

Improved West African peanut production for enhanced health and socioeconomic status through the delivery of research-based production systems in Ghana

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Early season insect management in light of the loss of a key product. The loss of Temik (aldicarb) created a significant void for peanut farmers in the U.S. This product was consistently used on more than 75% of the acreage in the U.S. and over more than a 30 year history had proven itself superior to all competitors. Issues in other commodities results in Bayer cancelling all uses in 2010. Due to the excellent efficacy and reasonable cost of Temik, agrichemical companies had put very few resources into discovering alternative approaches for Temik. Its loss created a significant void. Similar to the onset of tomato spotted wilt virus in 2002 in North Carolina, Peanut CRSP funding afforded the opportunity to address this issue very rapidly. Our previous studies had outlined cultural practices, such a plant populations, twin rows, varietal selections, and tillage practices and their impact on thrips (the primary early season insect pest).

Past research on host plant resistance had indicated little opportunity for assistance from built in resistance for thrips control. Two new chemistries, the concept of seed treatment with insecticides, and combinations of early season insecticides with cultural practices were all evaluated in an integrated approach to find a cost-effective alternative to Temik as an at plant insecticide. Growers initially sought to encourage the development of a generic Temik. However, recent successes in field trials with alternative approaches have been successful in moving them in the direction of adopting the use of slightly less efficacious materials, but utilizing cultural practices and post emergence treatments to obtain outstanding results. The new approaches typically provide 70-80% reductions in thrips abundance and leaflet damage as compared to the consistent 90% provided by Temik, but continued refinement of strategies will yield cost effective strategies for the future.

Strategies to combat pyrethroid resistance in peanuts for caterpillar control. The widespread occurrence of various caterpillars in the agro ecosystem associated with the peanut production areas of the southeastern U.S. results in numerous insecticides applications across many of the region's crops including cotton, peanuts and soybeans. As a result, resistance to pyrethroid insecticide is always a concern. Our attention to this problem in collaboration with Virginia has monitored corn earworm resistance levels and weekly updates to growers. Alternative classes

of insecticides, useful in resistance management, are available but are much more expensive and not a preferred approach for growers. By monitoring resistance levels we can avoid these rotations unless concerns are elevated.

Adoption of risk indices for intelligent insecticide use and pest management and the integration of pest management programming.

Monitoring of tomato spotted wilt incidence and production practices. Tomato spotted wilt virus became a significant problem in North Carolina peanuts in 2001-2003. A significant research effort focused on the use of cultural practices was immediately put into place and within 2 years an effective program to dramatically reduce tomato spotted wilt virus was developed and deployed to growers. In the nine years after the initial strategies were implemented, the incidence of tomato spotted wilt virus has been suppressed to below economic levels. Growers were willing to implement these strategies while the experience of the impact of tomato spotted wilt virus was fresh in their minds. In more recent years as we have moved beyond those years of yield loss due to this disease, growers are not using as many of the strategies since many, such as seeding rate, have a significant cost associated with that practice. Our monitoring of the incidence of tomato spotted wilt virus in the context of growers using fewer cultural practices and relying more on cultivar resistance, allow growers to move toward less cost production schemes while tomato spotted wilt virus remains at low levels. A website contains the decision making tool which is frequently updated with new cultivars, pesticides, etc. <http://www.peanuts.ncsu.edu/riskmgmt/>.

A similar program is also in place for managing the southern corn rootworm <http://ipm.ncsu.edu/scr>.

Digging Date Trials. Digging date can have a major impact on yield and market grade characteristics of peanut. Several factors including soil conditions at digging, heat unit accumulation, and disease can influence peanut response to digging date. Research was conducted in North Carolina at one location from 2003 to 2012 (17 experiments total) to determine the optimum digging date of the Virginia market type peanut cultivar Gregory when dug on five dates beginning in mid-September through mid-October. Peanut pod yield, percentages of extra large kernels (%ELK) and total sound mature kernels (%TSMK), days from seedling emergence to digging, and heat unit accumulation (DD_{56}) were determined. The interaction of experiment by digging date was significant for all parameters. However, pod yield was influenced most by this interaction compared with market grade characteristics. When pooled over all 17 experiments, the optimum digging date for pod yield occurred 138 days after peanut emergence (DAE) corresponding to 2798 heat units (DD_{56} calculation). The greatest increase in yield was noted when peanut was dug 128 DAE compared with 122 DAE (16% increase in yield as digging was delayed) while yield at 128, 138, and 145 DAE varied by less than 3%. Digging 153 DAE compared with 145 DAE resulted in a yield decrease of 13%. Percentages of ELK and TSMK increased as digging was delayed regardless of digging date. In a

separate experiment conducted at the same location from 2005 through 2012 (8 experiments), the cultivar Gregory was exposed to three fungicide regimes including no fungicide for leaf spot and stem rot, two early season sprays for these diseases, and five sprays throughout the season. Beginning in late September, peanut was dug at three intervals spaced 7-10 days apart. Percent canopy defoliation, pod yield, and market grade characteristics were determined. In 2 of 8 experiments, disease was relatively low regardless of fungicide regime and therefore data from these experiments were not included in the analysis. Percent canopy defoliation and pod yield was poorly correlated ($R^2 = -0.27$, $p \leq 0.0001$) most likely due to interactions of increased maturity when digging was delayed and less canopy defoliation resulting in pod shed and lower yield when peanut was dug earlier. The interaction of digging date and fungicide regime was significant for canopy defoliation, pod yield, and %ELK. In absence of fungicides, defoliation increased from 22% to 38% and 38% to 57% as digging was delayed from late September to early October and early October to mid-October, respectively. While two early season sprays decreased canopy defoliation compared with non-treated peanut, canopy defoliation increased from 9 to 15% and 15 to 41% at these respective digging dates. Four percent or less canopy defoliation was noted when peanut was treated with five fungicide sprays. When disease was poorly controlled, delaying digging to mid-October resulted in a decrease in yield compared with early digging. When moderate disease control was achieved, there was no difference in response to digging date. When a successful spray program was implemented which essentially eliminated canopy defoliation, delaying digging from late-September to early or late October increased yield. The higher yields at the last two digging dates combined with almost complete disease control exceeded that of the other two fungicide regimes irrespective of digging date. Results for these two studies emphasize the value of timely digging under disease-free conditions. These results also suggest that under conditions where disease is poorly controlled, peanut yield is often similar when peanut is dug earlier than typically expected based on mesocarp color determination, most likely because of pod shed in presence of disease. Protecting peanut from disease and delaying digging until optimum pod maturation occurs continues to be effective in obtaining the highest pod yield.

Planting Date Trials. Research was conducted from 2009-2012 in North Carolina to compare peanut yield and market grade characteristics of the Virginia market type cultivar CHAMPS and Perry planted approximately May 5, May 25, and June 8 when dug approximately September 5 and 25 and October 5 and 20. When dug at optimum maturity, as reflected in the highest yield among the four digging dates, yield and market grades generally varied little when peanut was planted in early or late May. In 3 of 4 years (2009-2011) peanut yield was lower when peanut was planted June 8 and dug October 20 compared with earlier plantings and digging at optimum maturity. However, in 2012 yield was highest when peanut was planted in early June and dug in late October compared with the other planting dates. While surprising, these results most likely can be explained by weather conditions during the growing season in 2012 relative to other years. Hot and dry conditions were noted during much of 2012 in June and early July compared with greater rainfall during this period of time during 2009-2011. This weather pattern during 2012 most likely reduced the number of flowers produced when peanut was planted earlier in the season compared with the later-planted peanut. Peanut planted during early June was in the vegetative stage during the hot and dry conditions of June and early July.

In mid-July rainfall and temperature patterns changed significantly in favor of both vegetative and reproductive growth and remained this way for most of the remainder of the growing season. While results from this experiment generally show that yield of peanut in the Virginia-Carolina region are optimal when planting in May, in some instances weather patterns may favor later-planted peanut. These results also indicated that exhibiting patience in the fall in terms of digging can result in higher peanut yields.

Interactions of Gypsum and Chlorpyrifos. Gypsum and chlorpyrifos often are applied in late June or early July to Virginia market type peanut to ensure proper kernel development and control southern corn rootworm, respectively. Concern about interactions of these materials has been expressed due to several instances of poor performance by chlorpyrifos. In addition to presence of gypsum (calcium sulfate) in the pegging zone and zone where control of southern corn rootworm is important, soil pH often decreases for several weeks after application of gypsum. The role of pH on performance of chlorpyrifos has not been evaluated for Virginia market type peanut. Research was conducted from 2006-2010 to determine if peanut yield response to application of chlorpyrifos for control of southern corn rootworm was affected by gypsum rate. Treatments included no chlorpyrifos or granular chlorpyrifos at the manufacturer's suggested use rate either preceding or following application of gypsum (85% calcium sulfate) at 0, 600, 1200, 1800, or 2400 pounds/acre. The manufacturer's recommended rate for this product is 600 pounds/acre. There was not interaction of gypsum rate and chlorpyrifos rate for scarring associated with southern corn rootworm feeding or pod yield. While pod yield was not affected by gypsum rate, yield increased 219 pounds/acre when chlorpyrifos was applied. Although not recorded in all experiments, pod scarring decreased by 2% when chlorpyrifos was applied (11% vs. 9%). These data suggest that growers can apply both gypsum and chlorpyrifos without concern that gypsum will adversely affect performance of chlorpyrifos.

Rotations with Unique Crops in North Carolina. Peanut rotation systems most often include corn and cotton. However, more diverse rotation systems can be found in some regions of North Carolina. Rotation crops can include clary sage, snap beans, and sweet potato. Clary sage is planted in August or September and harvested the following June. A common three-year sage/peanut rotation is sage-fallow/sorghum-peanuts-wheat-sage. Cotton growers often extend this rotation to 4 years and plant cotton prior to the peanut crop in this rotation. Sweet potato and snap beans may also be rotated with peanut in a 3- or 4-year rotation with peanut immediately preceding the potato or bean crop. Research suggests that peanut yield following these crops is not adversely affected by previous rotation systems that include these crops.

Response of Grain Crops to Previous Peanut Rotation Systems. Price of grain crops increased significantly during the past 5 to 7 years, and during that time period until 2011, price of grain crops was often more attractive than the price of peanut, especially given risk associated with economic investment in production of these crops. This scenario led to reductions in peanut acreage in many counties in North Carolina and a transition to grain crops. Cotton price during this time period was also relatively low compared with price of grains. For example, in 2004 approximately 12,000 acres of peanut were planted in Edgecombe County compared with a low

of 3,500 acres during 2009 and 5,500 acres during 2011. Corn, soybean, and wheat acreage increased in some years as a replacement for lost peanut acreage. A series of experiments was conducted in North Carolina during 1997-2006 to compare crop yield in peanut-based rotation systems that included corn, cotton, soybean, and tobacco depending on location. Peanut was included in all plots during 2006 following various cycles of peanut and other crops. During 2007-2011, the same grain crop was planted in all plots each year and included corn or wheat/soybean double crop to simulate a transition out of peanut-based cropping systems into grain production systems. At one location in Bertie County (Peanut Belt Research Station near Lewiston-Woodville), corn yield (2007, 2009, and 2011) and wheat/soybean yield (2008) were not affected by previous rotation while during 2010 yield of both wheat and soybean was affected by previous rotation. Peanut yield during 2006, prior to planting grain crops, ranged from 2600 lbs/acre to 5900 lbs/acre and reflected expected response based on the number of years between peanut plantings prior to 2006. At a second location in Edgecombe County (Upper Coastal Plain Research Station near Tarboro), differences in corn, soybean, and wheat yield due to previous peanut-based rotation were noted in 1 of 3, 0 of 2, and 2 of 2 years, respectively. At this location during 2006, peanut yield ranged from 2400 to 3770 lbs/acre based on previous rotation. At a third location in Columbus County (Border Belt Tobacco Research Station near Whiteville), yield of corn (2007 and 2009) and tobacco (2008) did not differ following previous rotations of peanut-based cropping systems.

Pesticide Compatibility Trials. Numerous agrochemicals can be applied in peanut to control pests. Field and laboratory experiments were conducted in North Carolina during 2009 and 2010 to define biological and physicochemical interactions when acephate was applied in combination with chloroacetamide and contact herbicides. Experiments were also conducted during 2011 to determine peanut response to acephate applied alone or with paraquat when peanut was planted either without aldicarb or when aldicarb was applied in the seed furrow at planting. Visible peanut damage caused by tobacco thrips (*Frankliniella fusca* Hinds.) feeding was greater when chloroacetamide herbicides were applied without acephate compared with application with acephate regardless of paraquat treatment. Visible injury caused by paraquat was higher when chloroacetamide herbicides were included compared with paraquat alone in one of two years. Visible injury by paraquat was lower when applied with acephate compared to paraquat alone in one of two years. Acephate applied to peanut foliage and aldicarb applied in the seed furrow at planting protected peanut similarly from damage associated with tobacco thrips feeding. Acephate alone or with chloroacetamide herbicides changed solution pH from slightly acidic to highly acidic. Several combinations of acephate formed transient precipitates.

A second set of experiments was conducted to evaluate the efficacy of clethodim and sethoxydim applied alone or with dimethenamid-*P*, pyraclostrobin, *S*-metolachlor, and 2,4-DB. When applied in combination with clethodim, pyraclostrobin often reduced goosegrass and large crabgrass control compared with clethodim only. Pyraclostrobin did not impact efficacy of sethoxydim in most instances. Dimethenamid-*P* and *S*-metolachlor did not negatively affect efficacy of clethodim and sethoxydim. The impact of 2,4-DB on efficacy of clethodim and sethoxydim was inconsistent. The magnitude of adverse impact on graminicide performance did not exceed 19% and was caused primarily by pyraclostrobin. Conversely, increased efficacy

of graminicides caused by chloroacetamide herbicides did not exceed 14%. Graminicides and chloroacetamide herbicides changed solution pH from slightly acidic to highly acidic. Several combinations of clethodim and sethoxydim produced temporary precipitates but no permanent precipitates. Results from these experiments suggest that applying tank mixtures containing up to four components will not dramatically reduce control of emerged annual grasses.

In a third set of field and laboratory experiments were conducted in North Carolina to characterize the biological and physicochemical interactions when the herbicides clethodim, imazapic, imazethapyr, lactofen, sethoxydim, and 2,4-DB were applied in combination with adjuvants, fungicides, insecticides, and micronutrients. A wide range of interactions was noted when comparing across herbicides, weed species, and agrochemical combinations. There was little consistency across weed species for a herbicide or across herbicides for a weed species when comparing significant main effects and interactions. In most instances, when compared with the standard herbicide treatment and adjuvants applied alone, herbicide efficacy was not affected in the presence of other agrochemicals. Changes in solution pH and formation of precipitates varied according to the herbicide combinations used. Boron, manganese, and 2,4-DB often caused dramatic changes in solution pH. Biological and physicochemical interactions when insecticides (fenpropathrin and lambda-cyhalothrin) or plant growth regulator (prohexadione calcium) were applied in combination with other agrochemicals including fungicides, herbicides, and micronutrients. Fenpropathrin or lambda-cyhalothrin combinations did not injure peanut in 2008 and 2009. Two sprays of prohexadione calcium improved row visibility and reduced main stem height compared with one prohexadione calcium spray irrespective of agrochemical combinations. In many instances, applying prohexadione calcium with other agrochemicals resulted in lower main stem height compared to prohexadione calcium alone. In one of the experiments, prohexadione calcium with prothioconazole plus tebuconazole lowered fall army worm population compared with prohexadione calcium alone. Addition of boron, manganese, and 2,4-DB to fenpropathrin, lambda-cyhalothrin, and prohexadione calcium combinations changed solution pH dramatically. Prohexadione calcium had the least effect on pH of the carrier. In a final group of trials fungicides were applied in combination with herbicides, insecticides, and micronutrients for the control of leaf spot disease and Sclerotinia blight. In both years, the program with three fungicide sprays was more effective in preventing canopy defoliation caused by early and late leaf spot disease than single fungicide spray irrespective of agrochemical combinations. Although several interactions were noted among agrochemical combinations, most combinations did not affect fungicide efficacy against canopy defoliation or Sclerotinia blight. In some instances, fungicide combinations protected peanut more effectively from canopy defoliation or Sclerotinia blight than standard fungicide treatment. Regardless of the other agrochemicals applied, boscalid was more effective than fluazinam in controlling Sclerotinia blight. Boscalid, boron, clethodim plus crop oil concentrate, chlorothalonil plus tebuconazole, manganese, and 2,4-DB had large effects on solution pH, whereas fluazinam, lambda-cyhalothrin, and pyraclostrobin had little effect on solution pH. Precipitates formed with all fungicide combinations and in most cases permanent precipitates were formed.

In a fourth group of experiments, biological and physicochemical interactions when clethodim and 2,4-DB were applied alone or with selected fungicides. Pyraclostrobin consistently reduced large crabgrass [*Digitaria sanguinalis* (L.) Scop.] control by clethodim. Chlorothalonil and tebuconazole plus trifloxystrobin reduced large crabgrass control by clethodim in two of four experiments while prothioconazole plus tebuconazole and flutriafol did not affect control. Palmer amaranth [*Amaranthus palmeri* (L.) S. Wats] control by 2,4-DB was not affected by these fungicides. Although differences in spray solution pH were noted among mixtures of clethodim plus crop oil concentrate or 2,4-DB and fungicides, the range of pH was 4.40 to 4.92 and 6.72 to 7.20, respectively, across sampling times of 0, 6, 24, and 72 h after solution preparation. Permanent precipitates were formed when clethodim, crop oil concentrate, and chlorothalonil were co-applied at each sampling interval. Permanent precipitates were not observed when clethodim and crop oil concentrate were included with other fungicides or when 2,4-DB was mixed with fungicides. Significant positive correlations were noted for Palmer amaranth control by 2,4-DB and solution pH but not for clethodim and solution pH.

Finally, the effect of delayed application of spray solutions is poorly understood with respect to efficacy of fungicides, insecticides, inoculants, and plant growth regulators commonly used in peanut (*Arachis hypogaea* L.). Research was conducted in North Carolina during 2009 and 2010 to determine if tobacco thrips (*Franliniella fusca* Hinds) control by acephate; early leaf spot (caused by *Cercospora arachidicola* Hori) and late leaf spot (caused by *Cercosporidium personatum* Berk. and Curt.) control by chlorothalonil, prothioconazole plus tebuconazole, pyraclostrobin, and tebuconazole; Sclerotinia blight (caused by *Sclerotinia minor* Jagger) control by boscalid and fluazinam; and improvement in row visibility by prohexadione calcium were affected by the time interval between solution preparation and application. Performance of the inoculant *Bradyrhizobium* was also compared when prepared in 25 different sources of water when application was delayed after preparation of solutions. Agrochemicals and prohexadione calcium solutions were prepared the day of application or 3, 6, and 9 days prior to application with all solutions applied on the same day. Similarly, inoculant solutions were prepared the day of application or 4 and 8 days prior to application and applied on the same day. Performance of fungicides, insecticides, inoculant, and prohexadione calcium was not reduced in most instances when left in spray solution up to 8 or 9 days. The magnitude of difference in efficacy was minor when differences were observed.

Irrigation and Tillage. Research, funded by the North Carolina Peanut Growers Association, was initiated during 2001 at the Peanut Belt Research Station near Lewiston-Woodville (Norfolk sandy loam soil) to compare crop response to agronomic and pest management practices in various irrigation systems including sub-surface drip (SSD). In general, yield increases from SSD irrigation vs. no irrigation were noted for corn, cotton, and peanut in 4 of 4, 6 of 9, and 4 of 6 years, respectively. The average increase in yield for these respective crops was 47% (range of 34 to 59%), 30% (range of 1 to 54%), and 21% (range of 6 to 34%). For year/crop combinations where a yield increase was not observed from SSD irrigation (5 of 19 year/crop combinations), the ratio of water provided by the combination of SSD irrigation and rainfall to rainfall only was 1.25, 1.27, 1.28, 1.29, and 1.43. When a yield increase was observed (14 of 19 year/crop combinations), this ratio was 1.42 in one instance and 1.50 to 4.67 in the remaining 13

year/crop combinations. More specifically, in one experiment conducted from 2007-2010 and repeated from 2008-2011, crop yield in strip tillage vs. conventional tillage was compared in SSD irrigation with no irrigation in a rotation of cotton-corn-corn-peanut. The interaction of experiment (2007-2010 vs. 2008-2011) by irrigation (SSD irrigation vs. no irrigation) was significant for corn, cotton, and peanut yield. Corn, cotton, and peanut yield increased with SSD irrigation compared with no irrigation regardless of tillage system, with differences in yield for experiments reflecting differences in the magnitude of response. Cotton and peanut yield was not affected by tillage system or interactions of tillage and irrigation systems. However, corn yield was affected by this interaction. Corn yield in the first year of the corn sequence was higher in strip tillage than conventional tillage in absence of SSD irrigation; yield was higher in conventional tillage with SSD irrigation. In the second year of the cycle of corn, no difference in yield was noted when comparing tillage systems in absence of SSD irrigation. However, yield in conventional tillage exceeded that of strip tillage when SSD irrigation was included.

Fertility. Inoculation is an important input in peanut production systems. Peanut yield increased by 32% in new ground fields (28 trials) and 4% in fields where peanut was planted previously (26 trials) over a 10-year period when inoculated with in-furrow application of liquid or granular *Bradyrhizobia*. When inoculant does not perform adequately, growers apply nitrogen (N) fertilizer as soon as nitrogen deficiency symptoms are evident. In five trials conducted in new ground fields, yield was 73% of inoculated peanut when inoculant and N were not applied. Nitrogen (as ammoniums sulfate) in absence of inoculant increased yield to 89% (60 lbs actual N/acre), 96% (90 lbs actual N/acre), and 98% (120 and 150 lbs actual N/acre) of inoculated peanut. Ammonium nitrate at these rates of N increased yield 86 to 92%. Results from these trials show the value of inoculation of peanut in all fields, that the rate of N needed to correct an N deficiency is at least 120 lbs/acre, and ammonium sulfate is a more effective source of N than ammonium nitrate.

Herbicide Resistance Weed Survey in North Carolina. Palmer amaranth has become one of the most challenging pests to manage in cropping systems across the southern United States. Glyphosate resistance in Palmer amaranth was first confirmed in North Carolina in populations examined in 2005. A broader geographical survey across the Piedmont and Coastal Plain region was conducted during fall 2010 using a grid sampling procedure. A total of 242 predetermined sites were selected. If no Palmer amaranth was found at the pre-designated site, an effort was made to survey surrounding areas within a one-mile radius. A total of 126 populations were sampled from soybean and cotton fields. Plants from seed collected at these sites including confirmed glyphosate-resistant and glyphosate-susceptible populations were grown in a greenhouse. Response of populations to a range of rates for fomesafen, glufosinate, and glyphosate was determined based on visible control and the number of surviving plants. Glyphosate resistance was found in 98% of the 126 Palmer amaranth-infested fields. Preliminary results with fomesafen and glufosinate do not point to resistance to these herbicides. Results from this survey provide information that can be used to assist in developing comprehensive strategies for glyphosate-resistant populations of Palmer amaranth across much of North Carolina and provide a baseline reference for future development of resistance in Palmer amaranth populations to herbicides other than glyphosate.

Palmer amaranth Control in Peanut. Palmer amaranth has become perhaps the most challenging weed to manage in southern row crops in the United States. Peanut is especially vulnerable to Palmer amaranth because of the low growth habit of peanut, digging requirement, and prominence of resistance to acetolactate synthase (ALS)-inhibiting herbicides. Developing new herbicide programs to control Palmer amaranth and refining traditional strategies are important for peanut growers and their advisors. Research was conducted during 2011 to compare herbicide programs to manage Palmer amaranth at the Upper Coastal Plain Research Station on a Goldsboro fine sandy loam soil. The cultivar Bailey was planted in late May in conventionally-prepared raised beds spaced 36 inches apart at a seeding rate designed to achieve an in-row population of 4-5 plants/ft. Peanut was planted into a dry seedbed and irrigated 5 days after planting with approximately 0.8 inches of water using a traveling gun irrigation system. Preemergence (PRE) herbicides were applied immediately after planting and prior to irrigation using a backpack sprayer calibrated to deliver 15 gpa at 31 psi using regular flat fan nozzles. Palmer amaranth was 3 to 4 inches in height when herbicides were applied POST. Herbicide treatments included both PRE and postemergence (EPOST or POST) applications. Visible estimates of percent Palmer amaranth control and peanut injury (0 to 100% scale) were recorded at various intervals during the season. Pod yield was determined in two of the three experiments. Data were subjected to ANOVA and means separated using Fisher's Protected LSD at $p \leq 0.05$.

As expected, Dual Magnum plus either Valor SX or Strongarm outperformed Dual Magnum alone. The decrease in control over the season noted for Strongarm most likely reflects resistance to ALS-inhibiting herbicides within this population. The Valor SX rate (2 oz/acre) in this experiment rarely controls weeds for the entire season even when activated well. In a second experiment, co-applied herbicides did not adversely affect control of emerged Palmer amaranth early in the season by Cobra while in some cases control increased slightly. By late season, control ranged from 65 to 81%. While peanut injury ranged from 33 to 46% at 6 days after treatment, injury decreased to no more than 16% by 14 days after treatment. Complete control of Palmer amaranth for the entire season generally would not be expected with a total POST program including one application of Cobra even with residual herbicides are included. Control from PRE treatments ranged from 73 to 100% prior to EPOST applications. One week after EPOST applications control was at least 96% with all treatments except Prowl (67%) or Dual Magnum (74%) only. By July 1, control was at least 95% with all herbicide programs that included EPOST or POST applications or sequential applications (EPOST and POST). Although control by Prowl and Dual Magnum decreased to 39% and 59%, respectively, control by Warrant was 83%. Similarly, by mid-August Palmer amaranth control by all programs that included EPOST or POST treatments and combinations of EPOST and POST as well as programs with Valor SX PRE was at least 92%. Warrant alone was more effective than either Dual Magnum or Prowl alone. Peanut injury with PRE applications of Dual Magnum, Prowl, and Warrant was 0 to 5% on June 15 while injury from these herbicides applied with Valor SX ranged from 10 to 30% with the least amount of injury observed from Dual Magnum plus Valor SX. In contrast, greater injury with Gramoxone Inteon plus Warrant was noted compared with Gramoxone Inteon plus Warrant by June 23. Peanut yield was generally higher when PRE

herbicide programs contained Valor SX or when EPOST or POST herbicides were applied. However, considerable variation in yields was noted in the experiment. Results from these experiments provide information on possible herbicide options to control Palmer amaranth in peanut. POST applications of PPO-inhibiting herbicides performed well in these experiments and reflected timely applications. Also, PRE herbicide performed well due in part to planting procedure. Peanut was planted in dry soil and irrigated to ensure emergence after PRE herbicides were applied. Under conditions when either limited rainfall occurs or irrigation is not available, performance of PRE herbicides most likely would be less than results reported here. Also, efficacy of Cobra most likely would be lower than reported here if Palmer amaranth was larger in size.

Web site. A comprehensive database-driven website was created to provide information to extension agents and growers in the Carolinas and Virginia regarding peanut production and IPM decisions. The website (www.peanut.ncsu.edu) hosts a Peanut IPM Risk Management Decision Aid (<http://www.peanut.ncsu.edu/riskmgmt/Risk.aspx>), and also serves as an educational resource to help stakeholders identify and manage pests, and learn about a wide variety of management and production topics. The website displays over 35 individual information sheets, authored by the PIs, that detail various production and management topics (i.e. planting, harvest, and maturity), as well as specific disease and insect identification and control methods. The website also features a key word index that links like publications and topics, and it provides access to Virginia and North Carolina weather-based disease advisories. From the homepage there are links to Cooperative Extension Service publications such as production manuals and pesticide handbooks. "Peanut Notes" and alerts are periodically posted to the site throughout the growing season to address current issues that may be of interest to stakeholders. Authorized project personnel can update the website using a web-based editing program that facilitates creation of html documents, uploading of pdf files and images, and automatic key word searches of documents. Users can search the website using the key word index, author, publication date, or publication number. The website has been demonstrated to Cooperative Extension Service agents and growers through field days and workshops specific to peanut production in North Carolina.

Heritage left from PCRSP Program in North Carolina and the Southeast production area. The greatest impact has been that during a challenging time for both land-grant state supported universities and political changes in peanut programming, the support of the Peanut CRSP has allowed the peanut research and extension program at North Carolina State University to not only survive, but effectively address new peanut production issues in a timely manner. The loss of the peanut program in the Farm Bill created many challenges for all peanut growers and continued success required a reinvigorated effort to address new concerns and needs. Without the Peanut CRSP and its support, during a time of when funding for state universities dramatically declined, allowed us to address these issues and develop forward thinking programs to keep peanut production viable in NC and the Southeast. This stable funding allowed for both short and long-term research programming. The value of this support cannot be overstated. The science has been expanded with the production of 24 refereed science journal articles in the past 5 years and 31 abstracts and 10 other journal articles prior to 2007.

Crops Research Institute, Kumasi, Ghana

PI: Brandford Mochiah

Peanut is an important crop in Ghana and in sub-Saharan Africa and contributes significantly to the agricultural GDP of Ghana. Peanut is cultivated for both subsistence purposes and local and regional export markets. Production of peanut is constrained by several factors. To arrest the problem, an Integrated Pest Management (IPM) programme initiated by CSIR-CRI in collaboration with North Carolina State University in United States of America. The scientists involved have been working tirelessly in assisting groundnut farmers in Ghana to produce groundnut profitably under minimum input cost and ultimately increase grain yield and income of the poor resource-farmer.

SCIR-CRI research team. In solving and addressing farmers concern a multidisciplinary approach is used which brings the following research scientists on board to constitute the research team: Dr. M.B. Mochiah (Entomologist), Dr. G. Bolfrey-Arku (Weed Scientist), Dr. K. Osei (Nematologist), Dr. J. N. L. Lamptey (Virologist/Mycologist), Dr. H. Braimah (Entomologist), Mr. I. Adama, (Entomologist), (Dr. K.O. Fening (Entomologist) and Technicians in the various disciplines who assist scientists in the execution of their research activities.

NCSU, USA collaborators. Dr. Rick L. Brandenburg (Entomologist) and Dr. David Jordan (Weed scientist).

Change of leadership. Dr. Michael Owusu-Akyaw, who has been then Coordinator and Principal Investigator (PI) of the PEANUT CRSP under the CSIR-Crops Research Institute, went on compulsory retirement since October, 2011. Dr. Moses Brandford Mochiah, a Senior Research Scientist and Entomologist is now acting as the new Coordinator and PI. Though Dr. Owusu-Akyaw is on retirement he has been involved mostly in the project's outreach activities bringing his rich experiences to bear on the project activities.

Brief statement of overall goal: Enhancing peanut production in Ghana using multidisciplinary approach.

Ojectives.

- to identify pests diseases and weed of groundnut/peanut
- to determine losses caused by major foliar and soil pests of groundnut
- to evaluate the resistance of selected groundnut germplasm to attack by soil and foliar pests

- to test the efficacy of fungicides and botanicals for control of groundnut disease
- to develop an Integrated Production Strategy (IPS) for the management of the soil pests, and diseases of groundnut
- to transfer the IPS to farmers and extension staff through field schools

Significant technical achievements-host country, US.

- Transferred groundnut IPM production technologies through Farmer Field Schools (FFS) to over 400 farmers and 30 MOFA extension staff which diffused to over 3500 FFS and non - FFS farmers and extension staff households at Ejura/Sekyedumase, and Drobonso in the Ashanti, Atebubu and Derma in the Brong Ahafo region; Somanya, Sadan and Nkwantanang in the Eastern region from May to October 2007 to 2012.
- Two local soaps, “Alata and Amonkye” soaps, have been found to be as effective as synthetic fungicides for the control of groundnut foliar diseases and also the rosette viral disease.
- Organized Field Days on Integrated Groundnut Production Using Farmer Field School Approach at Hiwoanwu in the Ejura – Sekyedumase District of Ashanti region on 24th July, 2004 and 25th September, 2007. Over 100 peoples including Farmers, Extension Officers, Directors of Agriculture, Officials from the District Assembly, Traditional chiefs and elders and Collaborators of the CRI/NCSU Peanut IPM Project from USA Participated at each occasion.
- At the 2007 field day, four CP3 knapsack sprayers, four pairs of Wellington/field boots, four sets of protective clothing (overall and trousers), 40 cutlasses, four liters of herbicide (Glyphosate/Roundup) and two groundnut shelling machines were donated to the FFS farmers at the Ejura/Sekyedumase District by the Peanut IPM Project. This was in recognition for adopting the groundnut IPM practices which resulted in an increase in their grain yield by at least three times.
- Organised a Field Day on Integrated Groundnut Production Using Farmer Field School Approach at Agatom, Somanya in the Yilo Krobo district of Eastern region on 27th September, 2007. Over 100 People Including Farmers, Extension Officers, Directors of Agriculture, Officials from the District Assembly, Traditional Chiefs and Elders and Collaborators of the CRI/NCSU Peanut IPM Project from USA participated. A knapsack spraying machine was donated by the project to the FFS farmers for application of local soaps (alata and amonkye) for control of groundnut diseases.
- Produced video documentaries and albums on field days on Groundnut IPM Farmer Field School (FFS) activities at Hiwoanwu, Ejura (25th September, 2007) and at Agatom, Somanya, Yilo Krobo District, Eastern region (27th September, 2007), organized by the CRI/North Carolina State University IPM Project. These are reference documents of the CRI/NCSU Peanut IPM Project for technology transfer.
- Documented Socio-economic information on production and pest management practices transferred by the groundnut IPM project.
- A strong IPM team has been formed, through the Groundnut IPM Project in collaboration with scientists from North Carolina State University, USA, for a

multidisciplinary approach of solving pest problems of groundnut and other mandate crops of CRI.

Distribution of groundnut shellers for use by farmers. Groundnut shellers were fabricated by CSIR-CRI mechanics for distribution to groundnut IPM farmers who participated in Farmers Field School organized under the Peanut CRSP activities. Beneficiaries of the shellers include Peanut farmers at Ejura, Boyon and Kasei (Ejura-Sekyedumasi district) in Ashanti region), Atebubu and Derma, all in Brong Ahafo region and Somaya in Eastern region. Distribution of the shellers began in 2010 and continued during the reporting periods of 2011 and 2012. Two of the shellers were sent to groundnut IPM lead scientist and collaborator at Savannah Agricultural Research Institute (SARI) for demonstration to groundnut farmers in Northern Ghana in 2011. Recently additional 5 have been sent to SARI to benefit more of the peanut farmers under the project.

Release of two (2) peanut varieties. Two peanut lines (ICG (X) SM – 87057 (early maturing) and RRR – ICGU 88709 (late maturing) together with other lines/varieties (Table 1) were assessed by the national variety release committee which were endorsed and officially released on 7th August 2012. The two varieties have pod yields of 2.7 ton/ha and 2.4 ton/ha respectively as against a reference local variety with pod yield of 1.4 ton/ha. The two varieties have been respectively named CSIR-CRI- “Yenyawoso” literally means there is no one like you and CSIR-CRI- “Otuhia” meaning drives poverty away in the local parlance.

We thank the USAID for their support in diverse ways to achieve such an objective of enhancing and improving the standard of living of the poor resource farmer through the release of the two groundnut varieties.

Savanna Agricultural Research Institute

PI: Mumuni Abudulai

Brief statement of overall goal. Improve West African peanut production for enhanced health and socioeconomic status through the delivery of research based production system in Ghana.

Significant technical achievements-host country, US.

- We demonstrated the efficacy of neem (*Azadirachta indica* A. Juss)-based treatments for managing soil arthropods for increased yield in peanut.
- High yielding peanut varieties with resistance to diseases especially to leaf spots have been released while other potential ones are being screened for release.

- Benefit of insecticides and fungicides in peanut pest management has been demonstrated to farmers.
- Manually operated peanut shellers have been distributed to farmers to ease the drudgery of shelling peanut with the fingers.
- IPM Farmer Field School training on good agronomic practices such as proper spacing and line planting has helped farmers to increase plant population and yield.

Capacity development, i.e. laboratory, field, equipment-host country, US.

- A truck was provided to CSIR-SARI in 2009 to facilitate movements and research.
- Through the US PI, CSIR-SARI also received peanut shellers for distribution to farmers.
- Funds provided to CSIR-SARI over the years enabled the Institute to procure basic laboratory needs and infrastructure such as computers to facilitate the conduct of research.

Human Capacity/training to be listed in a table that includes.

I supervised dissertation research on peanut of the under listed students from the University for Developments Studies.

Name	Gender	Country	Degree	Completion Date	Where trained	Employment
1. Kantam John	Male	Ghana	BS	2007	Univ. For Development Studies (UDS)	High School Teacher
2. Kumi Michael Oppong	Male	Ghana	BS	2010	UDS	N/A
3. Gariba Samuel Yakubu	Male	Ghana	BS	2011	UDS	High School Teacher
4. Mohammed Huseini	Male	Ghana	BS	2011	UDS	Ministry of Food & Agriculture (MoFA)
5. Asante Maxwell	Male	Ghana	BS	2012	UDS	High School Teacher

Key workshops/short-term trainings listed in a table that includes.

Year	Location	Training Type	Number of Participants	
			Male	Female
2008	Bagurugu	Farmer Field School (FFS)	25	15
2009	Tamalgu	FFS	24	6
2010	Bagurugu	FFS	25	15
2011	Bagurungu/Sung	FFS	20	10
2011	Malta	Workshop	-	-
2012	Sung & Zankali		32	18

Importance of Technical Achievements-

- The achievements made over the years were geared towards helping farmers to increase their peanut yields for improved incomes and livelihoods
- Adoption of better agronomic practices imparted to farmers would also lessen aflatoxin contamination in harvested peanut
-

Importance of physical and human capacity development-

- The truck provided to CSIR-SARI in 2009 facilitated movements and research at the Institute and Ghana at large
- A Philanthropist through PCRSP supported farmers in CSIR-SARI's mandate area with peanut shellers that have helped to reduce the drudgery of hand shelling,
- Funds provided to CSIR-SARI also enabled the Institute to procure basic laboratory needs and infrastructure such as computers to facilitate the conduct of research.
- Supervision of BS dissertation research on peanut increased the students knowledge and interest in finding solutions to some of the protection challenges associated with cultivation of peanut
- The students trained also constitute a potential core of future peanut scientists.

**Heritage left from workshops and short-term training-
Workshop.**

- Leant a lot about other scientists work in particular about aflatoxin research in other parts of the world
- The workshop also gave me the opportunity to meet a lot of people which widened my scope of network with colleagues from other parts of the world.

Short-term training.

- The training imparted to farmers empowered them to make informed decisions about their farm operations in particular reference to pests and disease management

Heritage left in publications.

1. The findings from the publications would serve as guiding tools for farmer empowerment on improved management practices for increased peanut production for better incomes and improved livelihoods.
2. The findings would also form the bases to build on for future research in Ghana.
3. In addition, the publications would also serve as references materials to peanut producers, processors, and industrialist as well as to students, and researchers.

Final Summary of Accomplishments by Objective.

- i) Field efficacy of neem (*Azadirachta indica* A. Juss) products for management of soil arthropod pests of peanut (2008-2010).

Objective. To evaluate neem products for managing damage by soil arthropod pests and diseases of field peanut for increased yield.

a). **Scientific Findings.** Results showed that chlorpyrifos and neem seed powder and water extract lowered percentages of scarified and bored pod damage at both Nyankpala and Bagurugu. Also, populations of soil arthropods, principally millipedes, whitegrubs and termites in 2008 and millipedes in 2009 were lowered in treated plots at Nyankpala. Millipede and white grub populations were lowered in 2008 and 2010, respectively at Bagurugu. Leaf spot severity and consequently leaf defoliation were also lowered by chlorpyrifos and neem treatments. These resulted in increased pod yield in chlorpyrifos and neem treatments at Nyankpala in 2008 and at Bagurugu in 2008 and 2009. The potential use of neem for control of damage by soil arthropods and leaf spot diseases in peanut has been demonstrated in this study.

b). **Technology Developed.** The results from the current study demonstrated the efficacy of neem for pest management in peanut. Neem is abundant in the wild in Ghana and can easily be harnessed by resource-poor farmers for pest management in peanut.

- ii) **Farmer Participatory Integrated Pest Management (IPM) in Peanut in northern Ghana (2007-2012).**

Objective. To empower farmers to improve their peanut yields through IPM-based farmer participatory research and training through Farmer Field Schools.

a). **Scientific Findings.** Forty farmers (15 women and 25 men) participated in the training in 2008, 30 (6 women and 24 men) in 2009, 40 (15 and 25) in 2010, 30 (10 women and 20 men) in 2011 and 50 (18 women and 32 men) in 2012. The season-long training took farmers through good agronomic practices such as line sowing, timely weed control, pest and disease identification and management, timely harvest and proper storage. Farmers also conducted experiments to compare the effects of farmers practices (FP) to those of IPM practices in paired plots on pest pressure, damage and yield. Generally, farmers practice plots where no pest and disease control were carried out had higher severity of leaf spots, soil arthropods, and pod damage resulting in lower yield compared with the IPM plots that had treatment for soil arthropods with chlorpyrifos and fungicide sprays with tebuconazole or chlorothalonil. In a checklist interview, farmers said that line sowing gave a higher plant population than their usual practice of haphazard sowing or broadcasting of seeds. They also appreciated the increase yields in IPM plots with the use of pesticides.

b). **Technology Developed.** Sowing in lines, general pest identification and management with pesticides were imparted to farmers. A few of the affluent farmers now control leaf spot diseases on their fields with pesticides..

Effects of herbicide and fungicide applications on management of weeds and *Cercospora* leaf spots in peanut (2009-2010).

Objective. To evaluate the effect of fungicide and herbicide applications on weed and severity of *Cercospora* leaf spot diseases, and pod and haulm yield of peanut.

a). **Scientific Findings.** Field experiments were conducted during the rainy seasons of 2009 and 2010 at the research farm of CSIR-Savanna Research Institute in Nyankpala and on-farm at Bagurugu for the management of *Cercospora* leaf spots and weeds of peanut. Herbicide and manual weed controls with or without foliar fungicide sprays were evaluated. Among the treatments, a combination of two hand weedings or application of the pre-emergent herbicide Pendimethalin with one supplementary hand weeding and fungicide sprays with Triadimefon and chlorothalonil resulted in the lowest intensity of early and late leaf spots and percentage defoliation and the highest number of pods, plant biomass and pod yield. Fungicide sprays alone lowered leaf spot severity and increased yield compared to untreated plots. The study showed the importance of proper weed management and fungicide treatments for increased peanut yield.

b). Technology Developed. The benefits of fungicide sprays and herbicide weed management were demonstrated to farmers in this study. A few farmers now apply fungicides to manage leaf spots in their fields unlike in the past when leaf spots were mistaken for signs of maturity.

c). Conclusions/Recommendations. Proper weed management and fungicide control lowered the intensity of weeds and leaf spot diseases and increased peanut yield.

iii) Field Evaluation of some Pre- and Post- Emergence Herbicides for Weed Control in Peanut (2011-2012)

Objective. Farmers in Ghana use both manual hand weeding and herbicides especially the pre-emergence herbicide Pendimethalin for control of weeds in peanut. The objective of the present study was to evaluate some pre- and post- emergence herbicides for control of weeds in peanut.

a). Scientific Findings. The results obtained over the two years study in 2011 and 2012 showed that the farmers practice of two hand weedings at 3 and 6 weeks after planting (WAP), application of pendimethaline plus one hand weeding at 4 WAP, and application of the post-emergence herbicide gallant at 3-4 WAP plus one hand weeding at 6-7 WAP resulted in significantly highest number of pods per plant. Also, the application of the post-emergence herbicides agil, basagram or gallant at 3-4 WAP plus one hand weeding at 6-7 WAP or at 4-5 WAP after pre-plant treatments with pendimethaline showed significant increase in number of pods per plant over the weedy check. Pod yield was the highest in the farmers practice treatment plots and those treated with pendimethalin at planting plus one hand weeding at 4 WAP. Plots treated with pendimethaline followed by gallant at 4-5 WAP or with gallant or agil or basagram at 3-4 plus one hand weeding at 6-7 WAP resulted in significantly higher yield than sole treatment of either of the post emergence herbicides agil or gallant, and the weedy check.

b). Technology Developed. The results showed a positive response in terms of increase in yield to the use of herbicides. Thus, the efficacy of herbicides in the control of weeds in peanut was demonstrated in this study. This technology will lessen the drudgery of weed control by farmers using the handhoe particularly those who cultivate large tracts of land to peanut.

c). Conclusions/Recommendations. Because of its slow initial growth, peanut is very susceptible to weed attack at the early stages of its development. It can be concluded from the current study that two hand weedings at 3 and 6 WAP or application of the pre-emergence herbicide pendimethalin plus one hand weeding at 4 WAP or the application of the post-emergence herbicide gallant at 3-4 WAP plus one hand weeding at 6 WAP was the best in terms of weed control and increasing peanut yield.

d). Future activities/The way forward. The study was conducted on-station and with a few pre and post-emergence herbicides. Future studies should consider testing a wider range of herbicides and also on farmers' fields.

Field Screening of Peanut Genotypes for Resistance to Leaf spot Diseases (2010-2012).

Objective. Field screen peanut genotypes and cultivars for resistance to early and late leaf spot diseases. This will enable us to select for and advance cultivars that are resistant and better adapted to the farming conditions of northern Ghana.

a). Scientific Findings. The results showed that the genotypes F-Mix, G122-TX 95, ICGV (FDRS)-20 × F-Mix-39, B106 TX95, PC 7979, F-MIX × SINK-24 and the cultivar NKATIESARI exhibited the greatest resistance to early leaf spots with significantly lower severity scores compared to the others. F-Mix, G122 TX95, F-MIX × SINK-24 and B106 TX95 also exhibited the greatest resistance to late leaf spots with significantly lower severity scores. Across the two leaf spot diseases, the genotypes F-Mix, G122-Tx 95, F-Mix x SINK-24 and B106 TX95 were the most resistant. Correlation analyses showed that pod yield and peanut haulm weight were both negatively related to leaf spot severity scores. Also, early leaf spots were highly positively correlated with late leaf spots, which showed that cultivars with high severity scores for early leaf spots also had high severity scores for late spots.

b). Technology Developed. High yielding peanut varieties with resistance to leaf spot diseases have been released by CSIR-SARI (e.g. NKATIESARI) while potential resistant lines have been identified in this study for future release.

c). Conclusions/Recommendations. The genotypes F-Mix, G122-Tx 95, F-Mix x SINK-24 and B106 TX95 that showed resistance across the two major leaf spot diseases are good candidates for inclusion in future releases.

d). Future activities/The way forward. The screening program will continue as new breeding lines are developed and as and when we receive new materials from Dr. Mark Burrow of Texas A & M. University in the US.

Accomplishments by Objective.

Objective 1: Continue the development and enhancement of advisories and risk indices and other pest management decision-making tools for U.S. peanut growers. Multiple decision making tools are now available to researcher's county agents and growers. These include tools for making pesticide application decisions, variety selection, planting dates, and other production tasks based upon risk. This risk indices concept is readily understood by growers and allows them to evaluate various production options and make educated decisions before,

during, and after the growing season. These risk indices are available online and include: the southern corn rootworm risk index, <http://ipm.ncsu.edu/scr>, and the Peanut Risk Management including tomato spotted wilt virus advisory <http://www.peanuts.ncsu.edu/riskmgmt/>.

Objective 2: Continue to evaluate germplasm for pest resistance and agronomic traits to improve production efficiency and yield potential. The development of high-yielding, pest resistant cultivars is central to the mission of developing economically and environmentally-sound peanut production strategies. Two varieties were released resulting from research at the Crops research Institute in Kumasi. The two varieties have been respectively named CSIR-CRI-“Yenyawoso” literally means there is no one like you and CSIR-CRI- “Otuhia” meaning drives poverty away in the local parlance. These cultivars show improved yield and quality as well as pest resistance. Several lines tested at the Savanna Agricultural Research Institute are nearing release. Extensive efforts in North Carolina to develop improved cultivars and developing appropriate production regimens for varieties such as Bailey have proven beneficial to growers.

Objective 3: Develop a strong database on the impact of emerging soil pest problems. As production has shifted to more reduced tillage and into sandier soils, we have monitored soil insect pest populations. Our traditional pest, the southern corn rootworm, is more problematic in heavier soils and as we have moved to lighter soils, this problem has decreased. Risk indices available online for the southern corn rootworm risk index, <http://ipm.ncsu.edu/scr> have helped farmers with these decisions. Assessing this risk has allowed us to reduce the amount of prophylactic insecticide used. Pests that often occur in sandier soils such as the lesser cornstalk borer have not materialized with expansion to more southern production areas. This monitoring has allowed us to help keep production income high by avoiding unnecessary inputs.

Objective 4: Efficient weed management strategies continue to be important in U.S. production areas. The need to develop cost effective strategies continues to be a key focus of this project. More recently, biotypes expressing resistance to acetolactate-synthase inhibiting herbicides have greatly reduced ability of farmers to manage difficult-to-control weeds like Palmer amaranth and other pigweeds. Equally as troubling is the development of biotypes of Palmer amaranth that are resistant to glyphosate, a herbicide used extensively in crops often rotated with peanut. Biotypes expressing resistance to glyphosate have been reported in most Coastal Plain counties in North Carolina where peanut are grown. Compatibility of pesticides and other agrichemicals has now been studied extensively and a complete set of guidelines for tank mixes and pesticide interactions has been developed for dealers, agents, and farmers to use. With new registration of pesticides and the need to make fewer trips across fields due to higher fuel prices, defining interactions more continues to be important in helping growers develop efficient pest management strategies. Studies in Ghana have shown that locally

available products have potential to be used post emergence with economic advantages, but more work is needed.

Objective 5: Changes in Federal farm legislation have resulted in movement of peanut production to several new regions of North Carolina requiring new rotations and production programs and the same is true with expansion of peanut production within the country.

Through extensive, long-term studies of rotation and cropping patterns, information on the impact of peanut on yield of other crops is now understood. The impact of these rotations and crops on peanuts and pest problems is now better understood and this allows growers in these new areas to move forward more aggressively with long-term production plans. While localized and seasonal weather created variability that makes separating out the impact of some rotational scenarios, much insight was gained and few rotations offer any concern. These rotations also included various tillage systems which appear to have more of an impact than the specific crop in rotation.

Objective 6: Train a current Ghanaian scientist involved with the Peanut CRSP program in a Master's program at N. C. State in an associated discipline of either Agronomy, Entomology, Plant Pathology, or Weed Science to then return to his/her institute in Ghana following completion of degree. Due to budget cuts at the U. S. institution, the increasing cost of graduate education, and lack of tuition remission for out-of-state students, this objective became cost prohibitive.

Objective 7: Continue to evaluate new germplasm on research stations and in grower villages Previous work at the Crops Research Institute in Kumasi clearly demonstrated the value of evaluating improved lines of peanuts as two new varieties are released with much greater yield potential. The additional of germplasm obtained from ICRISAT and the recent partnership with Dr. Mark Burow of Texas A&M and the linkage to his project in Burkina Faso has provided an opportunity to more rapidly expand the selection process and access to a much wider array of germplasm. More recently one of Dr. Burow's former Ph.D. students is now a part of this project having returned to West Africa. Evaluations of the new germplasm from this project have shown considerable promise in both northern and southern Ghana and seed multiplication is currently underway for additional testing. This project was still in its early stages at the conclusion of this phase. With additional funding we would continue to evaluate new germplasm on research stations and in grower villages. New promising varieties remain at the core of improved peanut production in West Africa.

Objective 8: Continue the development and refinement of IPM and production strategies and programs for cost-effective peanut production in Ghana and use research findings to produce a West African groundnut pest management manual. The past ten years have led to significant advances in our knowledge for the efficient production of peanuts in both northern

and southern Ghana. This information has led to numerous scientific journal articles (confirming the quality of the research) and been a part of many farmer field schools and training sessions at numerous villages and a major component of the University of Georgia led socioeconomic study. A nation-wide peanut production manual is in its final stages and this well illustrated guide utilizes the research finding and on-farm demonstration lessons to provide detail information on best management practices to grown peanuts in Ghana.

Objective 9: Evaluate the impact of IPM practices on the incidence of aflatoxin in harvested and stored peanut. Due to the promotion of one of the key scientists in Ghana, who would have led the project to measure aflatoxin contamination harvest nuts, to an administration position and the high cost of paying for a private laboratory to process these samples, this objective was not met.

Objective 10: Evaluate the impact of harvest date on peanut quality and yield. Initial efforts to obtain these data in Ghana faltered once it was determined that the aflatoxin contamination work would not be possible. However, yield data have been collected for the two new variety releases and the lines with potential in the Savanna Agricultural Research Institute trials and used for germplasm selection leading to new variety releases. Research conducted in North Carolina over 8 years to determine the optimum digging date of the cultivar Gregory determined the interaction of digging date was significant for all parameters of yield and quality. However, pod yield was influenced most by this interaction compared with market grade characteristics. When pooled over all 17 experiments, the optimum digging date for pod yield occurred 138 days after peanut emergence (DAE) corresponding to 2798 heat units (DD_{56} calculation). The greatest increase in yield was noted when peanut was dug 128 DAE compared with 122 DAE (16% increase in yield as digging was delayed) while yield at 128, 138, and 145 DAE varied by less than 3%.

Objective 11: Conduct baseline economic studies of current peanut production in villages and then continue studies in selected sites as IPM programming is evaluated and customized for local conditions and growers are educated on these strategies. This was conducted initially by Dr. Dankyii at the Crops Research Institute and resulted in one publication, but then became significantly expanded through joint funding with a project led by the University of Georgia. Considerable resources from the joint project were put into interviews and data evaluation from many of the villages impacted by the Peanut CRSP in Ghana. We have not seen the finished project report from this study, but assume it will be made available from the University of Georgia project. Our personal observations and interviews indicate 3 and 4-fold increases

Objective 12: Conduct regional training for scientists involved with peanut research in Burkina Faso and Mali. Budget restrictions and lack of effective coordination prevented this from happening in these two countries, but the potential to impact the scientists and growers

in those areas remains high. Time, funds, and energy were placed into more training of farmers within Ghana to further ensure technology transfer.

Students Trained in Conjunction with Peanut CRSP at North Carolina State University.

2005-2012

Advisors or Committee Members: Brandenburg and Jordan

S. Riniker MS 2006. Entmology. Male Full support

Danesha Seth Carley. PhD 2006 Crop Science. Female. Partial Support

Wendy Drake. MS 2009 Crop Science. Female. Partial Support

Gurinderbit. Chahal Ph.D. 2011. Crop Science. Make. Partial Support

Relevant Publications Associated with Peanut CRSP Project 2007-2013.

All Institutions

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