grower and estimated around 18-21% of a grower's variable costs (Smith and Rabinowitz, 2018a; 2018b). If the embryo could be extruded and processed for planting purposes, it could reduce seed weight needed to plant one acre of peanut from between 120 to 170 kg/ha (depending on seed size which varies by cultivar) to less than 10 kg/ha. This would also retrieve as much as around 91,000,000 kg of peanut kernel meat that would not need to be put in the ground and could instead be sold as an edible commodity each year. There are many obstacles that need to be overcome before this idea can come to fruition, such as how to safely remove and treat the embryo and supplying the necessary nutrients for emergence since the embryo's food source would be taken away. However, if the concept could be realized, it could revolutionize the industry. It is an area ripe with research possibilities to determine its feasibility. Hopefully at the 100<sup>th</sup> anniversary celebration of APRES, there will be a discussion of "how it was achieved" rather than "how do we get there?"

The topic of fertility and plant nutrition has already been alluded to several times and is another subject that has a lot of previous research as a foundation, but still needs a lot of attention because of confounding issues that arise with changes in management practices and productivity. With the noted increase in yield coming out of fields, there is a corresponding greater amount of nutrients being removed from those fields. Thus, adjustments to fertility and nutrient requirements need to be considered. In recent years, peanut rotations have also been trending shorter, meaning on average there are more fields being planted to peanut with fewer years between peanut plantings. Since a substantial amount of peanut's macronutrient fertility (especially P and K) comes from scavenging residual nutrients not used by the preceding fertilized crop, there is sequentially less

fertilizer being applied to the system with fewer crops planted between peanuts, and thus less residual fertilizer for peanut to scavenge. More work is also needed on Ca:K and Ca:K+Mg ratios because of the aforementioned fertility issues.

There is also a wide array of research still needed related to inoculants and N-fixation. Weather extremes have been a major detriment to peanut production over the past 5-10 years. In some situations, extremely hot and dry conditions have prevailed, which can potentially affect native *Bradyrhizobia* populations in the soil. Similarly, consistently wet soil conditions can deplete the soil of oxygen causing *Bradyrhizobia* to die and/or N-fixation to cease. There are many open avenues to better understand the benefits and need for various inoculant formulations in differing soil types and rotations following extreme soil conditions and weather events. There is also uncertainty in quantity to use for "new ground" soils never before planted to peanut, and comparing single-row to twin-row plantings since twin-rows doubles the amount needed on a per acre basis also doubling cost of the product. Since inoculants must be directly applied to the seed before furrow closure, it is often applied in a tank-mixture with other chemicals (fungicides, insecticides, etc.) raising the question of compatibility issues. Since one is a living bacteria and pesticides are typically designed to kill living organisms, residence time in the tank, pH of the solution, and other potential issues come into play. There is a need for a better understanding of how different strains of the *Bradyrhizobia* bacteria and other biological products on the market provide an economic benefit over native populations of the bacteria already present in the soil.

With respect to weed control and the evolution of herbicide resistant weeds, there is a great cause for concern in peanut production about how weeds will be controlled in the future. Considering it has been more than 37 years since the last new herbicide mode of action was introduced in peanut, and both peanut and cotton (the most common rotation crop partner in peanut cropping systems) rely heavily on protoporphyrinogen oxidase (PPO) inhibitor herbicides, there may be drastic changes in the methodology of weed control for peanut production in the future. Naturally, peanuts were being grown before the invention of chemical herbicides as we know them today. Therefore, if there are no new developments in registering new peanut herbicides, weed control practices may come full circle to the way they were controlled before APRES, using primarily mechanical cultivation tools.

Since peanut is an indeterminate crop, choosing the optimum time to harvest at peak maturity has always been an inexact science. For nearly four decades, the industry standard has been to use the Hull-Scrape Method which is based on mesocarp color of the pod hull after removal of the exocarp layer (Williams and Drexler, 1981). However, it was developed using an obsolete cultivar and still relied upon a lot of subjectivity. Color progression with the genetics of newer cultivars can create additional uncertainty. Some cultivars express hues of orange, brown, and black differently, leaving the projected maturity open for interpretation. Recent research on calibrating the maturity profile with different digging dates has shown that this method is currently predicting certain cultivars prematurely (causing reduction in peanut yield and grade due to immaturity) while other cultivars are overmature (causing reduction in yield and grade due to peanuts breaking dormancy and sprouting in the hull or pegs withering and leaving fully mature pods in the soil at digging) (Kvien, unpublished data, 2018). Additional research on assessing peanut maturity to either supplement, verify, or supplant the Hull-Scrape Method have been conducted. These include an adjusted growing degree day model (Rowland et al. 2006), crop canopy characteristics such as light wavelength reflectance and nutrient analysis (Rowland et al. 2008), and digital image analysis (Colvin et al. 2014). The expansion of these techniques and improvement of new technologies may make maturity determination a more objective decision in the future and reduce losses from not harvesting the crop at optimum maturity.

On the subject of optimizing maturity, work has been conducted on chemical control of late season flowering in order to influence the plant to behave more determinately by diverting resources away from late developing pods that will never reach harvestable weight in order to improve yield and/or grade of the already formed pods (Lamb et al. 2017). While the specific chemicals/rates used in the study are not currently labelled for late-season use in peanut, there was proof of concept that chemical flower termination in peanut can increase yield and grade of peanut over the control. This creates future research opportunities to advance this idea and search for feasible ways to accomplish the task.

Additional opportunities from new technologies should help continue upward trends in peanut yield and production. Global Positioning System (GPS) guidance is already widely adopted on peanut farms and some yield gain can be attributed to this (Ortiz et al. 2013; Santos et al. 2016; Vellidis et al. 2014). Although not as widely used, yield gains and

improved visibility for digging operations have also been attributed to the use of Prohexadione Calcium (plant growth regulator) (Beam et al. 2002; Culpepper et al. 1997; Jordan et al. 2001; Mitchem et al. 1996). Despite slow implementation of Prohexadione Calcium use on peanut primarily because of cost, there is still interest in their use, especially under the right conditions. It has been shown to hasten maturity (Culpepper et al. 1997; Mitchem et al. 1996), and the decreased vegetation allows quicker curing in the field after digging assisting growers with harvest activities when inclement weather is in the forecast. These benefits are difficult to apply a direct dollar value, but in some instances can mean the difference between reaching full maturity with a late-planted crop when cool fall temperatures set in, or in getting the crop out of the field before/between rain events in wet weather. Additional research is needed on the most effective rates and timing of application for new cultivars with robust vegetative growth, especially in irrigated production.

Predicting the future is a difficult proposition and it takes boldness to claim with confidence that a doubling of current yields will occur. In the state of Georgia, it took around 20 years for yields to increase from 1,100 kg/ha to 2,200 kg/ha on the statewide average, then another 40 years to double again to 4,400 kg/ha. There has been approximately 57 kg/ha/yr yield increase on average since peanut yields started to steadily ascend (1950 state average = 1,060 kg/ha; 2017 state average = 4,910 kg/ha). If a similar slope can be maintained, it should take close to 70 years from now to reach an 8,800 kg/ha yield average in the US. Considering we have already achieved the 9,000 kg/ha yield mark in research plots, it is certainly within the realm of possibility. As a researcher, it would be interesting to be there to see if it comes true.

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