Peanut Yield Gains Over the Past Fifty Years

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ABSTRACT

To commemorate the 50th anniversary of the American Peanut Research and Education Society (APRES) we examined the changes in average yields of peanut (*Arachis hypogaea* L.) during that time period. Before APRES, yields had never been greater than 2242 kg/ha (2,000 lb/ac). In 1967 the average yield was 1978 kg/ha (1967 lb/ac). In 2017 the average peanut yield was 4566 kg/ha (4074 lb/ac). Average yield gains for the first 50 years of APRES was 51.8 kg/ha/yr (46.2 lb/ac/yr). APRES played critical roles in facilitating research and extension to achieve these yield advances for the U.S. peanut industry.

Key Words: American Peanut Research and Education Society, Extension, Peanut, Yield Gains, Research.

When we started planning how we could commemorate the 50th anniversary during the opening session of our 2018 annual meeting, we decided to revisit yield gains during the 50-yr history of the American Peanut Research and Education Society (APRES). This traces back to a symposium that was held at the 45th Annual APRES meeting in 2013. The Crop Science Society of America (Holbrook et al., 2014) also published much of the information in that symposium in a book chapter on peanut yield gains. A graph in that chapter presented average yield for U.S. peanut production from 1909 to 2012. We have updated that figure for the current publication by including yield data through 2017 (Figure 1). Plotting the average peanut yields over this period illustrates several interesting stories. First, note the depressed yields in 1954, 1980, and several years in the 1990s. These were historic drought years for peanut production. This reminds me of a quote from Dr. John Baldwin who was a long-time member of APRES. Dr. Baldwin was a University of Georgia, Peanut Extension Specialist known for several quotes. One was "if it don't rain, it don't matter". In other words, growers can do all the right things, but if it is a historic drought year yields will be low.

Figure 2 presents the same graph divided into four periods, and the origin of APRES is noted. The first period are the years prior to about 1950. Peanut yields were flat during this time. Peanut is a regional crop and before the 1950s, there was very little investment by the states or federal government to support research and extension efforts. Without this investment, yields were stagnant.

The second period in Figure 2 spans from about 1950 until the mid-1980s. This was what we designate the first golden era for peanut research and extension. Several states and the federal government began to invest significant amounts of funding for peanut research and extension activities. Because of this investment, this period was also the first golden era for U.S. peanut production. During this period there was a huge increase in average peanut yields. APRES was established in this era. APRES was formed with three primary missions: 1) Instruct and educate, 2) Promote scientific research, and 3) Disseminate scientific information and research papers. The annual meetings of APRES were critical venues where people could get together and share information and ideas. Also, very important was the society's refereed journal, *Peanut Science*, where scientists could publish the results of their latest research. This information was disseminated to other scientists throughout the country, and to other areas of the world.

Some of the research advances that were made during this first golden era included: 1) the first chemical weed control, 2) the development of new fungicides for leaf spot control, 3) agronomic practices to reduce soil borne diseases, and 4) seed treatments to reduce seedling diseases caused by *Rhizoctonia solani* and *Aspergillus niger*. Also, during this time period several states and the U.S. Federal Government established a number of programs for cultivar development.

The cultivar development programs established during this time period resulted in the release of 'Florunner' (Norden *et al.*, 1969) which soon dominated acreage for the runner market-type, and 'Florigiant' (Carver, 1969) which soon dominated acreage for the virginia market-type. These were transformative cultivars for U.S. peanut production. However, as Austin (1994) and Tracy *et al.* (2004) discussed, it is very difficult to precisely

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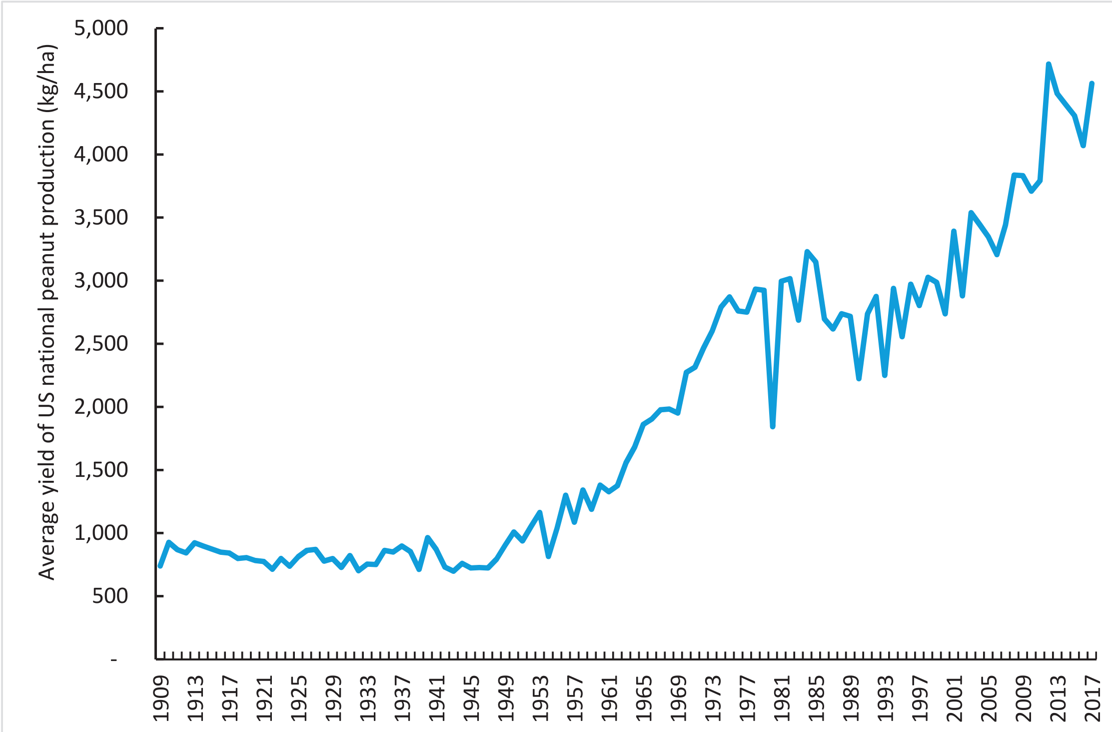

Fig. 1. Average yield for U.S. peanut production from 1909 to 2017. Source: USDA-NRCS (www.nass.usda.gov, accessed 15 December 2018).

estimate the amount of yield gains that can be attributed to improved cultivars. Older cultivars, bred for farming systems that prevailed when they were first grown, may be at a disadvantage under modern farming systems and may lack resistance to the prevalent strains of important pests and diseases. Nevertheless, cultivar development obviously was an important element of research that

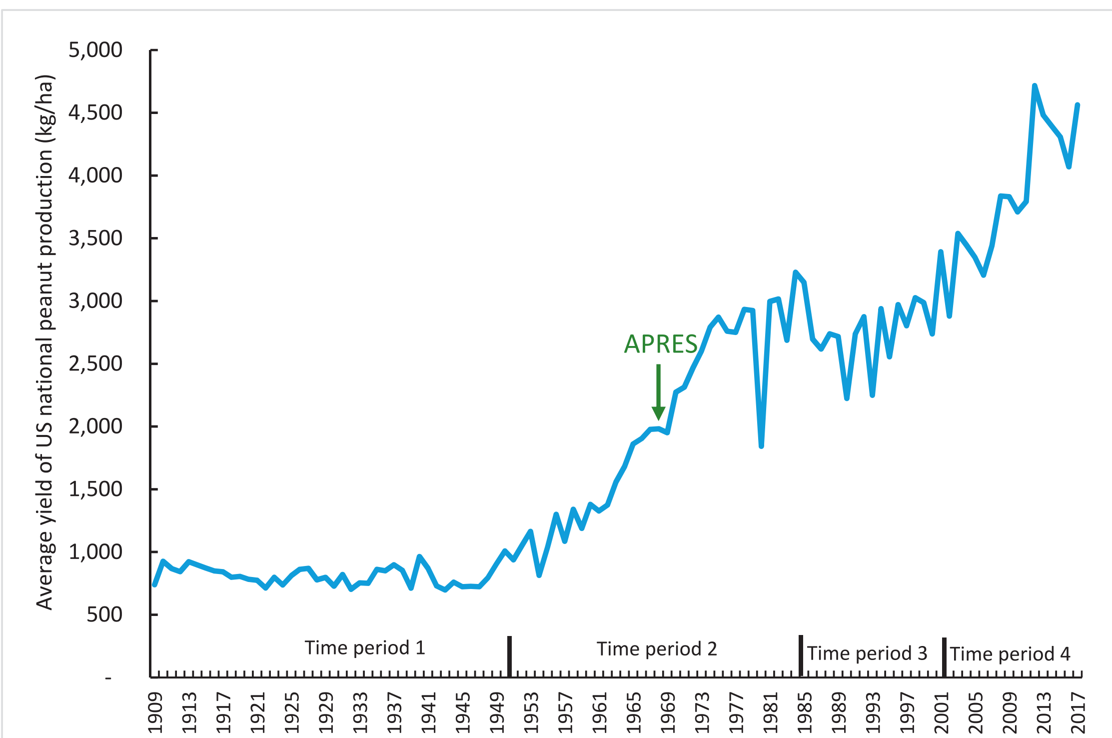

Fig. 2. Average yield for U.S. peanut production from 1909 to 2017 divided into four time periods. Source: USDA-NRCS (www.nass.usda.gov, accessed 15 December 2018).

Fig. 3. Georgia ton per acre club for peanut farmers who achieved yields of 2242 kg/ha (2000 lb/ac).

contributed to peanut yield increases during this period. Duncan *et al.* (1978) reported as much as a 100% increase in yield potential of runner-type cultivars during this era. Mozingo *et al.* (1987) presented studies that estimated that improved virginia-type cultivars accounted for 18.5% of the yield increase from the 1940s to the 1980s, with a yearly increase of the contributions from cultivar development at 15 kg/ha/yr (13.4 lb/ac/yr). Several studies indicated that these yield gains from improved cultivars were due to improved reproductive efficiencies (Emery *et al.*, 1973; Duncan *et al.*, 1978; Coffelt *et al.*, 1989; Wells *et al.*, 1991; Boote and Tollenaar, 1994).

Extension also made critical contributions during this 1st golden era for peanut production. Growers were instructed to use a package approach to growing peanuts (Henning *et al.*, 1982; 1979; 1973; 1965). Growers were encouraged to grow the improved cultivars using the best agronomic practices. The Georgia Extension Service established the Georgia Ton Per Acre Club (Figure 3) as an incentive for growers to adopt this package approach. At the time, peanut yields of 2242 kg/ha (2000 lb/ac) were almost unimaginable. Frank McGill was the Peanut Extension Specialist in Georgia, and a founding member of APRES. He spoke at the Symposium during the 2013 APRES meeting (McGill, 2013). He stated that in the early years of the Georgia Ton Per Acre Club some growers were hesitant to be named as members of the club because they feared their neighbors might doubt their honesty in reporting such high yields.

Clearly peanut production came a long way during the 1st golden era of U.S. peanut production, and APRES played key roles in these advances. The establishment of APRES provided forums for scientists to share their latest research findings, and for extension agents to talk about the most effective ways to convey this information to growers.

The next time period (Mid 1980 to early 2000's) on Figure 2 shows a trend in average peanut yields that was flat to decreasing. This period was obviously not a second golden era for peanut production, however, we believe it was a second golden era for peanut research and extension. Warren (1998) examined yield trends for several U.S. crops. He noted this flat to declining yield trend for peanut and proposed two negative factors to explain this observation. One was the loss of the most effective nematicides, the other was an increase in acreage that was disrupting recommended crop rotation patterns. These were certainly important factors that were detrimental to peanut yields, but a more important factor was probably the emergence of *Tomato spotted wilt tospovirus* (TSWV). Spotted wilt disease, caused by TSWV, was first observed in the Southeast production region in the late 1980s and rapidly became a major limiting factor for peanut production (Culbreath and Srinivasan, 2011). Without a herculean effort in peanut research and extension, average yields would have shown a steep decline. This was certainly not a golden era for peanut production, however, the fact that average yields were stabilized makes this a second golden era for peanut research and extension. Peanut breeders, plant pathologists, entomologists, and agronomists redirected their programs to address this challenge that had the potential to wipe out the U.S. peanut industry in the Southeast, which is the largest production region.

All peanut cultivars in the mid 1980's were highly susceptible to TSWV (Culbreath *et al.*, 1992). Fortunately, peanut breeders had been using a plant introduction collected from Brazil in the 1950s (PI 203396) as a source of resistance to late leaf spot in their breeding programs. This plant introduction was subsequently discovered to have some resistance to TSWV, and progeny from crosses with this PI were rapidly selected and released as cultivars that were moderately resistant to TSWV.

Many researcher and extension agents dropped other things they were doing, and focused their efforts on addressing the TSWV crisis. This resulted in changes in cultural practices. The recommended seeding rate was increased from 13 to 20 seed per meter (4 seed per foot to 6 seed per foot) after agronomist and plant pathologist observed that severity of damage from the virus was lessened by an increase in the seeding rate. The

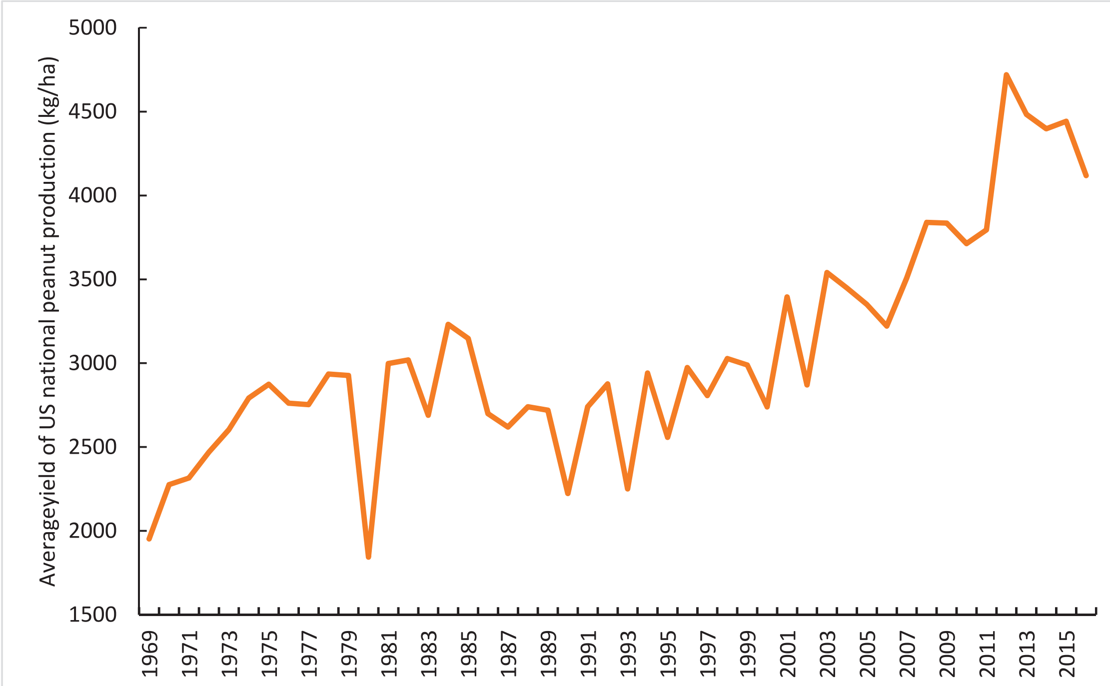

Fig. 4. Average yield for U.S. peanut production during the 50-year history of APRES. Source: USDA-NRCS (www.nass.usda.gov, accessed 15 December 2018).

use of a twin row spacing, and the avoidance of early and late plantings were also recommended for the same reason. Research and extension scientists then combined this information on genetic, chemical, and cultural practices for management of spotted wilt disease into a spotted wilt risk index (Brown *et al*., 2005). This index was then conveyed to growers so they could better understand how their decisions influenced their risk of having severe spotted wilt disease. If you go back and look at the proceeding from APRES during this time, a large percent of the papers presented at the meetings involved research or extension efforts to minimize the severity of TSWV. APRES certainly played a key role in what was a second golden era for peanut research and extension.

The last time period spans from the early 2000s to the present (Figure 2). Yield trends indicate that a base was built in the third time period because of research and extension efforts and we have entered a second golden era for peanut production, and a third golden era for research and extension. Similar to the first golden era for peanut productions, yield advances in the second golden era can be attributed to several factors. One factor is the continued development and release of improved cultivars. This resulted in cultivars with even higher levels of resistance to TSWV. Cultivars with resistance to the peanut root-knot nematode [*Meloidogyne arenaria* (Neal) Chitwood race 1] were also developed and released. Cultivars with improved resistance to other diseases were also released. The peanut cultivars grown in this time period have greater yield potential enabling growers to increase their average yield per acre. During this time period plant pathologist developed improved chemistries, and improved application methods for enhancing disease control. Growers also have access to some improved chemistries for enhanced weed control. It is also likely that harvest losses have been reduced by increased use of real-time kinematic (RTK) based auto-guidance on tractors and implements using global positioning systems (GPS) (Leidner, 2012).

Research has also been devoted to reducing input costs to enhance economic returns for growers. Isleib *et al*. (2001) published a study in *Peanut Science* to look at the impact of the U.S. peanut germplasm collection on cultivar development. Dr. Isleib developed pedigrees and coefficient of parentage to see what percent of the genetics was contributed by certain plant introductions. As coauthors, we surveyed pathologist, extension specialist, and breeders to estimate the economic impact of those new traits that were coming from the plant introductions. The traits that breeders have mined from the germplasm collection included resistance to Sclerotinia (*Slerotinia minor* Jagger), the Peanut Root-knot Nematode, Cylidrocladium Black Rot [*Cylindrocladium crotalariae* (C.A. Loos) D.K. Bell & Sobers], and TSWV. We estimated an economic impact of almost $240 million annually. About \$200 million of that was due to the contribution of resistance to TSWV by PI 203396. This is strong justifications for the funding that goes into the national germplasm collection. The U.S. peanut germplasm collection is truly a national treasure. It saved us from the devastating impacts of TSWV, and we do not know what challenges in the future might only be addressed with this genetic diversity.

In conclusion, average U.S. peanut yields during the 50-year history of APRES are presented in Figure 4. Before APRES yields had never been greater than 2242 kg/ha (2,000 lb/ac). In 1967 the average peanut yield was 1978 kg/ha (1967 lb/ac). In 2017 the average peanut yield was 4566 kg/ha (4074 lb/ac). Average yield gains for the first 50 years of APRES was 51.8 kg/ha/yr (46.2 lb/ac/yr). This is very impressive and would not have been achieved without the existence of APRES. APRES played critical roles in facilitating research and extension to achieve these yield advances for the U.S. peanut industry.APRES is also well positioned to continue to facilitate research and extension for the benefit of the U.S. peanut industry in the next 50 years.

Literature Cited

Austin, R.B. 1994. Plant breeding opportunities. *In:* K.J. Boote, J.M. Bennett, T.R. Sinclair, and G.M. Paulsen, editors, Physiology and determination of crop yield. ASA, CSSA, SSA, Madison, WI. p. 533–565.

Boote, K.J., and M. Tollenaar. 1994. Modeling genetic yield potential. *In:* K.J. Boote, J.M. Bennett, T.R. Sinclair, and G.M. Paulsen, editors, Physiology and determination of crop yield. ASA, CSSA, SSA, Madison, WI. p. 533–565.

Brown, S.L., A.K. Culbreath, J.W. Todd, D.W. Gorbet, J.A. Baldwin, and J.P. Beasley, Jr. 2005. Development of a method of risk assessment to facilitate integrated management of spotted wilt of peanut. Plant Dis. 89:348–352.

Carver, W.A. 1969. Registration of Florigiant peanut (Reg. No. 1). Crop Sci. 9:849–850.

Coffelt, T.A., M.L. Seaton, and S.W. VanScoyoc. 1989. Reproductive efficiency of 14 Virginia-type peanut cultivars. Crop Sci. 29:1217–1220.

Culbreath, A.K., and R. Srinivasan. 2011. Epidemiology of spotted wilt disease of peanut caused by Tomato spotted wilt virus in the southeastern U.S. Virus Research 159:101–109.

Culbreath, A.K., J.W. Todd, and J.W. Demski. 1992. Productivity of Florunner peanut infected with tomato spotted wilt virus. Peanut Sci. 19:11–14.

Duncan, W.G., D.E. McCloud, R.L. McGraw, and K.J. Boote. 1978. Physiological aspects of peanut yield improvement. Crop Sci. 18:1015–1020.

Emery, D.A., J.C. Wynne, and P.W. Rice. 1973. Can reproductive efficiency in cultivated peanuts be improved? Oleagineux 28:399–403.

Henning, R.J., J.F. McGill, L.E. Samples, C. Swann, S.S. Thompson, and H. Womack. Reprinted September 1982. Growing Peanuts in Georgia: A Package Approach. University of Georgia College of Agriculture Cooperative Extension Service Bulletin 640. 48 pages. Previous editions: Revised June 1979, May 1973, February 1965.

Holbrook, C.C., T.B. Brenneman, H.T. Stalker, W.C. Johnson III, P. Ozias-Akins, Y. Chu, G. Vellidis, and D. McClusky. 2014. Peanut. *In:* S. Smith, B. Diers, J. Specht, and B. Carver, editors, Yield Gains in Major U.S. Field Crops. CSSA Special Publication 33. ASA, CSSA, SSSA, Madison, WI. p. 101–122.

Holbrook, C.C., M.D. Burow, C.Y. Chen, M.K. Pandey, L. Liu, J.C. Chagoya, Y. Chu, and P. Ozias-Akins. 2016. Recent Advances in Peanut Breeding and Genetics. *In:* H.T. Stalker and R.F. Wilson, editors, Peanut: Genetics, Processing and Utilization. Academic Press and AOCS Press.

Isleib, T.G., C.C. Holbrook, and D.W. Gorbet. 2001. Use of plant introductions in peanut cultivar development. Peanut Sci. 28:96–113.

Leidner, J. 2012. Precision farming payoff in peanuts. Southeast Peanut Farm Mag. 50(5):10–12.

McGill, J.F. 2013. A roller coaster ride through peanut yield history; 1951-1982. Proc. Amer. Peanut Res. and Educ. Soc. 45:13.

Mozingo, R.W., T.A. Coffelt, and J.C. Wynne. 1987. Genetic improvement in large-seeded Virginia-type peanut cultivars since 1944. Crop Sci. 27:228–231.

Norden, A.J., R.W. Lipscomb, and W.A. Carver. 1969. Registration of Florunner peanuts (Reg. No. 2). Crop Sci. 9:850.

Tracy, W.F., I.L. Goldman, A.E. Tiefenthaler, and M.A. Schaber. 2004. Trends in productivity of U.S. crops and long-term selection. Plant Breed. Rev. 24:89–108.

Warren, G.F. 1998. Spectacular increases in crop yields in the United States in the twentieth century. Weed Technol. 12:752–760.

Wells, R., T. Bi, W.F. Anderson, and J.C. Wynne. 1991. Peanut yield as a result of 50 yr of breeding. Agron. J. 83:957–961.