YIELD PHYSIOLOGY OF PEANUTS (*Arachis hypogaea* L.)

By

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Scientific breeding of peanuts was initiated in 1928 at the University of Florida. Since that time the potential yield has more than doubled due to the release of four improved cultivars. These cultivars were Dixie Runner released in 1943, Early Runner released in 1952, Florunner released in 1969, and Early Bunch released in 1977. No previous attempt had been made to discover the physiological differences among the four cultivars that accounted for the large increase in potential yield. A growth analysis was conducted during the 1976 growing season at the University of Florida using the four Florida cultivars, a Spanish type peanut, and one soybean cultivar (Glycine max [L.] Merr.).

There were two major physiological differences among the four Florida cultivars which were responsible for the majority of the potential yield increase. The new higher yielding cultivars reached a stable pod number earlier. Dixie Runner reached a stable pod number about day 105, Early Runner about day 96, Florunner about day 84, and Early Bunch about day 75. By early initiation of a full pod load the newer cultivars had a longer period in which to fill the last pods established. The major difference among the cultivars which resulted in the increased yield potential was a higher partitioning of assimilates to the reproductive portion of the plant in the higher yielding cultivars. Dixie Runner partitioned about 31% of its photosynthate to the pods, Early Runner 61%, Florunner 74%, and Early Bunch 85%. As the amount of photosynthate partitioned to the reproductive portion of the plant increased, the plants demonstrated an increased deterioration of the vegetative portion late in the filling period. The highest yielding peanuts more closely resembled the "self destructive" characteristics of the determinate soybean.

In 1977 22 of the highest yielding genotypes from 11 different countries were analyzed to determine if they had similar characteristics to the high yielding Florida cultivars. The environment markedly affected the development of some of the genotypes which were bred for different climates. The harvest date and partitioning factor were found to be positively and significantly correlated to yield. The study indicated that in some of the cultivars yield may be increased by increasing the filling period and/or partitioning factor.

In 1978 a high yielding Florida cultivar, Florunner, and a lower yielding Florida cultivar, Dixie Runner, were analyzed to determine if the canopy deterioration demonstrated by the high yielding cultivars late in the season was the result of increased remobilization of nutrients and assimilates from the canopy to the pods. Florunner was found to increase the remobilization of nitrogen and starch during the filling period. The increased remobilization of materials from the vegetative portion may be responsible for the increased canopy deterioration. No effect of the filling period on the remobilization of nitrogen and starch was found in Dixie Runner. A shading study conducted on Florunner provided evidence that the pods may have priority over the vegetative portion for assimilates and nutrients. Shading increased the remobilization of materials from the leaves and hastened the deterioration of the canopy.

INTRODUCTION

Peanuts, as with all legume crops, exhibit relatively low yields when compared to the cereal crops. Yield breakthroughs in cereals, such as those during the Green Revolution, have not occurred in legumes. Record corn and sorghum yields exceed 20,000 kg/ha. Record peanut yields are slightly less than 10,000 kg/ha. Even when the higher percentage of oil and protein in peanuts is accounted for, record peanut yields would only be equivalent to 16,500 kg/ha. There appears to be potential for improvement in increasing peanut yields.

An analysis of the yield physiology of peanuts is pertinent to the goal of increasing yields. The development of new peanut cultivars by plant breeders at the University of Florida had led to a unique opportunity to study the physiological aspects of yield development. Through the release of four peanut cultivars, the potential yield of peanuts has been more than doubled. These cultivars were developed in the same environment, using closely related breeding lines, and using standardized methods. Analysis of these cultivars has hopefully led to a better understanding of the dynamics of yield for peanuts and legume crops in general.

LITERATURE REVIEW

Potential Yield Improvement in Florida

Peanut yields in Florida have increased remarkably for a legume crop (Figure 1). Yields have increased over four-fold since 1948. This increase continues with no tendency for leveling-off (McCloud, 1976). Much of the yield increase can be attributed to the development of new cultivars. Plant breeders at the University of Florida have more than doubled the potential yield of peanuts. This doubling of yield potential involved the release of four major cultivars (Dixie Runner, Early Runner, Florunner, and Early Bunch).

In 1928, Dr. Fred H. Hull found that pollen sacs of the peanut flower could be safely removed between 9:00 and 11:00 P.M. When pollen from other plants was applied to emasculated peanut flowers early the next morning, pollination was usually successful. These were the first artificially crossed peanuts in America and probably in the world (Carver and Hull, 1950). In 1933, Small White Spanish was crossed with Dixie Giant (a large-seeded Virginia Runner type peanut). From this cross the Dixie Runner cultivar was isolated and purified.

The Dixie Runner peanut was released in 1943 and gained wide popularity in Florida and adjacent areas of

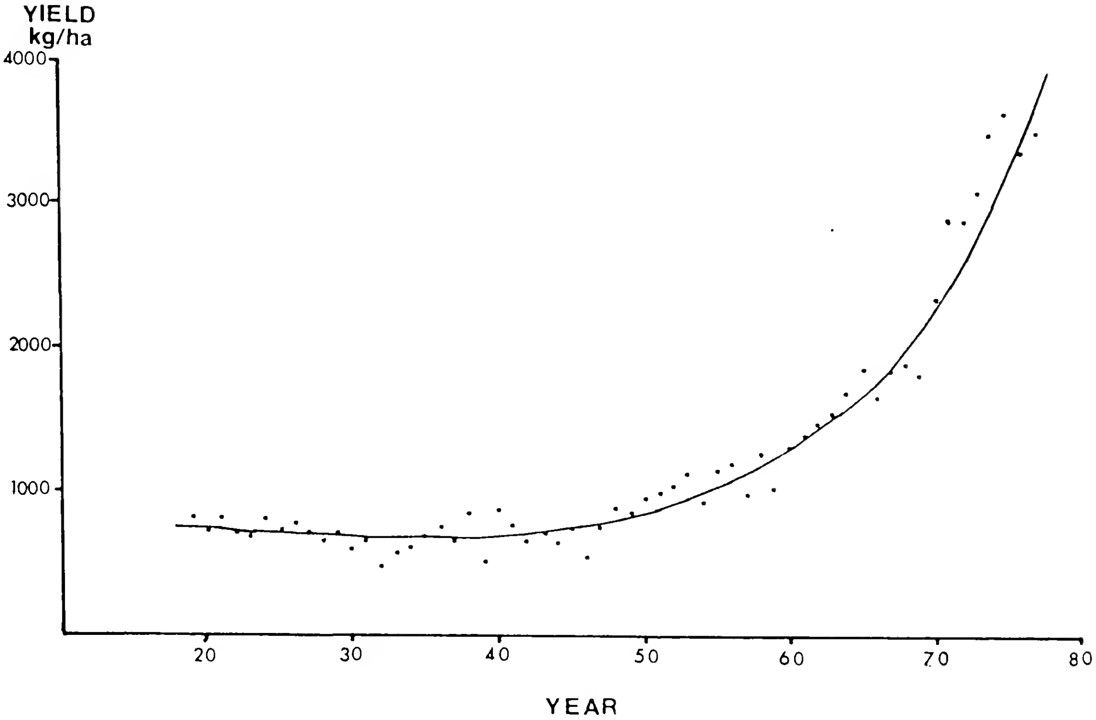

Figure 1. Yearly yield of peanuts for the State of Florida from 1919 to 1977 (Anonymous, 1977).

neighboring states. Carver and Hull (1950) report that in variety tests conducted in 1946, 1947, 1948, and 1949 Dixie Runner yielded 27% higher than the previously planted common runner peanuts. The most important differences between the two cultivars were the superior seed quality and the superior yielding ability of Dixie Runner. They observed Dixie Runner to mature 10 days earlier than the common runner peanuts, and the branches were more prostrate and compensated for the gaps left by missing hills.

In 1952 the Early Runner peanut cultivar was released. It was selected from the cross made in 1933 between Small White Spanish and Dixie Giant (Carver et al., 1952). It matured about three weeks sooner than the common runner peanut. Studies conducted from 1946 through 1951 found no differences in the yielding ability between Dixie Runner and Early Runner. Carver et al. (1952) stated that the principal advantage of Early Runner over Dixie Runner was its shorter growing season.

In 1969 the Florunner peanut cultivar was released. The Florunner cultivar quickly replaced Early Runner which had been the most widely grown cultivar in the area. The Florunner cultivar currently is grown on over half the land area devoted to peanuts in the United States and yielded 60% of the total crop output (Hammons, 1976). Florunner was derived from a cross made in 1960 of the cultivars Early Runner and Florispan (Norden et al., 1969). The maturity of Florunner (134 days) at Gainesville, Florida, is approximately two days earlier than Early Runner.

The foliage is somewhat less dense in Florunner than Early Runner, and a greater proportion of the pods is concentrated near the central branch. The seed also matures more uniformly.

Tests in Florida, Alabama, and Georgia over a three year period found the yield of Florunner to be greater than Early Runner (Norden et al., 1969). By 1975 almost 100% of the Florida acreage was planted to Florunner (Anon., 1975). The average yield for peanuts in Florida had doubled since Florunner's release in 1969 (Figure 1).

In 1977 the Early Bunch peanut cultivar was released. Early Bunch was derived by pedigree selection from a cross made at Gainesville in 1961 between F406A and F420, two Florida breeding lines. The male parent (F420) traces to a 1955 cross between Florida line 231-51 (a small-podded line closely related to Dixie Runner) and 392-12-1-7 (Norden et al., 1977a). Early Bunch matures from several to 10 days earlier than Florunner. In yield tests conducted from 1971 through 1976 in Florida, Early Bunch out yielded Florunner by an average of 5% (Norden et al., 1977b). Early Bunch has a spreading bunch growth habit (Norden et al., 1977a). Side branches are somewhat upright giving the plants a rounded appearance. The cultivar averages 73 to 80% Virginia-size pods (pods riding presizer roller spacing set a 34/64 inch).

The remarkable increase in yield potential that resulted from the release of these four cultivars was accomplished by using standardized breeding methods developed early in the program within a narrow range of germplasm and in the same environment.

Physiological Explanation for Increased Yield Potential

No previous attempt had been made to discover the physiological differences among the four cultivars that account for the large increase in yield potential. Better understanding of the physiological differences should aid in future progress in yield improvement. Many agronomists have studied yield in agronomic plants. Fisher (1975) stated that, yield potential is expressed by grain production under optimal agronomic management and without disease, weeds, or other controllable limitations to the plant. However, when only final yields are determined, little knowledge can be gained on how high yields are achieved. Growth analysis is an effective way to study the dynamics of yield physiology.

There are three plausible major explanations for the differences in yield found among different peanut cultivars. Yield can be increased by increasing the partitioning factor, the filling period, or the photosynthetic rate.

In the higher yielding cultivars more of the daily production of assimilate may be apportioned to the developing fruit and less to vegetative growth than in the lower yielding cultivars. This difference in apportioned or distributed photosynthate between the vegetation and reproductive portion of the plant is called the partitioning factor (Duncan et al., 1978). The partitioning factor is different from "harvest index." Harvest index may be broadly defined as the percentage of biological yield represented by economic yield (Wallace and Munger, 1966). It generally expresses the percentage of total aerial weight at maturity, not including abscised leaves, that represents seed weight. Harvest index only reveals what conditions exist at harvest, whereas the partitioning factor reveals the distribution of photosynthate during seed filling.

Gaastra (1962) stated that yields depend on the total dry-matter present at harvest and on the dry-matter distribution among the organs of the plant. Brouwer (1962) questioned whether it is possible to increase the useful output of a crop by influencing the percentage of dry-matter in the products to be harvested. He suggested the possibility of increasing the yield of the product to be harvested by changing the distribution between plant parts was not likely because an increase in the harvested product generally is associated with a reduction in the other organs and thus at the same time reduces the total amount of product to be harvested. However, Van Dobben (1962) noted that the partitioning of dry-matter among different parts of the plant is as important as the total yield. He stated that an increase in yield resulting from the use of better varieties may be limited to a shift in the distribution of dry-matter to more valuable organs without an increment in total yield.

Van Dobben was one of the first researchers to bring out the distribution between growth and development. He noted that warm climates (25° C) shorten the period of development without giving sufficient compensation by faster growth. As a result the plants remain smaller than in a cool climate. The overall growth of a plant is dependent on the growth rate of its various organs. Van Dobben (1962) observed that all organs do not react similarly to changes in environmental conditions. There are changes in the ratios of various plant parts (i.e., vegetative vs. reproductive components). The influence of environmental factors such as temperature, light intensity, soil moisture, and row spacing on the development of various crop plants has been corroborated by many authors (Brouwer, 1962; Shear and Weber, 1966; Spiertz, 1974).

In a personal communication, Dr. K. J. Boote and Dr. W. G. Duncan (Associate Professor and Professor, University of Florida) reported that, with peanuts, the rate of increase in the dry weight of a single tagged fruit is essentially constant under reasonably uniform growing conditions and temperatures. Egli and Leggett (1976) had similar observations for soybeans. Duncan et al. (1965) reported that the day-to-day weight growth of corn kernels was positively correlated with average air temperature and relatively independent of solar radiation. Koller (1971) found that seed growth rate in soybeans appeared to be controlled primarily by regulatory mechanisms within the seed, rather than by external availability of assimilates. Shibles and Weber (1966) reported that seed yield in soybeans was not correlated with total dry-matter produced, dry-matter produced during seed formation, or solar radiation intercepted. They noted that seed yield was a function of differential utilization of photosynthate between vegetative and seed production.

Another explanation for the differences in yield among different peanut cultivars would be a longer fruit filling period for the higher yielding varieties. Lengthening the total life of the crop could lead to increased productivity (Alberda, 1962; Brouwer, 1962; Daynard et al., 1971). The longer the crop is able to continue to use sunlight to fix CO_2 the more dry-matter the crop can accumulate. Brouwer (1962) concluded that selection for longer vegetative periods could be a way of improving yields. However, the period in the life of the crop which should be lengthened is the filling period (Daynard et al., 1971; Egli and Leggett, 1973). The filling period is the time in which the crop is actually partitioning photosynthate into the yield component of the plant. Hanway and Weber (1971b) studied dry-matter accumulation in eight soybean varieties. They found that the major differences in the final seed yields resulted primarily from differences in the filling period rather than from differences in the rates of dry-matter accumulation. Daynard et al. (1971) noted similar results in corn. They observed a significant linear relationship between grain yield and effective filling period duration. Effective filling period duration was defined as final grain yield divided by the average rate of grain formation and, hence, is a relative measure of the length of the grain filling period.

The filling period appears to be affected by the environment. Egli and Leggett (1973) and Egli et al. (1978) found differences in the filling period for the same varieties over different growing seasons. Low temperatures were associated with low seed growth rates, a longer filling period, and larger seed for soybeans. Sofield et al. (1974) found that in wheat, higher temperatures increased the rate of growth per ear by decreased yield due to a decrease in the filling period. In corn, Peaslie et al. (1971) found that nutrition influenced the rates at which corn plants developed through certain stages and that the changes in these rates of development were associated with differences in corn yields.

The filling period can also be modified by changing the seed growth rate. If seed size remains constant, then decreasing the seed fill rate would require a longer filling period to completely fill the seed. Egli et al. (1978) observed that longer effective filling periods were associated with lower temperatures during the filling period and low seed growth rates in soybeans.

The third plausible explanation for the difference in yield among peanut cultivars may be a difference in the total photosynthetic efficiency of the crop canopies. A cultivar with a more efficient canopy would produce more photosynthate with a given amount of radiation and would be capable of producing a higher yield. Bhagsari and Brown (1976) measured photosynthetic rates of attached leaves of 31 peanut genotypes, including six wild (*Arachis* L.) species and 24 genotypes of the cultivated species (*Arachis hypogaea* L.). The photosynthetic rates of genotypes of *A. hypogaea* ranged from 24 to 37 mg CO_2 dm^{-2} hr^{-1}. Florunner had consistently higher rates than most other peanut genotypes. Pallas and Samish (1974) measured the net photosynthetic rates of nine cultivated peanut genotypes and found significant differences in photosynthetic rates at similar light intensities. Trachtenberg and McCloud (1976) measured the photosynthetic rates of Florunner, Early Bunch, and Dixie Runner. They observed no significant differences in photosynthetic rates between the high and low yielding varieties.

Shading will reduce the amount of solar radiation reaching the plants. Earley et al. (1967) reported that shading corn for 21 days during the reproductive phase was more detrimental to grain production per plant than shading for longer periods during vegetative and maturation phases.

Plants shaded at 60% or higher during the reproductive phase had a full complement of normal leaves but initiated and developed only a limited number of kernels. Prine (1977) found that shading soybeans for as little as 5 or 7 days could reduce the seed yield over 15% compared to the unshaded check. In peanuts, Hudgens and McCloud (1975) reported that the peak flowering period was the period most sensitive to a reduction in solar radiation intensity. An and McCloud (1976) in a similar experiment on peanuts observed that shading during the pod filling and maturity stages only slightly decreased the number and dry weight of mature pods. Shading was also found to decrease specific leaf weight.

Bowes et al. (1972) grew soybeans at different light intensities. They found that higher light intensities during growth resulted in increased photosynthetic rates and a higher specific leaf weight. Dornhoff and Shibles (1970) noted a correlation between specific leaf weight and photosynthesis and suggested that this parameter may be a useful index for the selection of soybeans with high photosynthetic rates.

Specific leaf weight may be related to the rate of translocation out of the leaf. Egli et al. (1976) studied soybeans by varying the source-sink ratios. They reported that removal of 50% of the pods increased the specific leaf weight of the leaves. The pod removal treatment had a greater percentage of ^{14}C in the leaf than the control.

They state that the primary effect of altering the source-sink ratio was on the movement of ^{14}C labeled assimilate out of the leaf.

Reduction in the specific leaf weight in the field may be the result of more than shading or increased translocation out of the leaf. Tukey (1971) reports that up to 6% of the dry-weight equivalent could be leached from young bean leaves during 24 hours, mainly in the form of carbohydrates.

Plant Reproductive Characteristics

Flowering in peanuts is usually described in the literature as having a seasonal frequency curve similar to a normal frequency distribution (Bolhuis, 1958; Goldin and Har-Tzook, 1966; Smith, 1954). Flowering begins approximately 5 weeks after planting and may continue until the end of the growing season. Smith (1954) stated that flowering did not come to end until the plants were killed by frost in the cultivars he studied. However, McCloud (1973) observed that in the high yielding Florunner cultivar, flowering did not continue throughout the growing season but only lasted for about 60 days. Cahaner and Ashri (1974) noted that peanut plants are characterized by indeterminate growth and continuous flowering. If fruiting is prevented, both vegetative growth and flowering can continue for more than one year. Under normal field conditions flowering is reduced as pods are formed, so that it extends over a two to three month period.

The development of pods appears to inhibit the rate of flowering. In flower removal studies Smith (1954) found that when flowers were continually removed, and no fruit were set, the plants continued to flower at mid-season rates. However, if the flowers were not disturbed and fruit development proceeded normally the rate of flower production decreased. Removal of the fruits under normal fruiting conditions resulted in a prompt restoration of the conditions necessary for active flowering.

Peanut plants produce many more flowers than mature pods (Bolhuis, 1958; Smith, 1954; McCloud, 1973). Goldin and Har-Tzook (1966) reported flower numbers to range from 500 per plant to 300 per plant between different growing seasons. The number of pods per plant remained essentially the same indicating that pod production is not closely related to flower number. The flowering efficiency of peanuts is generally between 10 and 20% of the flowers producing mature pods (Cahaner and Ashri, 1974; Goldin and Har-Tzook, 1967; Smith, 1954). The pods that do develop come primarily from the first flowers (Cahaner and Ashri, 1974; Har-Tzook and Goldin, 1967; Shear and Miller, 1955).

Of the pegs that are produced, many do not develop into mature pods (Har-Tzook and Goldin, 1967; Shear and Miller, 1955). Shear and Miller (1955) determined that only 15% of the pegs formed pods in the plants they studied.

The first pegs produced the most pods. In peg removal studies they observed that plants that had fruit formation delayed by the removal of pegs early in the season still developed a comparable number of fruits as compared to the control plants. Har-Tzook and Goldin (1967) stated that there appears to exist an early fruit inhibition phenomenon, i.e., the presence of already mature pods prevents or inhibits the development of later pegs.

A large portion of the pods that are formed do not reach full maturity (Har-Tzook and Goldin, 1967; Smith, 1954). Har-Tzook and Goldin found that only about two-thirds of the total number of pods produced reach full maturity. The yield potential of the pods that reach maturity is not reached in the field because even in late harvests the oldest mature pods may be lost because of the weakened attachment of the pegs (Cahaner and Ashri, 1974). The reduction in flowering after pod set and lack of peg and pod formation is at least partially a result of the lack of photosynthetic assimilates (Hicks and Pendleton, 1969). The ovaries, pegs, and pods which fail to reach maturity are not eliminated by abscission as in many legumes but remain attached to the plant and live until late in the growing season (Smith, 1954). The excess flowering, pegging, and pod production has been thought to reduce the potential yield of the peanut (Bolhuis, 1958; Smith, 1954). It is doubtful that this excess production would markedly affect yield as the dry-matter involved in not great.

Nutrient Transfer

Many researchers (Hammond et al., 1951; Hanway and Weber, 1971a; Hanway and Weber, 1971c; Henderson and Kamprath, 1970; Kollman et al., 1974) indicated that the vegetative tissue of the soybean plant serves as a reservoir for mineral nutrients during the vegetative growth of the plant and that minerals are translocated to the seed during the filling period. The concentration of nitrogen in the vegetative portions of the soybean plant has been shown to decrease steadily during the growing season (Brevedan et al., 1977; Hammond et al., 1951; Henderson and Kamprath, 1970). Hammond et al. (1951) calculated that 58 to 64% of the nitrogen, 56 to 71% of the phosphorus, and 59 to 97% of the potassium in soybean seeds could be accounted for by N, P, and K lost from leaves, stems, and pods. Calculations by Kollman et al. (1974) from Hanway and Weber's (1971a) research indicated that losses from leaves, stems, and pods could account for 57% of the nitrogen, 52% of the phosphorus, and 55% of the potassium in mature seed. Brevedan et al. (1977) stated that an increase in the nitrogen available for redistribution may be a factor in increasing soybean yields.

Egli et al. (1978) studied the effect of nitrogen removal at the early pod filling period. They found that removal reduced yield, primarily as the result of smaller seed. Twenty to 24% of the nitrogen in the seed came from redistribution in the control, whereas, removing the nitrogen at early podfill increased this contribution to nearly 60%. Removal of nitrogen resulted in earlier leaf abscission and hastened maturity of the soybean plant. They found no appreciable effect of the treatment on the concentration of nitrogen in the abscissed leaves and suggested that a leaf can lose nitrogen to a relatively constant level before it loses its physiological activity and abscises.

Carbohydrate is also translocated to the pods from vegetative tissue. Kollman et al. (1974) observed in a pod removal study that as the sink size increased from zero to 2.7 pods per node, the carbohydrate content of the leaf blades decreased 64%. Egli et al. (1976) reported similar results.

In wheat plants, Rawson and Donald (1969) noted that 84% of the nitrogen from sterile tillers was remobilized into the main shoots as the tillers died. The remobilized nitrogen only accounted for 3% of the total nitrogen of the plant. Mikesell and Paulsen (1971) found that removal of senescing lower leaves reduced the nitrogen content of the grain.

High yielding peanut cultivars such as Florunner and Early Bunch exhibit a marked decline in leaf area late in the growing season (McCloud, 1973; Duncan et al., 1978). Enyi (1975), in a defoliation experiment with peanuts, reported that complete or half defoliation during peg or pod formation (eight to twelve weeks after planting) significantly reduced seed weight. The decline in leaf canopy late in the season is thought to possibly be responsible for some loss in yield. McCloud (1974) stated that the low leaf area coupled with older, possibly less efficient leaves during the final pod filling period could limit the amount of photosynthate available and reduce final yield. It is possible that some of the canopy decline may result from nutrient transfer from the leaves and stems to the pods very late in the season.

The idea that nutrient transfer could be so great as to be a limiting factor to the potential yield of a crop plant has been thought to apply only to soybeans. Sinclair and DeWit (1975) were the first to put forth the hypothesis of "self-destruction." They analyzed 24 crop plants based on their biochemical seed composition and energy conversions to glucose. The biomass productivity (grams of seed produced per grams of photosynthate available) was calculated. It ranged from a low of 0.42 for sesame (peanuts were 0.43, soybeans 0.50) to a high of 0.75 for rice and barley. The low productivity of sesame, peanuts and soybeans was due mainly to the high oil content of the seeds. The difference in biomass productivity from 0.42 for sesame to 0.75 for rice and barley suggests an almost twofold difference in seed yield even when the photosynthetic productivities of the crops are equal. The nitrogen required by the seed was calculated as the milligrams of nitrogen required per gram of photosynthate.

When the nitrogen required per gram of photosynthate was plotted against biomass production per gram of photosynthate, the crops segregated into four distinct groups. Soybeans were in a group by themselves. The soybean requires a large amount of nitrogen in seed production and is also one of the lowest producers of seed biomass per unit of photosynthate. The peanut is in a group with most of the world's oil seed crops. It has a low production of seed biomass per unit of photosynthate but does not require as much nitrogen in seed production as soybeans.

Sinclair and DeWit estimate that healthy, adequately fertilized crops will produce photosynthate for seed production at a rate of about 250 kg/ha/day. Generally crop growth rate potentials are estimated at about 200 kg/ha/day depending on the latitude (DeWit, 1972). Duncan et al. (1978) found crop growth rates (vegetative materials) for peanuts in Florida of about 200 to 210 kg/ha/day.

Sinclair and DeWit (1975) estimate a nitrogen uptake rate of 5 kg/ha/day. Division of the estimated nitrogen uptake rate by the photosynthate production rate (250 kg/ha/day) yields an estimate of the nitrogen supply to the seed from the soil of 20 mg of nitrogen per gram of photosynthate. This nitrogen supply is not enough to meet the nitrogen demands of the soybean and pulses which require from 23 mg of nitrogen per gram of photosynthate for chick pea to 29 mg of nitrogen per gram of photosynthate for soybean. They hypothesize that the high rates of nitrogen uptake demanded by the seeds of these species may cause a rapid translocation of nitrogen from the vegetative plant parts. This destruction of proteins for nitrogen in the vegetative plant parts leads to a loss in physiological activity, senescence of the plant, and a shortened period for seed development. Therefore, the duration of the seed filling period is intimately tied to the rate of nitrogen uptake by the "self-destructive" crop during seed fill. A low rate of uptake results in a large nitrogen demand and leads to extensive nitrogen translocation to the seeds from vegetative tissue, and shorter period of seed development. A shorter period of seed development would result in smaller seed and a lower total yield. The peanut which requires 18 mg of nitrogen per gram of photosynthate would not be expected to "self-destruct" by Sinclair and DeWit. However, observations by Duncan et al. (1978) and McCloud (1974) indicate that in high yielding varieties of peanuts the canopies do tend to "self-destruct" to some extent.

It is possible that Sinclair and DeWit's (1975) conclusion that the species (such as peanut) which do not require 20 mg of nitrogen per gram of photosynthate are not limited by the potential rate of nitrogen supply, but rather the total amount of available nitrogen, may not be totally correct. Sinclair and DeWit imply that the photosynthate production will remain constant throughout the fruit filling period. Duncan et al. (1978) and McCloud (1974) noted that the higher yielding peanut cultivars demonstrated a marked decline in the leaf area index. Toward the last few weeks of the filling period the leaf area index dropped below that required for complete ground cover. Loss of complete ground cover would lower the light interception and decrease the amount of photosynthate produced. Assuming the pods have priority for the photosynthate produced in the latter part of the filling period, a decline in the photosynthetic rate may reduce the amount of photosynthate going to the roots. This would reduce the ability of the nodules to supply nitrogen for the seed-filling late in the season as the nodules require photosynthate to fix atmospheric nitrogen. Lawn and Brun (1974) conducted an experiment on soybeans which was designed to alter the relationship between the photosynthetic source and sink components in the plants. Treatments designed to enhance the photosynthetic source/sink ratio (supplemental light and depodding) maintained nodule activity well above the control in both varieties. Conversely, treatments designed to reduce the source/sink ratio (shading and defoliation) decreased nodule activity below the level of the control. Their results may be interpreted as evidence that symbiotic nitrogen fixation may decline during pod-filling as the result of inadequate photosynthetic supply to the nodules.

Minchin and Pate (1973) on studies with the garden pea reported that nodules constitute an average of approximately 25% of the respiratory load of the nodulated root and the nodule's share of root respiration diminished throughout their experiment. Nodule senescence coincides with the initiation of flower primordia. They conclude that after the initiation of flower primordia the nodules may fare badly in competition with the root for photosynthate. On a dry weight basis the nodules respire and fix nitrogen less intensively as they age and grow. They postulated that the decline in fixation rate of nodules may be associated with the increase in senescent bacterial tissue. Many other researchers have reported that nodules senesce with the onset of fruiting. Weil and Ohlrogge (1972) noted an increase in the percentage of green nodules after flowering in soybeans. Streeter (1972) observed in soybeans that nodules started to lose color in early pod-filling (71 days after planting) and by the middle of pod-filling, most of the nodules were green. Pate (1958) observed a similar phenomenon in vetch. LaRue and Kurz (1973) using acetylene reduction found that activity dropped sharply after the onset of pod-filling.

The senescence of nodules late in the season coupled with the high demand for nitrogen from the higher yielding peanut cultivars may result in a demand for nitrogen which cannot be supplied from the roots. This may result in nutrient transfer from the vegetative portion of the plant. The canopy would decline and reduce the photosynthetic rate. The reduced photosynthetic rate may further enhance nitrogen deficiency by reducing the amount of photosynthate transported to the roots. Thus, the higher yielding cultivars may exhibit a "self-destruct" condition late in the filling period.

Many researchers have studied the translocation of nutrients from leaves. The direction of movement from a given leaf depends upon the age and position of the leaf on the stem (Thaine et al., 1959). A young leaf forms part of the major apical sink for upward-moving assimilate from the leaves below and for its own photosynthetic products, exporting nothing to the rest of the plant (Thaine et al., 1959; Thrower, 1962). When the leaf has reached 60% of its maximum size, it ceases to import assimilate and increases in importance as an exporting organ (Thaine et al., 1959). Pate (1958) reported that in young pea plants (three to five leaf plants) a free circulation of solute occurs with upper and lower leaves supplying photosynthate to both roots and shoots. Later, as more leaves develop (seven to 12 leaf pea plants), nutrition becomes stratified in such a manner that upper leaves are effective in supplying assimilates to young leaves and to the shoot apex. Lower leaves supply the roots and leaves in the middle of the stem supply adjacent stem tissues and to a lesser extent the root and shoot apex.

Blomquist and Kust (1971) observed two distinct patterns of translocation in soybeans. The first occurs before pods started to fill and was characterized by nonspecific transport to meristematic regions above the fed leaf. The second occurs during rapid pod-filling and was primarily to pods at the axil of the fed leaf and at the second axil below the fed leaf. As the plants approached maturity, a greater proportion of the total assimilate was translocated from the fed leaf.

MATERIALS AND METHODS

The first year's research was conducted at the agronomy farm of the University of Florida during the 1976 growing season. The soil was a Jonesville taxajunct, now classified as loamy, mixed, thermic Arenic Hapludalf. After 560 kilograms per hectare of 2-10-10 fertilizer was broadcast, the field was turned and disked. One week before planting, 7 liters of benefin and 2.3 liters of vernolate per hectare were applied. Seven liters of alachlor and 14 liters of dinoseb were also applied at cracking (emergence) to control weeds. To control disease and pests during the growing season, beginning at flowering, 1.7 kilograms of chlorothalonil and 1.7 kilograms of carbonyl per hectare were applied at 10 to 15 day intervals. The fertilizers, herbicides, and fungicides applied were at recommended levels for maximum yield.

The seeds were hand planted on May 4 and 5 at a nearly equidistant spacing of 30 X 25 cm. This spacing resulted in 12.9 plants per square meter which is within the range of maximum yield for Florunner peanuts. Two seeds were placed at each planting point and after emergence thinned to one plant to insure a uniform stand. Overhead irrigation was applied at planting to encourage uniform germination and during periods of low rainfall to insure adequate soil moisture. The rainfall, solar radiation, maximum and minimum temperatures for the sampling periods are given in Figure 2.

Five peanut cultivars and one soybean cultivar were planted. In addition to the four peanut cultivars discussed in the literature review (Dixie Runner, Early Runner, Florunner, and Early Bunch) which resulted in the great increase in potential yield, Spancross peanut cultivar and Bragg soybean (Glycine max [L.] Merr.) were also studied. Spancross was included to provide information on a Spanish type peanut as the other cultivars were runner and Virginia types. Bragg soybean was included to allow comparison with another extensively studied legume crop.

In 1970 the Spancross peanut cultivar was released. Spancross was developed by continuous selection for Spanish type plants in progenies from an interspecific cross between P.I. 121070-1 and the wild annual, decumbent species Arachis monticola Krap. et Rigoni (Hammons, 1970). Spancross is a Spanish type peanut with a slightly higher frequency of reproductive branches than other Spanish types. It has a high concentration of pods nearer the tap-root, and uniform pod maturity. Approximately 120 days are required for maturity of the plants. In yield tests conducted in Georgia from 1964 through 1966, Spancross produced 6.9% more pods than Argentine (the most widely grown Spanish peanut in Georgia prior to the release of Spancross). Spancross had an average seed weight of 0.38 grams, similar to Argentine.

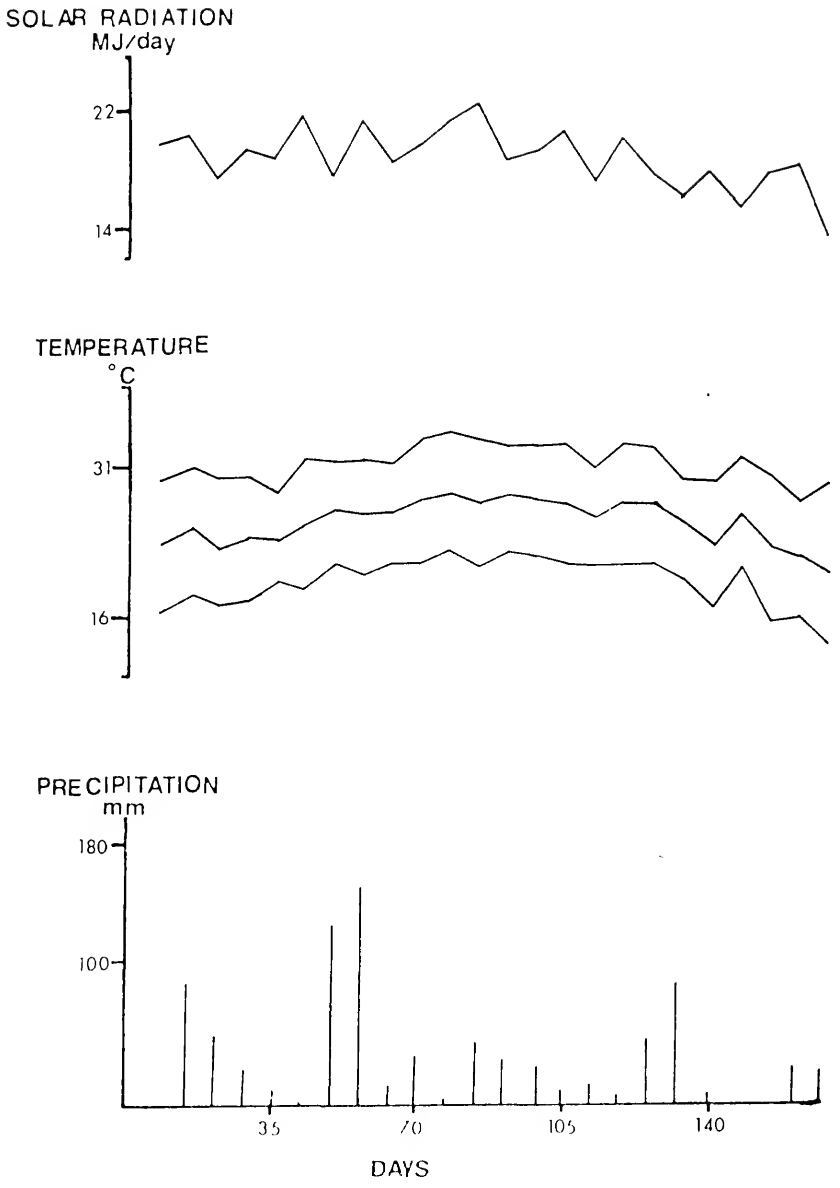

Figure 2. Average weekly solar radiation, average weekly temperature, and total weekly precipitation for the 1976 growing season.

Bragg soybeans were released in 1963. Bragg was developed at the University of Florida and was found to be a high yielding variety if grown in an area best suited for maturity group VII (Hinson and Hartwig, 1964).

The six cultivars were planted in a randomized block design with four blocks. Each block was divided into subplots consisting of five rows of 15 plants each. Four rows of 11 plants (44 plants) were used in each sample. Two border rows were between each variety and one border row was between each subplot. Samples were taken from each subplot beginning at one end of the field and moving successively across the field.

Sampling began 21 days after planting and continued at 7 day intervals. As samples were taken on weekly basis, specific data such as when flowering began or when peak LAI was reached are only approximate. In order to insure that full maturity was reached, the plants were sampled until a decline in yield was recorded. At each sampling the plants were pulled by hand early in the morning. No special measures were taken to remove all the roots, however, the soil was coarse textured and it is believed that the majority of the root-mass was removed. From each subplot the 44 plants were divided into forty-, three-, and one-plant samples. The three- and one-plant samples were selected for uniformity and transported to the laboratory for analysis.

The one-plant samples were used to determine the individual plant characteristics. Numbers of pegs, pods, and flowers were recorded. Both wilted and unwilted flowers were counted. The length of the main stem, the four longest branches, and the tap root were measured. After separation into stems, leaves, roots, and pods, the plants were dried at 105° C and the dry weight recorded. Before drying, a 100-leaf subsample was removed for calculation of the Leaf Area Index. The leaf area of this sample was measured on a Hayashi Denko Co., Ltd., Automatic Area Meter, Type AAM-5. The dry weight of the subsample was also recorded. The leaf area was determined by calculation of an area per unit weight ratio from the leaf subsample. From the leaf area per plant and the plant population of the crop, the Leaf Area Index was calculated. After the pods were dried and the dry weight recorded, the seeds were removed with a shelling machine and the dry weight of the seeds recorded.

The three-plant samples were used to determine the pod number and pod weight on a per plant basis. The pods were removed by hand, counted, dried at 105° C and the dry weight taken.

The forty-plant samples were used to determine the dry weight yields of the vegetative and reproductive plant parts. Early in the season before the pod number became too high, the plants were washed and the pods removed by hand. When the pod number increased the peanut plants were left in the field to permit the dew to dry while the one- and three-plant samples were being analyzed. Dry plants were needed for easy operation of the peanut thresher. The pods were then removed with a Japanese "Ce Co Co" peanut thresher. The pods and vegetative component were dried at 105° C and the dry weight recorded.

The percent ground-cover was determined by estimating the area covered within a one-tenth to one-third square meter area. Five observations were taken within a block and the average of these twenty samples calculated. Observations were taken each week until 100% ground-cover was obtained.

During the 1977 growing season 22 of the highest yielding cultivars from 11 countries were studied. A list of these cultivars is given in Table 1. These cultivars were grown to determine if differences in the physiological characteristics that determine yield existed. The plant density and cultural practices were similar to those used in 1976. This permitted a closer correlation with past results. Climatic data for the growing season are shown in Figure 3.

The 22 cultivars were planted in a randomized block design. Two forty-plant samples were taken during the vegetative phase (after 95% ground cover and before a pod load had been set) to determine the crop growth rate. The plants were dried at 105° C and weighed. Two forty-plant pod samples were taken during the pod loading phase to

Table 1. List of cultivars grown during the 1977 growing season.

Country	Variety Name	P. I. Numbers
Argentina	Blanco Rio Sequndo	402595
	Manfredi 68	292280
	Colorado Irradiado INTA	386349
	Colorado Correntino INTA	386348
Brazil	Tatu CA 34	410414
	Roxo 80-1	410413
Egypt	Giza-4	410417
Israel	Shulamith	
Mali	47-10	410716
Mexico	Bachimba 74	410713
	Rojo Regional	410715
Nigeria	2938.71	410778
Rhodesia	Egret	409035
	Valencia R2	409038
	Makula Red	409037
	Apollo	
South Africa	Sellie	410411
	NC-5	410412
	G120-15	410510
United States	Florunner	
	Early Bunch	
Upper Volta	TS 32-1	410777

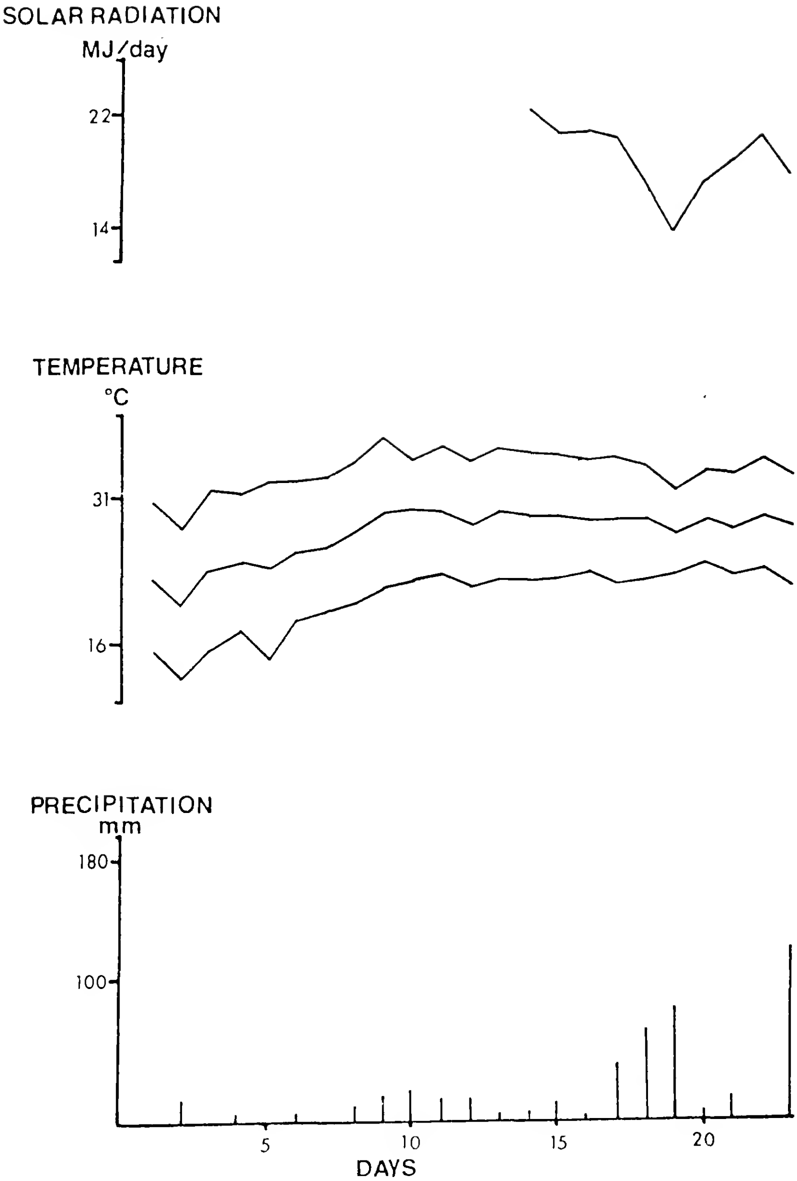

Figure 3. Average weekly solar radiation, average weekly temperature, and total precipitation for the 1977 growing season.

determine the pod growth rate. The pods were separated from the plant with a Japanese "Ce Co Co" peanut thresher, dried at 105° C and weighed. A forty-plant pod sample was also taken to determine the final yield at harvest. The time of harvest was based on visual observations taken in the field of pod attachment strength and darkened pod shell walls.

During the 1978 growing season Florunner and Dixie Runner peanuts were grown to determine if the higher yielding peanut cultivars (Florunner) exhibit more nutrient transfer from the vegetative material to the pods than the lower yielding cultivars. The two cultivars were grown with the same plant density and cultural practices as used during the first two years of research. The climatological data for the growing season are shown in Figure 4.

Four-plant samples were taken for each cultivar on a weekly basis to determine the specific leaf weight and Leaf Area Index. The total stem length was also measured. The total stem length included all stems (main, lateral, and branch).

The leaves were analyzed for nitrogen and starch to determine if there is a difference in the nutrient transfer from the leaves of the two cultivars as a result of the difference in partitioning. The procedure for nitrogen analysis is given in Appendix 1-A and for starch analysis in Appendix 1-B.

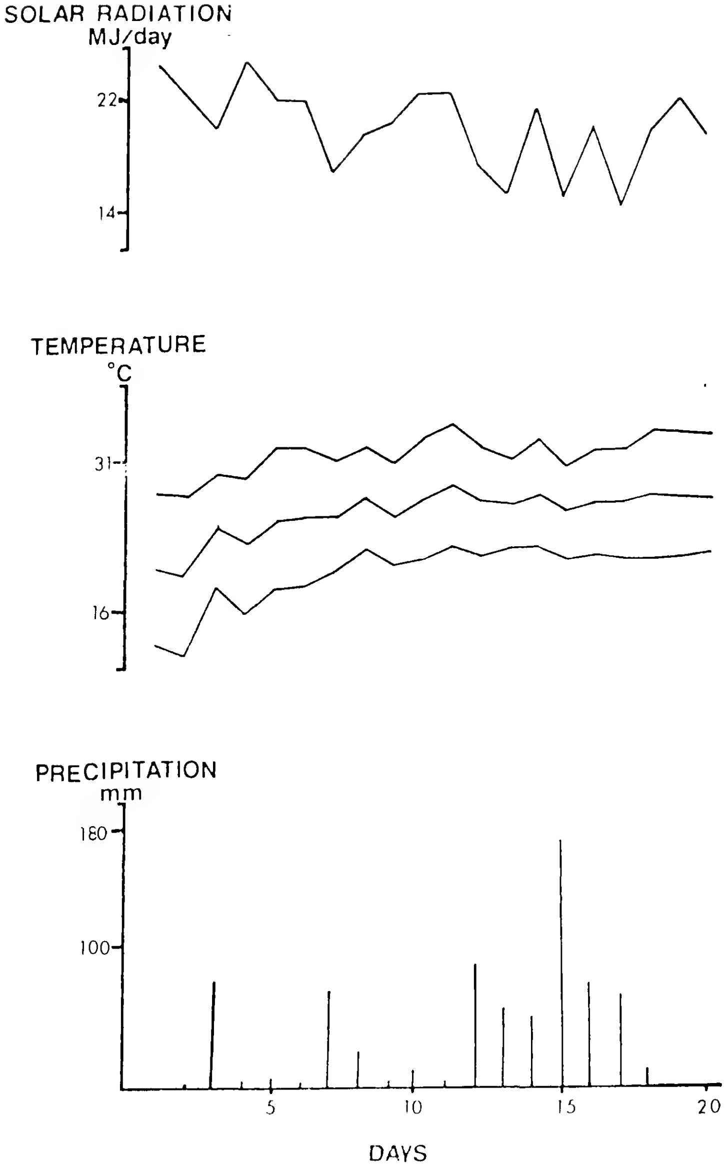

Figure 4. Average weekly solar radiation, average weekly temperature, and total weekly precipitation for the 1978 growing season.

The first leaf samples for chemical analysis were taken at the beginning of the pod loading phase (at the end of flowering) in order to determine the level of nitrogen and starch in the leaves of the plant prior to any effect that may result from the pod load. Analysis was made on the oldest leaves (the yellow leaves that have not dropped from the plant) and from the newest fully developed leaves. To determine which leaf to remove for the new leaf samples, a series of leaf samples were taken starting at the tip of the branch and moving down the stem. The area and dry weight of the leaf samples were measured. The node number (counted from the apex) of the leaf with the highest average specific leaf weight was recorded. The leaves taken for the new leaf samples were all from this node number. Samples were also taken to determine the effect of age on the nitrogen and starch content of the leaves. At the first sampling period, the node number (counted from the base) of the new leaf samples was recorded. Then, at two week intervals, samples were taken from the same node until harvest.

When the first sample was taken a 75% shade was placed on each of the cultivars. The weekly sample was expanded to include the shaded treatment.

At harvest samples were taken of the new and old leaves of both cultivars and for the shaded and unshaded treatments. A forty-plant sample was also taken to determine final yields.

RESULTS AND DISCUSSION

1976 Growth Analysis

Ground Cover and Leaf Area Index

The plant canopy can only function at its maximum potential when all the incoming radiation is being intercepted. Without a complete ground cover, solar radiation will reach the ground instead of the leaves and not be utilized in photosynthesis. The percent ground cover is the precent of the soil surface that is actually covered by the crop canopy and is related directly to the amount of solar radiation intercepted. The Leaf Area Index (LAI) is the total leaf area per unit of surface area. The LAI is not directly related to the amount of solar radiation intercepted by the plant. With variable leaf and canopy structures and plant densities some crop species will require a different LAI to intercept all the incoming radiation.

In this study all the cultivars including the soybean increased ground cover at a similar rate. All cultivars reached complete ground cover by about day 56 from planting (Figures 5-10). The ground cover increased geometrically in all cultivars with approximately a 50% increase in ground cover during the last week before full ground cover was reached.

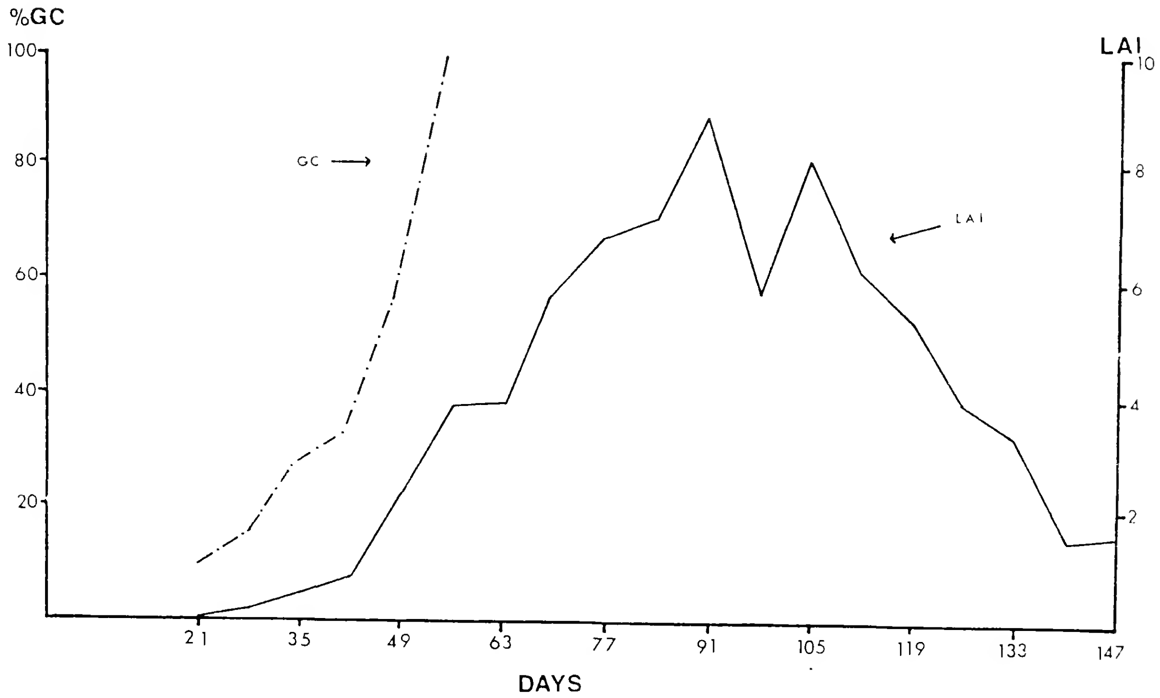

Figure 5. Ground Cover and Leaf Area Index during the 1976 growing season for Dixie Runner peanuts.

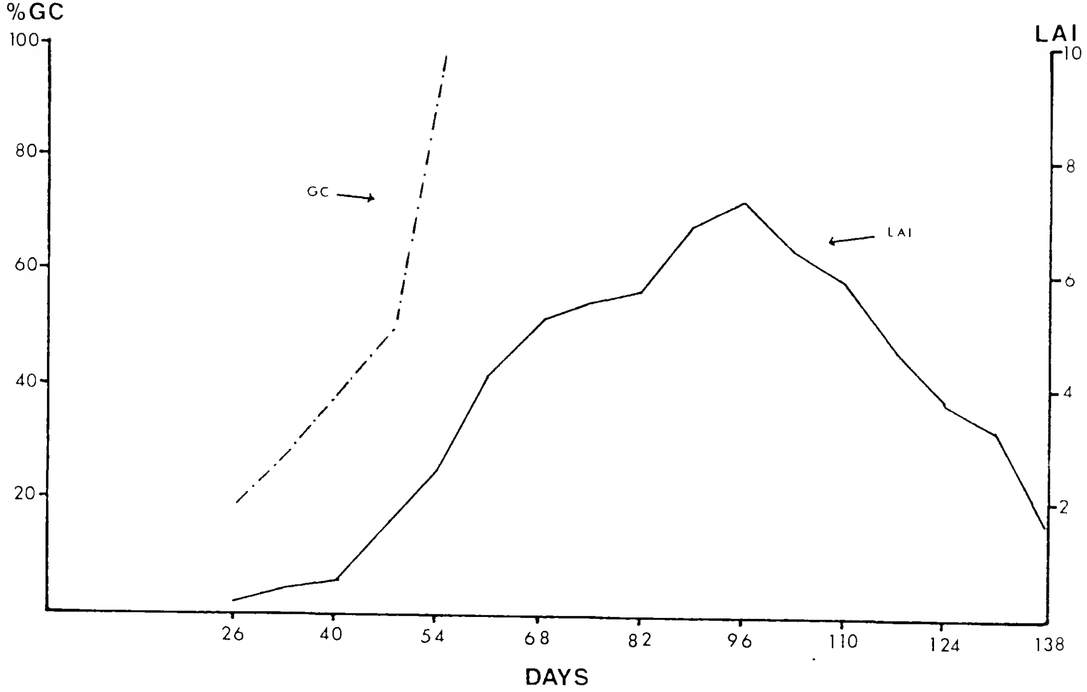

Figure 6. Ground Cover and Leaf Area Index during the 1976 growing season for Early Runner peanuts.

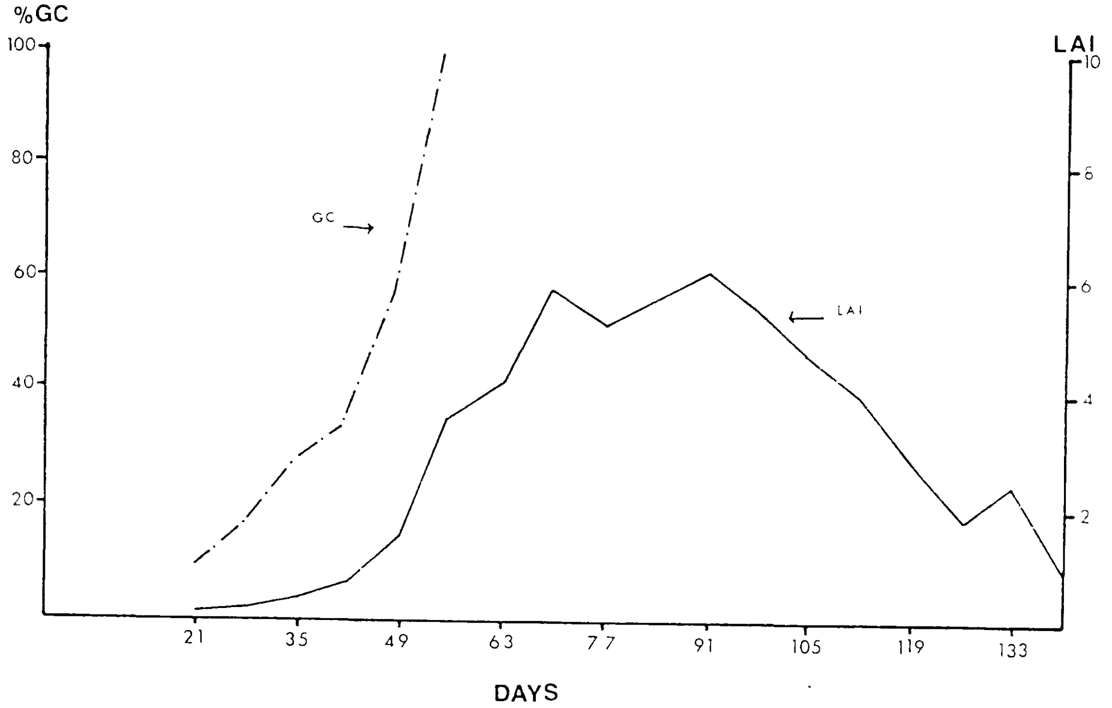

Figure 7. Ground Cover and Leaf Area Index during the 1976 growing season for Florunner peanuts.

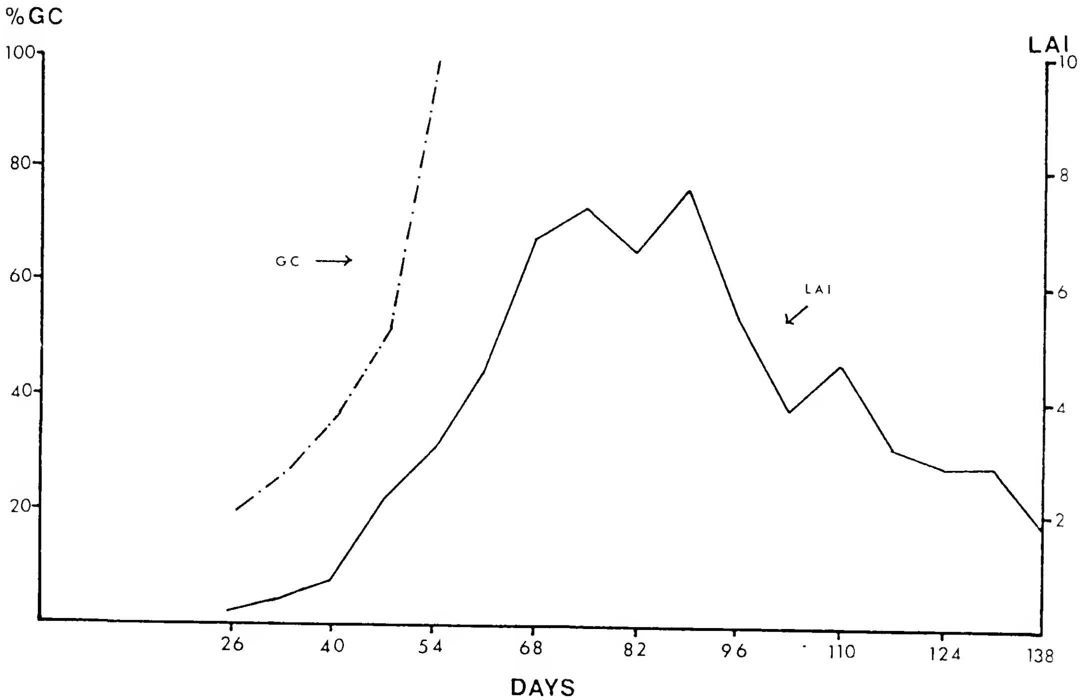

Figure 8. Ground Cover and Leaf Area Index during the 1976 growing season for Early Bunch peanuts.

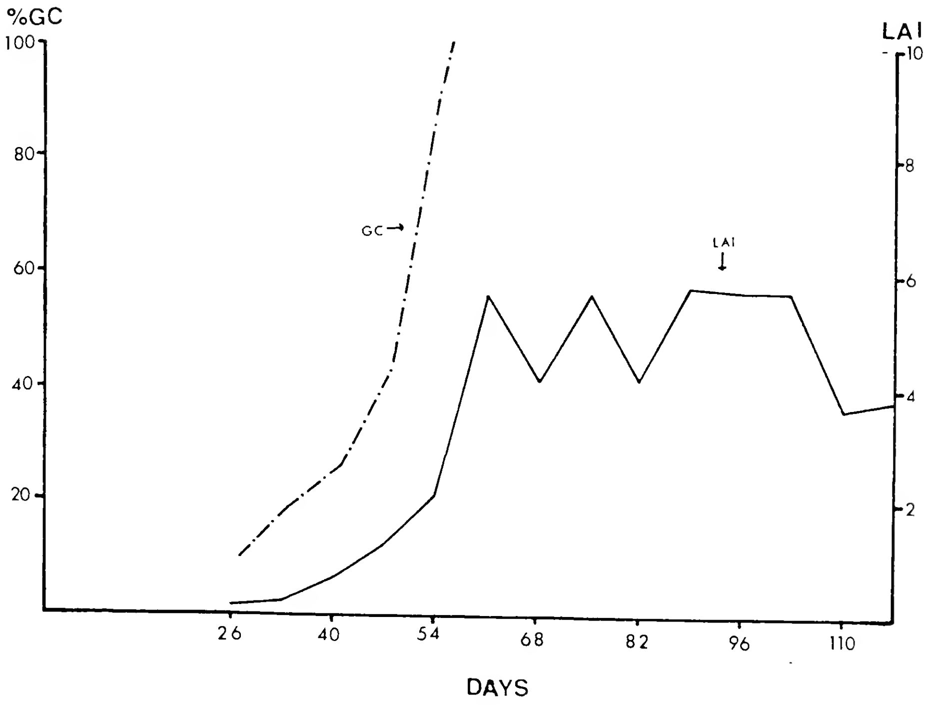

Figure 9. Ground Cover and Leaf Area Index during the 1976 growing season for Spancross peanuts.

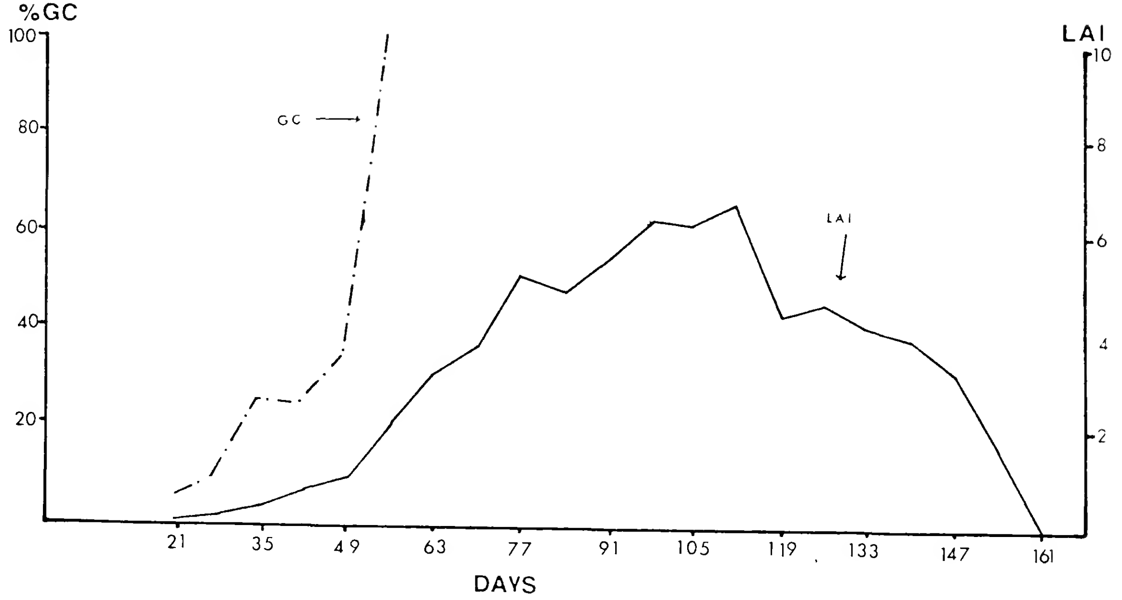

Figure 10. Ground Cover and Leaf Area Index during the 1976 growing season for Bragg soybeans.

Dixie Runner, the oldest of the peanut cultivars studied, had an LAI of 3.7 when complete ground cover was reached, and by day 70 the LAI had increased to 5.7. At this time the LAI appeared to plateau at an average of 6.8 for the next eight weeks. The peak LAI of 8.9 was reached on day 91. At day 119, three weeks before harvest, the LAI began decreasing rapidly. The decline was attributed to leaf spot disease, insect attack, and leaf senescence. The LAI was 3.3 the week before harvest. Harvest was defined as the week when the highest pod yield was achieved. One additional sample was taken after the harvest sample to insure that the highest yield possible for the cultivars would be recorded. The value of 3.3 is close to the value required for complete ground cover. At harvest the LAI was 1.5 which is below that required for complete ground cover. A reduction in LAI to that at or above what is required for complete ground cover is unlikely to have a sizeable effect on photosynthate production. A reduction in LAI below that required for complete ground cover will effect photosynthate production as not all the solar radiation will be intercepted by the crop canopy. The LAI for Dixie Runner was low enough during the last week to negatively effect photosynthate production.

Early Runner peanuts, the cultivar released after Dixie Runner, had an LAI of about 2.6 when complete ground cover was reached (Figure 6). By day 68 the LAI had increased to 5.2. At this time the LAI appeared to plateau with an average of 6.2 for the next seven weeks. The peak LAI of 7.3 was on day 96. At day 110, three weeks before harvest, the LAI began to decrease rapidly. At harvest the LAI was 3.4 which is above that required for a complete ground cover. Then, Early Runner would not be expected to have its potential yield reduced by incomplete ground cover.

Florunner peanuts, the cultivar currently grown by the majority of United States peanut growers, had an LAI of 3.6 when complete ground cover was reached (Figure 7). By day 70 the LAI appeared to plateau at an average of 5.6 for the next five weeks. The peak LAI of 6.1 was reached on day 91. At day 98, five weeks before harvest, the LAI began to decrease rapidly. This rapid decrease in LAI was two weeks earlier for Florunner than either Dixie Runner or Early Runner. The LAI had decreased to 2.8 by day 119, which is slightly below that required for complete ground cover. Thus, Florunner did not maintain a complete ground cover two to three weeks before harvest.

Early Bunch, the newest of the Florida line of peanut cultivars, had an LAI of about 3.1 when complete ground cover was reached (Figure 8). By day 68 the LAI had increased to 6.7. At this time the LAI appeared to plateau at an average of 6.7 for the next five weeks. The peak LAI of 7.7 was reached on day 89. At day 96, five weeks before harvest, the LAI began to decrease rapidly. The canopy decline began about the same time as Florunner and two weeks earlier than Dixie Runner and Early Runner. The LAI had decreased to 3.2 by day 117, two weeks before harvest. Early Bunch, like Florunner, did not maintain an LAI sufficient enough for complete ground cover two to three weeks before harvest.

Spancross peanuts, the Spanish type cultivar, had an LAI of about 2.1 when complete ground cover was reached (Figure 9). By day 61 the LAI had increased to 5.6. At this time the LAI appeared to plateau at an average of 5.2 for the next seven weeks. The peak LAI of 5.8 was reached on day 89. The LAI did not show the rapid decline as in the other peanut cultivars. It did decline to about 3.7 at harvest; however, this is higher than that required for complete ground cover.

Bragg soybean had an LAI of about 2.1 when complete ground cover was reached (Figure 10). By day 77 the LAI had increased to 5.2. At this time the LAI appeared to plateau at an average of 5.5 for the next eight weeks. The peak LAI of 6.6 was reached on day 112. By day 112, seven weeks before harvest, the LAI began to decrease rapidly. This decline began about two weeks earlier than that for Florunner and Early Bunch. The LAI of Bragg soybean declined to 3.2 by day 147, two weeks before harvest. By harvest on day 161 the LAI was approaching zero, indicating that for about the last two weeks before harvest complete ground cover was not maintained.

The cultivars studied may be separated into four groups. Spancross peanuts are in a group by themselves. Spancross peanuts did not appear to have a very significant canopy decline late in the growing season. Only during the last week did the LAI decrease and it never dropped below that required for complete ground cover before harvest (Figure 9). Dixie Runner and Early Runner appear to be in another grouping. They both began a decline in LAI approximately three weeks before harvest. Dixie Runner's LAI declined below that required for complete ground cover at harvest. The third group consists of Florunner and Early Bunch. The two newer cultivars began to decline in LAI about five weeks before harvest. They both had an LAI about two weeks before harvest which indicates that complete ground cover was not maintained until harvest. The fourth group consists of Bragg soybean. It differs from the newer peanut cultivars in that the canopy decline began about two weeks earlier and was more complete at harvest. Bragg soybean, similarly to Florunner and Early Bunch, had an LAI below that required for complete ground cover about two weeks before harvest.

Flowering

By about the fifth week after planting all the peanut cultivars had begun to flower. Bragg soybean began flowering about two weeks later. The flower frequency curve for Dixie Runner (Figure 11) describes an increasing flower production to a peak of 53 flowers per plant on day 77.

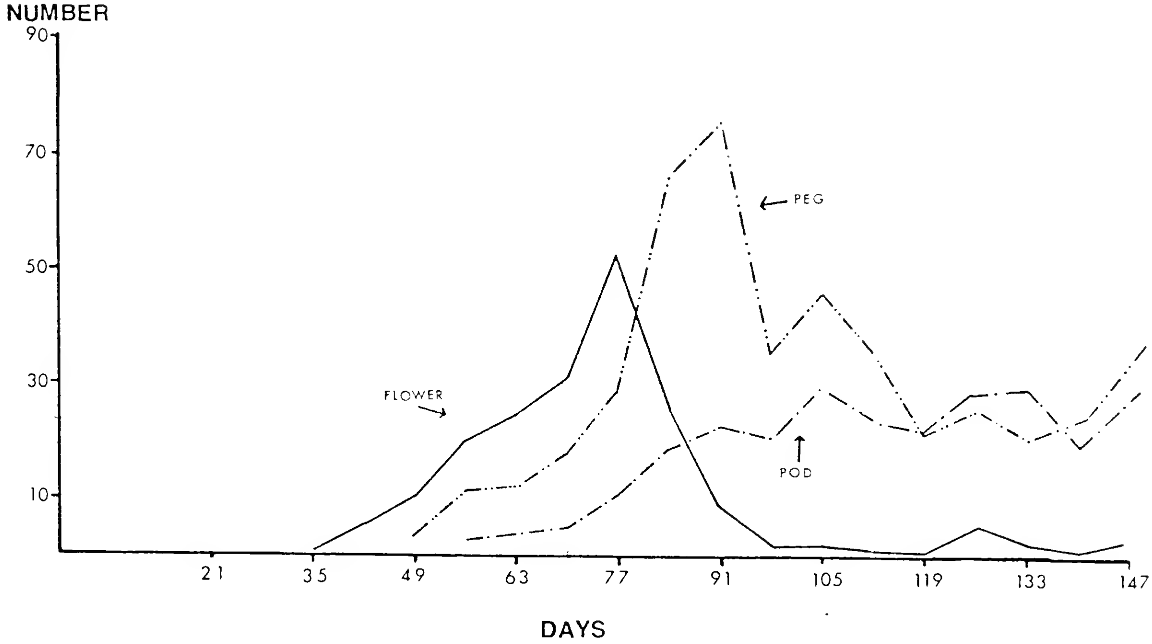

Figure 11. Weekly number of flowers, pegs, and pods for Dixie Runner peanuts during the 1976 growing season.

After which the flower production declined rapidly but never completely ceased. The flower production was only about two flowers per plant the last seven weeks before harvest. The Early Runner flower frequency curve (Figure 12) shows a similar distribution to that of Dixie Runner. However, the Early Runner curve reached a peak flower count of 55 flowers per plant on day 82, then declined very rapidly to only 0.5 flowers per plant three weeks later. After sampling on day 103 the plants ceased flowering completely. Florunner had a flower frequency curve (Figure 13) which increased to a plateau on day 56. There were about 31 flowers per plant for a three week period after which the flower count decreased rapidly. After day 91, flowering ceased. The Early Bunch flowering frequency curve (Figure 14) was similar to that for Florunner. The flower number increased to about 28 flowers per plant on day 61. Flowering continued at about the same frequency for four weeks then declined to about three flowers per plant one week later. After day 89, flowering ceased. Spancross increased in flowering frequency to a maximum of 56 flowers per plant on day 75 (Figure 15). Flowering decreased rapidly after this but never ceased. Bragg soybean began flowering around day 56 and continued to flower at about eight flowers per plant for about eight weeks (Figure 16). By day 112 flowering had decreased to one flower per plant. After day 112 flowering ceased.

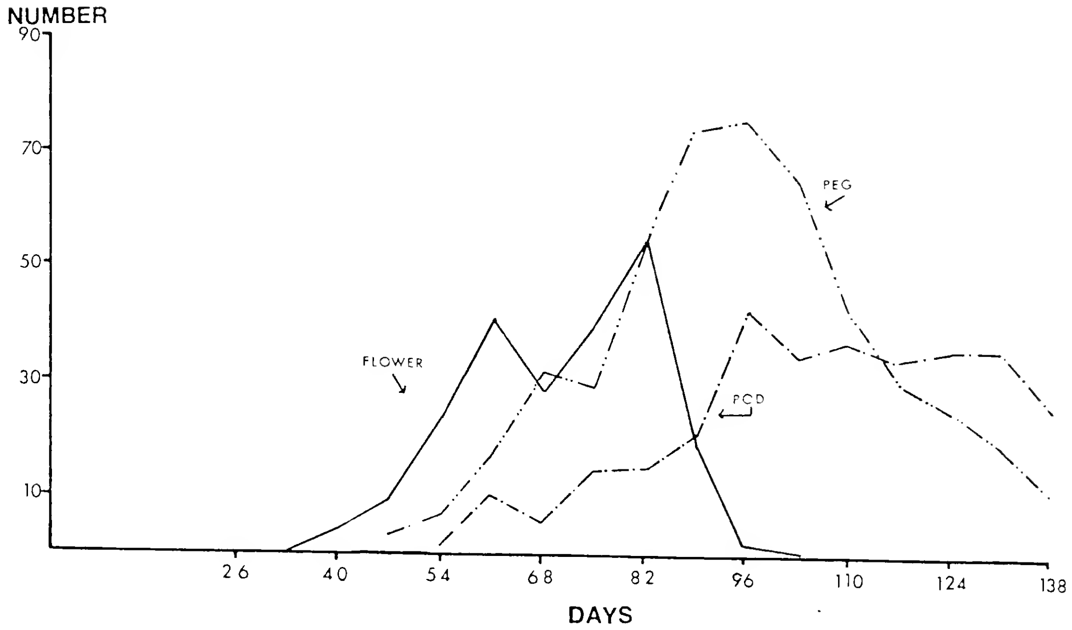

Figure 12. Weekly number of flowers, pegs, and pods for Early Runner peanuts during the 1976 growing season.

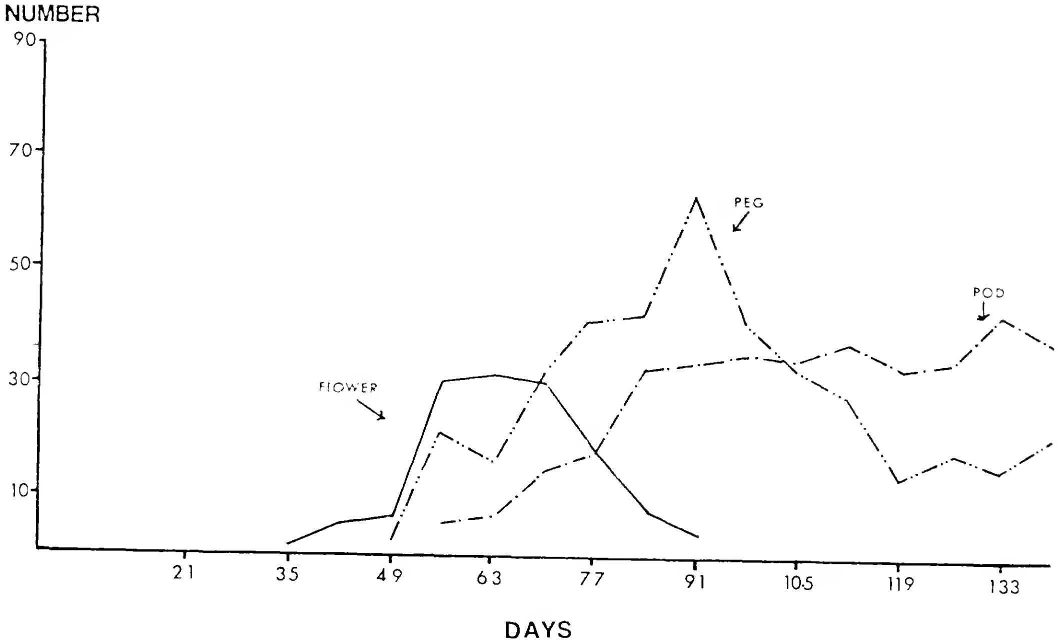

Figure 13. Weekly number of flowers, pegs, and pods for Florunner peanuts during the 1976 growing season.

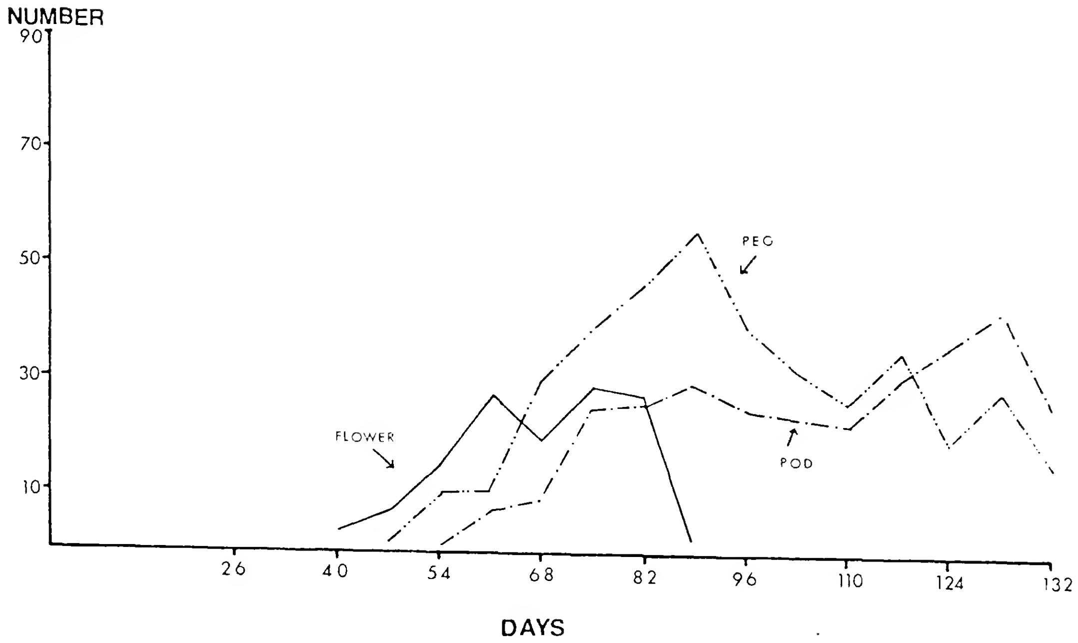

Figure 14. Weekly number of flowers, pegs, and pods for Early Bunch peanuts during the 1976 growing season.

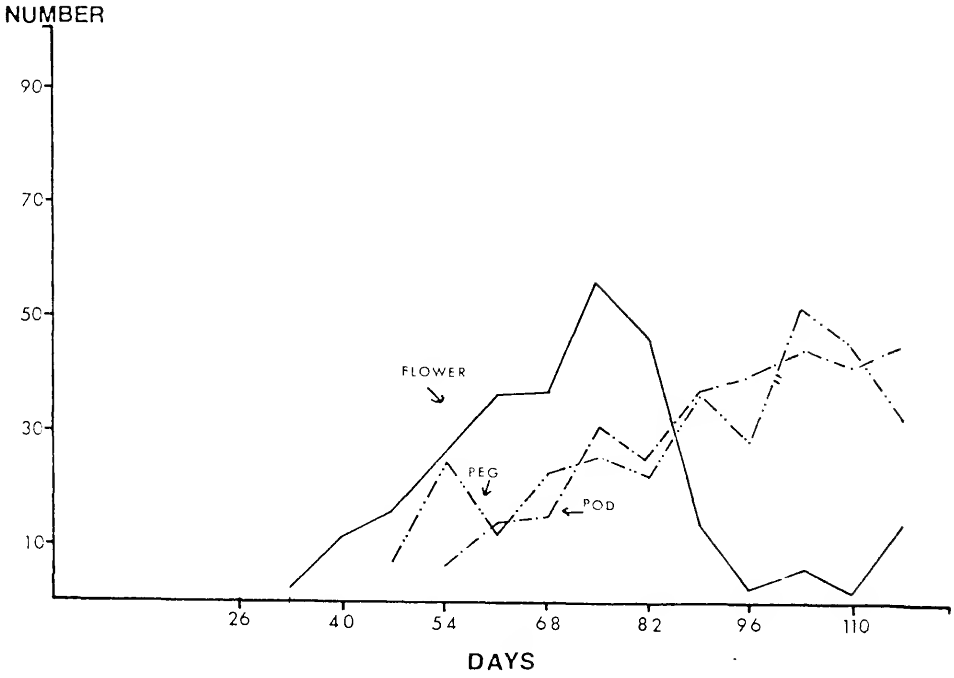

Figure 15. Weekly number of flowers, pegs, and pods for Spancross peanuts during the 1976 growing season.

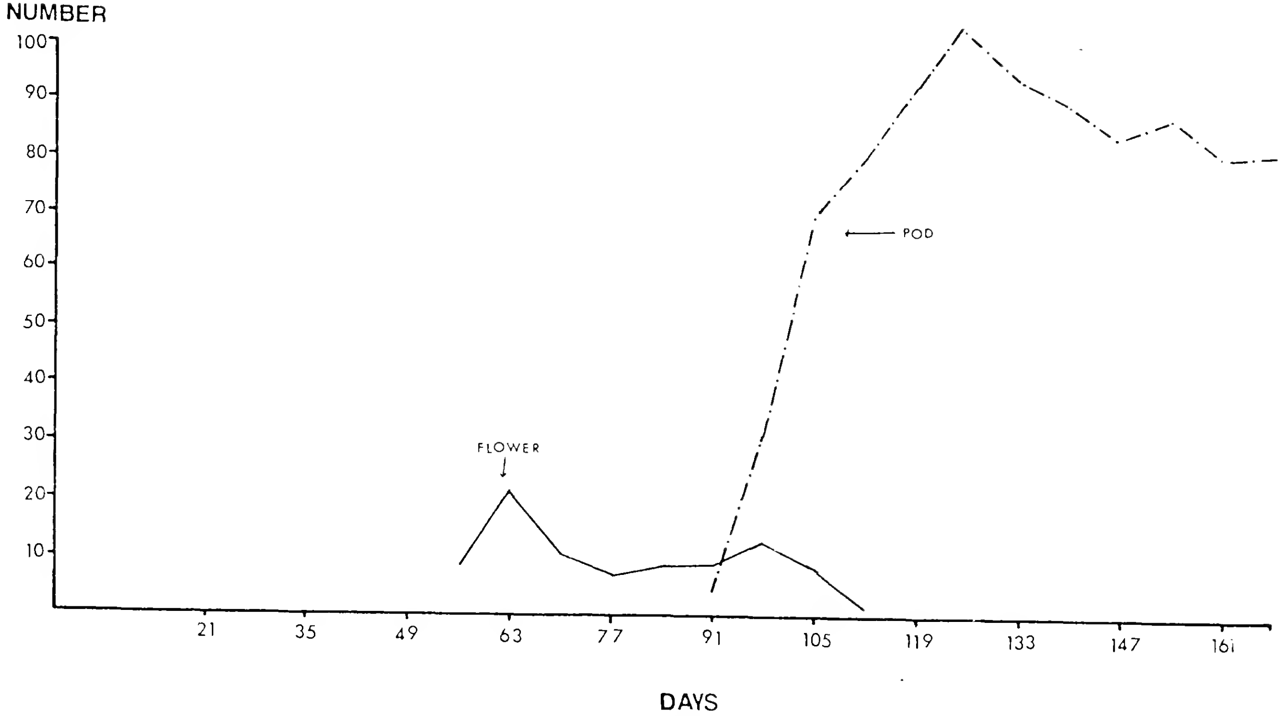

Figure 16. Weekly number of flowers and pods for Bragg soybean during the 1976 growing season.

Dixie Runner, the oldest cultivar, and Spancross, the low yielding Spanish cultivar, both continued flowering for the entire growing season. The newer, higher yielding cultivars (Early Runner, Florunner, and Early Bunch) ceased flowering five or six weeks before harvest. Early Runner, the oldest of the three, flowered for about 11 weeks. Early Bunch, the newest cultivar, flowered about eight weeks. Florunner flowered for about nine weeks. Bragg soybean, which is a determinate legume with "self-destructive" characteristics, flowered for about eight weeks then ceased much like the newest peanut cultivars.

Pegging

The first pegs appeared one to two weeks after the first flowers for all the peanut cultivars. All of the peanut cultivars studied had sufficient quantities of pegs for production of higher yields. There were always unfilled pegs available even at harvest (Figures 11-15). The peg frequency curves for the four Florida peanut cultivars showed an increase in peg count up to about day 91 to 96. After this time the peg count decreased sharply. This sharp decline was not thought to be attributed to pegs forming new pods as the pod count had already stabilized by this time. Peanuts do not have an abscission layer for eliminating unfilled pegs. The decline resulted from rotting of the pegs. Spancross did not show the same peg frequency curve as the Florida cultivars (Figure 15). The peg count appeared to increase steadily throughout the season with about the same number of unfilled pegs as pods.

Pod Fill

The peanut cultivars began producing pods one week after the first pegs were formed. Dixie Runner, the oldest of the Florida cultivars, had a steadily increasing pod count up to about day 105 (Figure 11). At day 105 the pod frequency curve plateaued at approximately 25 pods per plant until harvest. The seeds began to fill about day 77 (Table 2). The shelling percentage increased to a maximum of 71 at harvest. At harvest Dixie Runner had an average pod weight of 0.75 grams per pod.

Early Runner had a steadily increasing pod count up to day 96 (Figure 12). At day 96 the pod frequency curve plateaued at an average of 37 pods per plant. The seeds began to fill by day 75 (Table 3). The shelling percentage climbed erratically. The highest shelling percentage was 69, and was reached as early as day 110. The final shelling percentage was 67. Early Runner had an average pod weight of 0.77 grams per pod at harvest.

Florunner reached pod count stability by day 84 (Figure 13). A pod count of approximately 35 pods per plant was maintained from day 84 to harvest. The shelling percentage climbed erratically until day 112 when it reached a maximum of 73 until harvest (Table 4). Florunner had an average pod weight of 0.93 grams per pod at harvest.

Early Bunch reached pod count stability at about day 75 (Figure 14). Early Bunch had the earliest establishment of a stable pod number of the Florida cultivars. The oldest

Table 2. Average weekly dry weight of components of Dixie Runner peanuts during the 1976 growing season.

Day	Total	Leaf	Stem	Root	Pod	Seed	Shelling
	g	g	g	g	g	g	%
21	0.70	0.30	0.21	0.19			
28	1.42	0.69	0.48	0.25			
35	2.43	1.41	0.81	0.21			
42	5.05	2.71	1.87	0.47			
49	11.03	5.35	4.94	0.74			
56	21.26	10.03	10.07	1.13	0.04		
63	24.52	10.95	12.70	0.69	0.18		
70	35.52	15.65	19.03	0.59	0.26		
77	50.39	19.92	28.85	0.74	0.89	0.16	18
84	66.46	24.18	37.26	0.99	4.03	1.20	30
91	73.65	24.55	41.90	1.07	6.14	2.15	35
98	59.42	16.85	35.30	0.87	6.40	3.09	48
105	82.16	24.24	45.59	0.87	11.46	6.12	53
112	76.44	19.63	44.76	0.69	11.36	6.52	57
119	81.95	19.70	45.30	0.84	16.08	10.23	64
126	79.77	16.57	42.06	1.15	17.99	11.64	65
133	75.50	11.62	39.39	1.03	23.46	16.40	70
140	54.35	5.12	33.87	0.75	14.62	10.42	71
147	61.49	5.24	36.74	0.89	18.62	11.78	63

Table 3. Average weekly dry weight of components of Early Runner peanuts during the 1976 growing season.

Day	Total	Leaf	Stem	Root	Pod	Seed	Shelling
	g	g	g	g	g	g	%
26	1.49	0.70	0.47	0.32			
33	3.27	1.76	1.02	0.49			
40	4.51	2.41	1.56	0.54			
47	9.97	4.84	4.11	1.02			
54	18.08	8.40	8.71	0.91	0.06		
61	29.02	12.47	14.20	1.37	0.98		
68	37.85	15.62	19.58	0.79	1.86		
75	46.84	17.64	23.84	0.77	4.60	1.86	40
82	55.16	19.79	28.20	0.78	6.39	3.01	47
89	65.65	21.90	32.47	1.38	10.52	5.71	54
96	88.27	23.82	39.75	1.42	23.29	14.07	60
105	80.36	20.83	36.23	1.22	22.08	14.65	66
110	86.71	19.98	38.28	1.13	27.52	18.86	69
117	95.99	13.50	31.23	0.76	30.50	16.79	55
124	75.92	11.44	31.73	1.23	31.52	21.82	69
131	73.25	11.42	32.52	1.29	29.03	19.46	67
138	63.17	6.74	28.47	0.70	27.26	19.55	72

Table 4. Average weekly dry weight of components of Florunner peanuts during the 1976 growing season.

Day	Total	Leaf	Stem	Root	Pod	Seed	Shelling
	g	g	g	g	g	g	%
21	1.04	0.38	0.28	0.38			
28	1.66	0.75	0.56	0.35			
35	2.53	1.34	0.88	0.31			
42	4.74	2.47	1.71	0.56			
49	9.45	4.71	3.95	0.76			
56	24.65	11.36	11.76	1.43	0.17		
63	27.78	12.59	13.38	1.27	0.54		
70	46.36	18.55	23.81	0.892	3.11	0.82	26
77	47.47	16.51	24.74	0.648	5.57	2.62	47
84	57.35	18.65	27.37	1.26	10.06	4.54	45
91	63.52	18.28	29.56	0.81	14.87	8.32	56
98	65.62	17.59	28.08	1.11	18.84	12.43	66
105	66.48	12.25	28.05	1.10	21.17	13.87	66
112	69.22	14.21	24.21	0.81	30.00	21.83	73
119	64.07	11.40	24.16	0.54	27.98	20.26	73
126	67.42	7.96	24.85	1.30	33.31	24.64	74
133	75.68	6.50	28.16	0.89	40.13	28.75	72
140	71.60	4.29	28.43	0.51	38.37	29.14	76

cultivar, Dixie Runner, had the latest; the time required for a stable pod number decreased with each new variety. Early Bunch had an average of 29 pods per plant. The seed began to fill about day 75 (Table 5). The shelling percentage increased to a maximum of 74 at harvest. Early Bunch had an average pod weight of 1.50 grams per pod at harvest.

Spancross reached a stable pod count about day 90 (Figure 15). After that time the plants maintained an average of 41 pods per plant. The seed began to fill by day 82. The shelling percentage increased to a maximum of 67 at harvest (Table 6). Spancross had an average pod weight of 0.62 grams per pod at harvest.

Bragg soybean began producing pods about five to six weeks after flowering. The pod count increased rapidly to day 119 (Figure 16). A stable pod count of approximately 92 pods per plant was maintained from this time until harvest. At harvest the average pod weight was 0.41 grams per pod at harvest. The final shelling percentage was 73 (Table 7).

Growth Analysis

The growth of Dixie Runner followed a sigmoid curve (Figure 17). The early geometric phase covered the first seven weeks. It was characteristized by the accumulation of dry matter in the vegetative components. The largest component in terms of dry weight during this phase was the leaf (Table 8). The leaves of the plant comprised as much

Table 5. Average dry weight of components of Early Bunch peanuts during the 1976 growing season.

Day	Total	Leaf	Stem	Root	Pod	Seed	Shelling
	g	g	g	g	g	g	%
26	1.75	0.75	0.59	0.41			
33	2.83	1.47	0.83	0.53			
40	4.84	2.71	1.57	0.56			
47	9.50	4.96	3.68	0.86			
54	17.80	9.26	7.37	1.15	0.02		
61	26.05	11.40	12.47	1.32	0.86		
68	42.12	17.97	20.79	0.93	2.44		
75	57.75	21.21	28.02	1.06	7.48	2.43	32
82	59.31	19.70	26.62	1.00	11.98	4.63	37
89	73.90	21.58	34.30	1.32	16.70	8.49	51
96	67.46	15.60	28.56	1.13	22.18	14.38	65
103	55.21	11.67	22.43	0.51	20.60	13.19	64
110	74.01	13.81	26.58	0.69	33.00	23.35	71
117	83.89	10.54	30.73	0.91	41.71	25.12	60
124	93.83	9.52	28.33	0.90	55.07	40.63	74
130	109.50	9.74	34.70	1.01	64.05	47.36	74
138	79.35	6.02	24.36	0.91	48.06	34.36	71

Table 6. Average weekly dry weight of components of Spancross peanuts during the 1976 growing season.

Day	Total	Leaf	Stem	Root	Pod	Seed	Shelling
	g	g	g	g	g	g	%
26	1.01	0.44	0.34	0.23			
33	1.71	0.82	0.60	0.29			
40	3.63	1.96	1.32	0.35			
47	8.21	4.14	3.41	0.66			
54	16.97	8.01	7.69	0.91	0.37		
61	23.63	10.43	11.31	1.06	0.83		
68	37.26	15.16	17.76	0.98	3.38		
75	52.85	19.10	23.84	0.90	9.01		
82	50.72	16.73	22.16	0.85	10.98	5.50	50
89	66.72	18.78	27.25	1.06	19.63	10.90	56
96	77.06	20.70	32.43	1.67	22.26	14.06	65
103	88.46	20.78	38.36	1.51	27.81	17.72	64
110	76.41	14.45	34.67	1.38	25.91	17.29	67
117	81.85	13.72	38.49	1.33	28.31	15.82	56

Table 7. Average weekly dry weight of components of Bragg soybean during the 1976 growing season.

Day	Total	Leaf	Stem	Root	Pod	Seed	Shelling
	g	g	g	g	g	g	%
21	0.56	0.19	0.08	0.29			
28	0.97	0.41	0.22	0.34			
35	1.54	0.69	0.29	0.56			
42	3.79	1.79	1.15	0.85			
49	5.05	2.33	1.77	0.96			
56	12.11	5.03	4.90	2.19			
63	17.27	7.03	7.24	3.00			
70	23.19	8.33	10.11	4.75			
77	35.93	13.06	18.59	4.28			
84	41.56	13.33	19.55	8.68			
91	47.81	14.54	25.89	7.34	0.04		
98	66.99	23.07	34.37	7.86	1.70		
105	68.51	17.89	31.86	13.14	3.61		
112	67.25	16.53	34.76	7.61	8.35		
119	62.04	14.19	30.82	6.61	10.42		
126	74.34	14.98	32.14	8.15	19.07		
133	68.88	13.60	26.71	8.26	20.32	11.30	56
140	82.78	13.68	28.19	15.11	24.80	13.69	55
144	73.52	10.44	22.74	8.54	31.80	19.50	61
154	95.95	5.51	20.72	13.16	33.13	24.09	73
168	52.64	0.16	14.64	4.51	33.33		

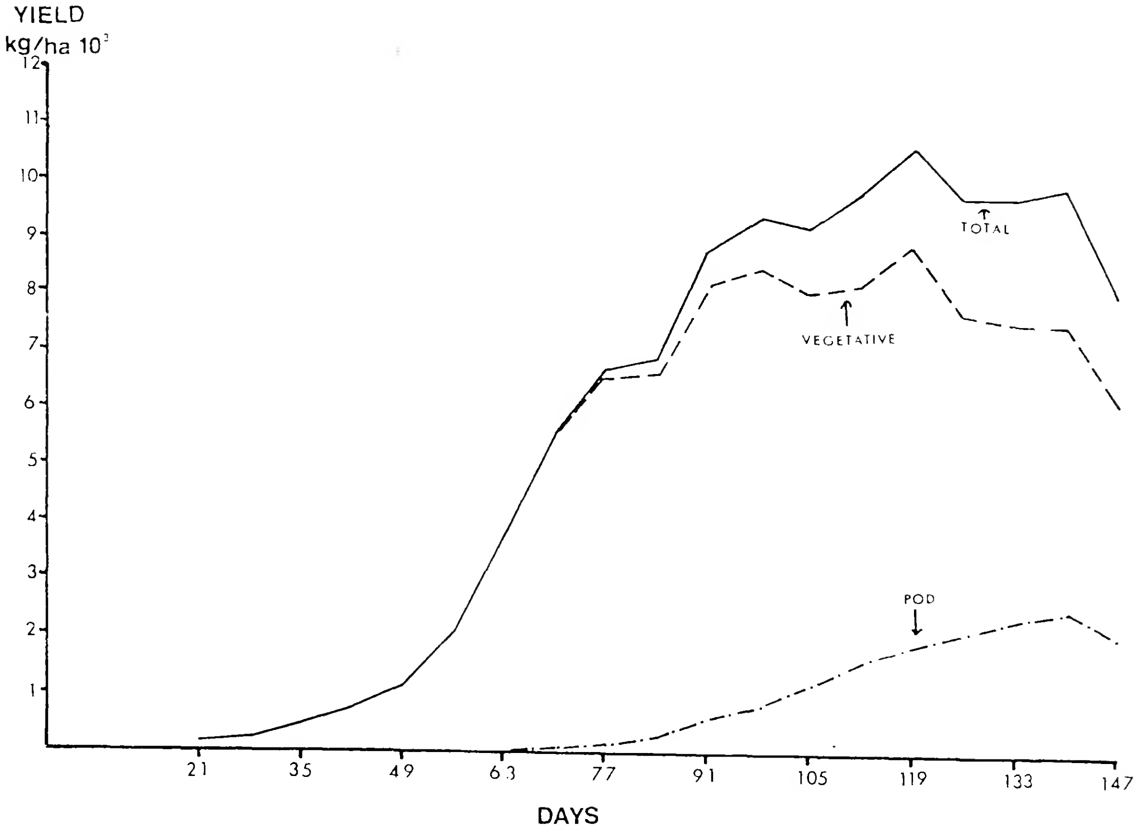

Figure 17. Total biomass dry weight partitioning into vegetative and pod components for Dixie Runner peanuts during the 1976 growing season.

Table 8. Root, stem, leaf, and pod dry weight percentages for Dixie Runner during the 1976 growing season.

Day	Root	Stem	Leaf	Pod
21	27.1	30.2	42.7	
28	17.4	33.6	49.0	
35	8.5	33.3	58.2	
42	9.3	37.0	53.7	
49	6.7	44.8	48.5	
56	5.3	47.3	47.2	0.2
63	2.8	51.8	44.7	0.7
70	1.7	53.6	44.0	0.7
77	1.5	57.3	39.5	1.7
84	1.5	56.1	36.4	6.1
91	1.5	56.9	33.3	8.3
98	1.5	59.4	28.4	10.8
105	1.1	55.5	29.5	13.9
112	0.9	58.5	25.6	15.0
119	1.0	55.3	24.0	19.7
126	1.5	54.1	21.3	23.1
133	1.4	52.2	15.4	31.1
140	1.4	62.3	9.4	26.9
147	1.4	59.7	8.5	30.3

as 58% of the total plant dry weight during this phase. The roots initially constituted 27% of the dry weight, but rapidly decreased to 6.7% by the end of the early geometric phase. The stem component was 27% of the plant at the first sampling period and increased throughout this phase.

The linear growth phase began around day 49 and continued for approximately 10 weeks. The crop growth rate from day 49 to day 70 was 222 kg/ha/day (Table 9). The equation for this relationship is $Y = -10016 + 222X$ with a coefficient of determination (r^2) of 0.983, a standard error of the Y-estimate of 319 kg/ha, and a standard error of the slope-estimate of 20 kg/ha/day. The period from day 49 to day 70 was during the linear growth phase and prior to seed development. This growth rate may be used to estimate the amount of photosynthesis available for crop growth. During this period the canopy was not greatly affected by insect attack or disease.

After day 77 the seeds of Dixie Runner began to fill and the development of the plants began to shift from total vegetative growth to partial reproductive growth (Table 2). As the pod count increased and the plants partitioned more of the available photosynthate into the reproductive component, the vegetative components began to decrease in rate of growth due to lack of photosynthate. The reduction in photosynthate available for vegetative growth was demonstrated in Dixie Runner by the flower count decline

Table 9. Crop growth rates, pod growth rates, partitioning factors, and final yields for the cultivars grown in the 1976 experiment.

Cultivar	Crop Growth Rate kg/ha/day ± SEE	r^2	Days	Pod Growth Rate kg/ha/day ± SEE	r^2	Days	Partitioning Factor	Final Yield kg/ha[a]
Early Bunch	191 ± 20	.959	40-75	98.7 ± 6.0	.985	75-110	0.85	5377 a
Florunner	212 ± 15	.985	49-77	95.0 ± 4.2	.992	77-112	0.74	4642 b
Bragg Soybean	116 ± 11	.959	49-91	79.3 ± 3.2	.995	119-147	0.96	4282 bc
Early Runner	200 ± 14	.986	47-75	74.1 ± 6.0	.975	82-117	0.61	3823 c
Spancross	182 ± 24	.966	47-68	63.7 ± 1.3	.998	68-110	0.58	2941 d
Dixie Runner	222 ± 20	.983	49-70	41.9 ± 1.4	.992	77-133	0.31	2472 d

[a] Values with different letters are significantly different based on Duncan's Multiple Range Test (Alpha = .05).

which began after day 77 (Figure 11). The LAI plateaued about day 70 (Figure 5). The leaf dry weight plateaued by day 84 (Table 2). The pod count stabilized at approximately 25 pods per plant by day 105 (Figure 11). The stem elongation slowed (Figure 18) and the stem dry weight stopped increasing (Table 2) by day 112. The total biomass curve slowed in rate of increase about day 91 (Figure 17). The total biomass growth rate decreased due to leaf loss and also because more photosynthate is required in the production of dry matter in the seed than in the vegetative portion as a result of the higher percentage of oil and protein in the seed.

The final growth phase covers the last three weeks before harvest. This phase was characterized by a reduction in the total biomass of the plants (Figure 17). During this phase the LAI decreased sharply (Figure 5). The leaf and stem dry weights also decreased sharply (Table 2). The pod growth rate, however, continued to increase at a linear rate until harvest (Figure 17).

The pod growth rate calculated from day 77 to day 133 was 41.9 kg/ha/day (Table 9). The equation for this relationship is $Y = -3193 + 41.9X$ with a coefficient of determination of 0.992, a standard error of the Y-estimate of 77 kg/ha, and a standard error of the slope-estimate of 1.4 kg/ha/day. The final yield was 2472 kg/ha/day, the lowest of all the cultivars studied (Table 9).

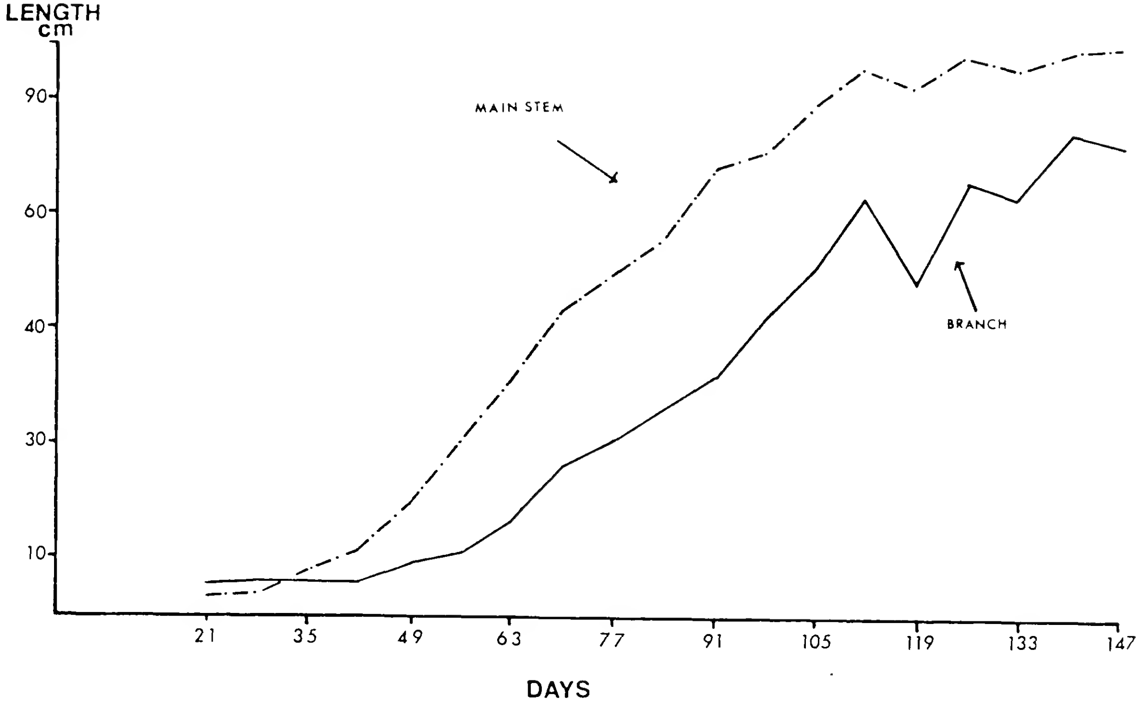

Figure 18. Length of the main stem and average length of the four longest branches of Dixie Runner peanuts, measured weekly during the 1976 growing season.

The growth of Early Runner was similar to that of Dixie Runner (Figure 19). The early geometric phase covered approximately the first seven weeks. The leaf component was the largest in terms of dry weight up to 53.5% of the total plant weight (Table 10). At the first sampling date the roots constituted 21.5% of the dry weight, but rapidly decreased with time. The stem component was initially 31.7% and increased throughout the geometric phase.

The linear growth phase began around day 47 and continued for approximately seven weeks. The crop growth rate from day 49 to day 75 was 200 kg/ha/day (Table 9). The equation for this relationship was $Y = -8048 + 200X$ with a coefficient of determination of 0.986, a standard error of the Y-estimate of 301 kg/ha, and a standard error of the slope-estimate of 14 kg/ha/day. The period from day 47 to day 75 was during the linear growth phase and before seed development.

After day 75 the seeds began to fill and the plants began to change from total vegetative growth to partial reproductive growth (Table 3). As the pod count increased and the plants began to apportion more photosynthate into the seeds, less was available for vegetative growth. Early Runner was higher yielding than Dixie Runner (Table 9) and partitioned even more photosynthate into the reproductive component. The effect on the rate of growth of the vegetative components is even more pronounced. The

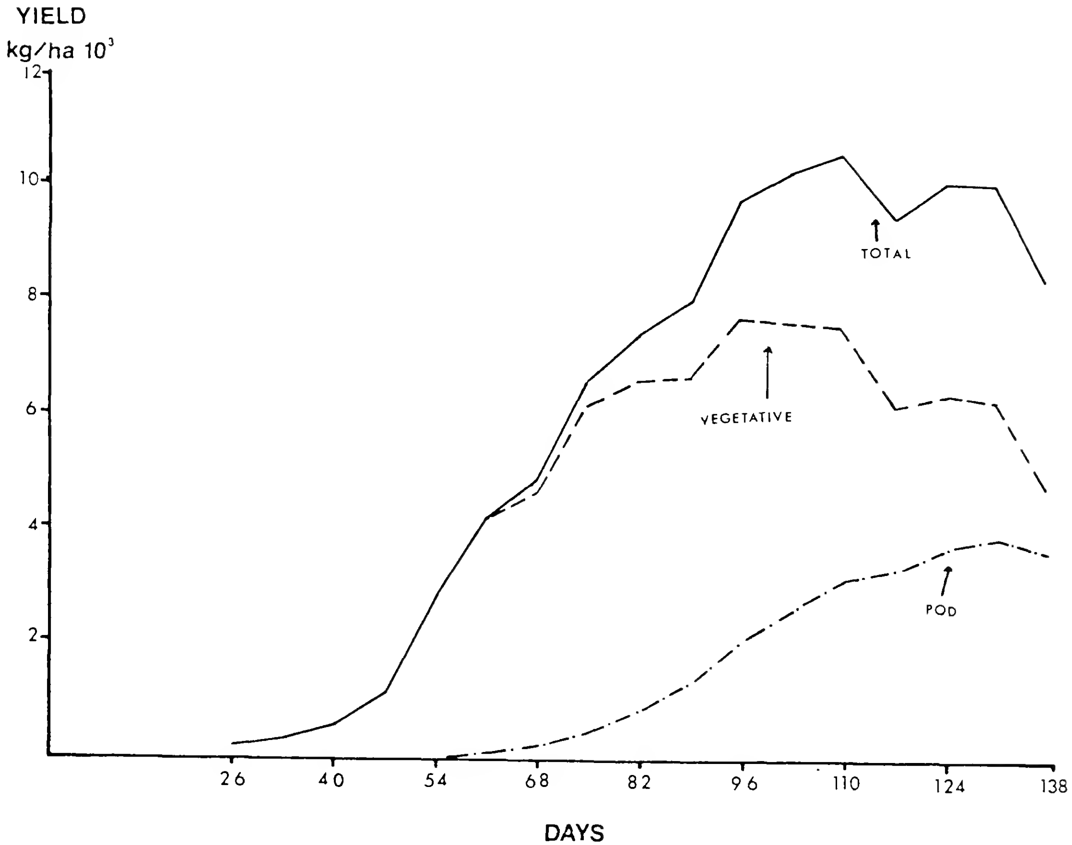

Figure 19. Total biomass dry weight partitioning into vegetative and pod components for Early Runner peanuts during the 1976 growing season.

Table 10. Root, stem, leaf, and pod dry weight percentages for Early Runner peanuts taken during the 1976 growing season.

Day	Root	Stem	Leaf	Pod
26	21.5	31.7	46.8	
33	14.1	31.5	54.4	
40	12.0	34.5	53.5	
47	10.3	41.2	48.5	
54	5.0	48.2	46.5	0.3
61	4.7	48.9	43.0	3.4
68	2.1	51.7	41.3	4.9
75	1.6	61.6	30.3	9.8
82	1.4	51.1	35.9	11.6
89	2.1	49.5	33.4	16.0
96	1.6	45.0	27.0	26.4
103	1.5	45.1	25.9	27.5
110	1.3	44.1	22.8	31.7
117	1.0	41.1	17.8	40.1
124	1.6	41.8	15.1	41.5
131	1.8	44.4	15.6	38.3
138	1.1	45.1	10.7	43.2

flower count declined rapidly then ceased completely about day 103 (Figure 12). Dixie Runner plants never completely ceased flowering. The stem elongation, as evidenced particularly by the main stem, slowed about day 103 (Figure 20). The reduction in stem elongation was about one week earlier than Dixie Runner. The stem weight stopped increasing about day 96, which is about two weeks earlier than Dixie Runner (Table 3). The effect on the LAI and the leaf dry weight occurred at about the same time for the two cultivars (Figure 6 and Table 3).

The final growth phase covers the last five weeks (Figure 19). This phase was characterized by a decrease in the vegetative components. The pod growth rate continued to increase at a linear rate until harvest (Figure 19).

The pod growth rate calculated from day 82 to day 117 was 74.1 kg/ha/day (Table 9). The equation for this relationship was $Y = -5189 + 74.1X$ with a coefficient of determination of 0.975, a standard error of the Y-estimate of 175 kg/ha, and a standard error of the slope-estimate of 6.0 kg/ha/day. The final yield was 3823 kg/ha/day.

The growth of Florunner followed a sigmoid curve (Figure 21). The early geometric phase covered approximately the first seven weeks. The dry weight percentage followed a similar pattern to the other peanut cultivars (Table 11). The leaf component was the largest, reaching 52.8% of the plant dry weight. The root percentage was

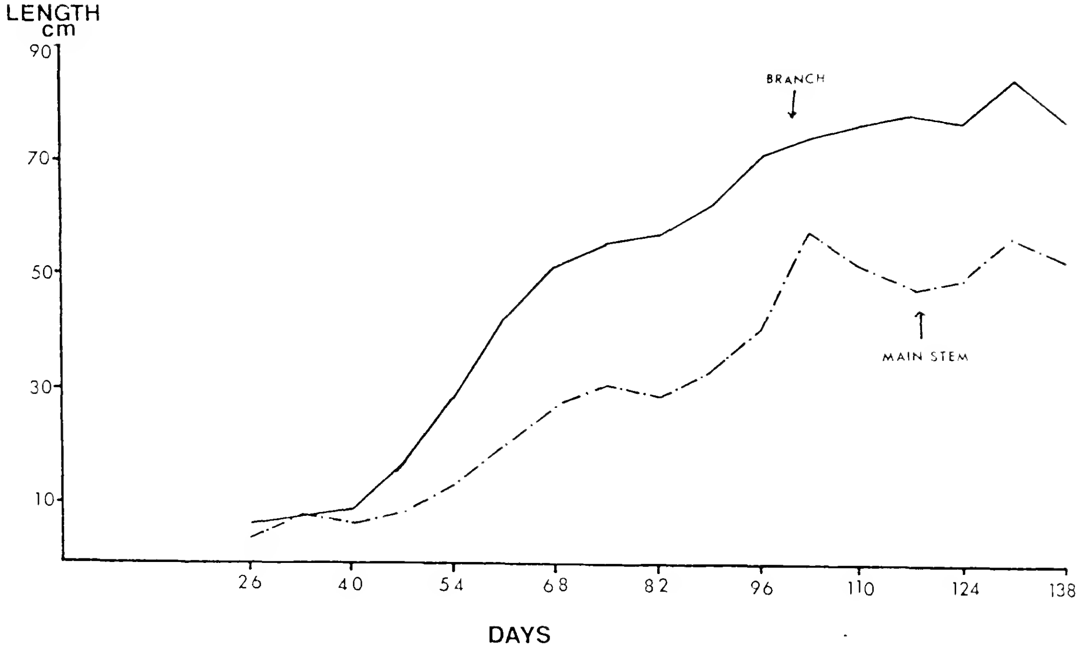

Figure 20. Length of the main stem and average length of the four longest branches of Early Runner peanut, measured during the 1976 growing season.

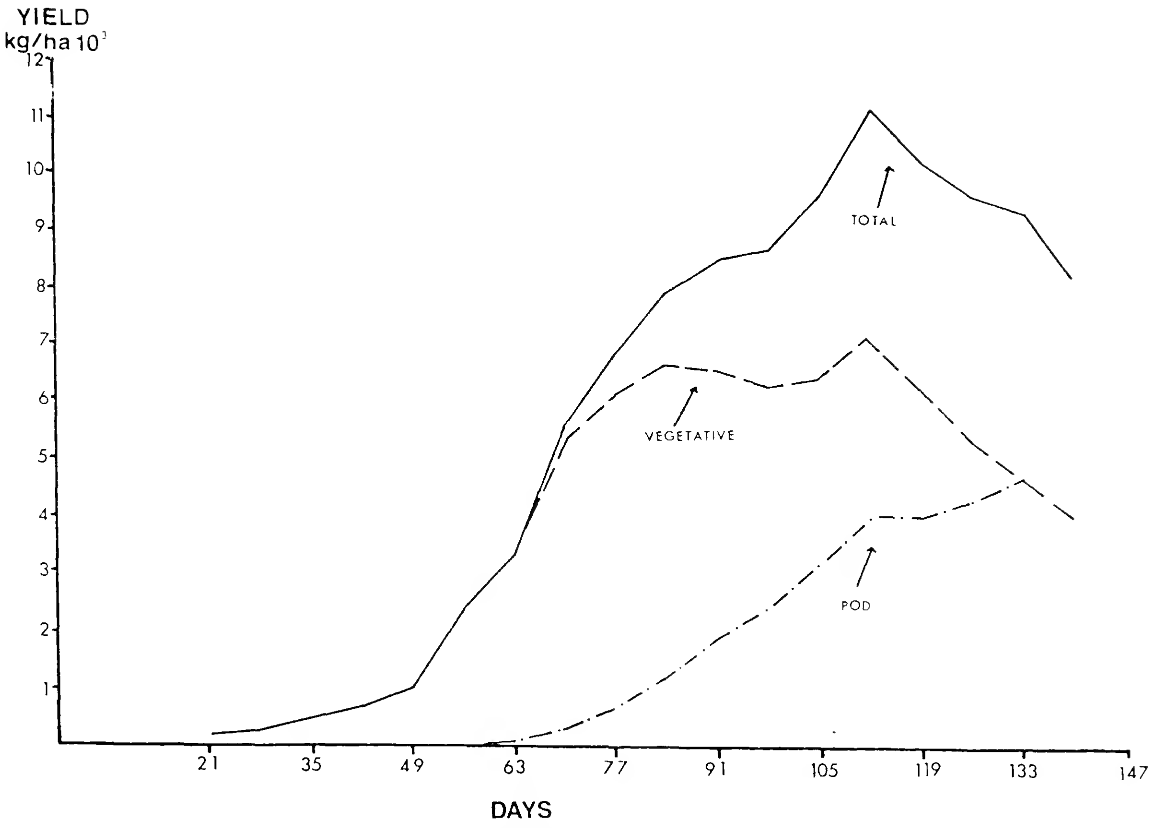

Figure 21. Total biomass dry weight partitioned into vegetative and pod components for Florunner peanut during the 1976 growing season.

Table 11. Root, stem, leaf, and pod dry weight percentages for Florunner taken during the 1976 growing season.

Day	Root	Stem	Leaf	Pod
21	36.5	27.0	36.5	
28	21.3	33.7	45.0	
35	12.4	34.8	52.8	
42	11.8	36.0	52.2	
49	8.4	41.8	49.8	
56	5.8	47.7	45.9	0.6
63	4.6	48.2	45.3	1.9
70	1.9	51.4	40.0	6.7
77	1.4	52.1	34.8	11.7
84	2.2	47.7	32.6	17.5
91	1.3	46.5	28.8	23.4
98	1.7	42.8	26.8	28.7
105	1.7	42.2	24.3	31.8
112	1.2	35.0	20.5	43.3
119	0.8	37.2	8.6	53.0
126	1.9	36.9	11.9	49.4
133	1.2	37.2	8.6	53.0
140	0.7	39.7	6.0	53.6

initially very high then decreased with time. The stem component was 27% at the first sampling date and increased to 41.8% by the end of the geometric growth phase.

The linear growth phase began about seven weeks after planting. The crop growth rate from day 49 to day 77 was 212 kg/ha/day (Table 9). The equation for this relationship was $Y = -9522 + 212X$ with a coefficient of determination of 0.985, a standard error of the Y-estimate of 338 kg/ha, and a standard error of the slope-estimate of 15 kg/ha/day. The period from day 49 to day 77 was during the linear growth phase and before significant seed development.

Florunner began to fill seeds about day 70 (Table 4). As the pod count increased and more photosynthate was partitioned into seed filling, less was available for vegetative growth. Florunner had a much higher pod yield than Dixie Runner and Early Runner (Table 9). The increased photosynthate requirement for the higher yield meant that even less photosynthate was available for vegetative growth. This was evident in the complete cessation of flowering about day 91. Also stem elongation ceased by about day 98 (Figure 22). The cessation of stem elongation was much more pronounced and earlier in Florunner than Early Runner. Dixie Runner, the lowest yielding cultivar, did not appear to cease stem elongation before harvest. The stem weight for Florunner stopped increasing about day 91 (Table 4) which was earlier than Early Runner and Dixie Runner. The LAI began to decrease two weeks

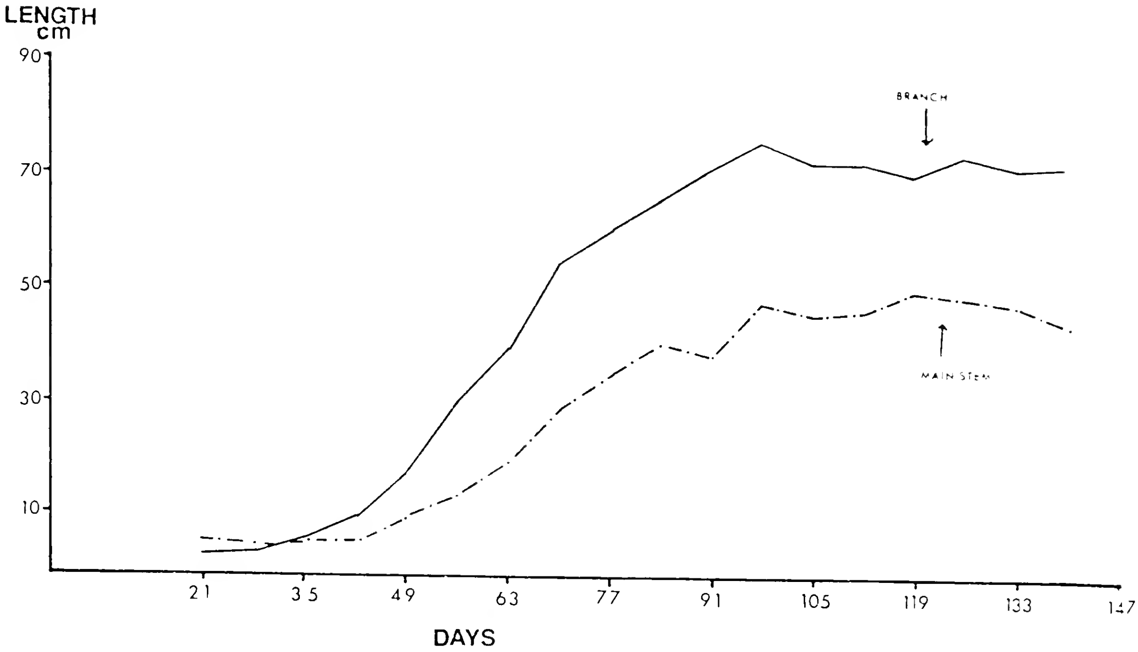

Figure 22. Length of the main stem and average length of the four longest branches of Florunner peanuts, measured weekly during the 1976 growing season.

earlier in Florunner, compared to the other two older cultivars (Figure 7). The LAI was below that required for complete ground cover two to three weeks before harvest.

The final growth phase covered the last three weeks (Figure 21). This phase was characterized by a decrease in the vegetative components. The pod growth rate continued to increase at a linear rate until harvest.

The pod growth rate calculated from day 77 to day 112 was 95.0 kg/ha/day (Table 9). The equation for this relationship was $Y = -6788 + 95.0X$ with a coefficient of determination of 0.992, a standard error of the Y-estimate of 124 kg/ha, and a standard error of the slope-estimate of 4.2 kg/ha/day. The final yield was 4942 kg/ha.

Early Bunch had an early geometric phase which lasted approximately the first six weeks (Figure 23). The leaf component was the largest in terms of percent dry weight. It reached 56% of the total plant weight during this phase (Table 12). The root dry weight percentage was 23.6 at the first sampling period then decreased rapidly with time. The stem dry weight component was 33.7% initially and increased throughout the early geometric phase.

The linear growth phase began about day 40 (Figure 23). The crop growth rate from day 40 to day 75 was 119 kg/ha/day (Table 9). The equation for this relationship was $Y = -7492 + 191X$ with a coefficient of determination of 0.959, a standard error of the Y-estimate of 577 kg/ha, and a standard error of the slope-estimate of 20 kg/ha/day.

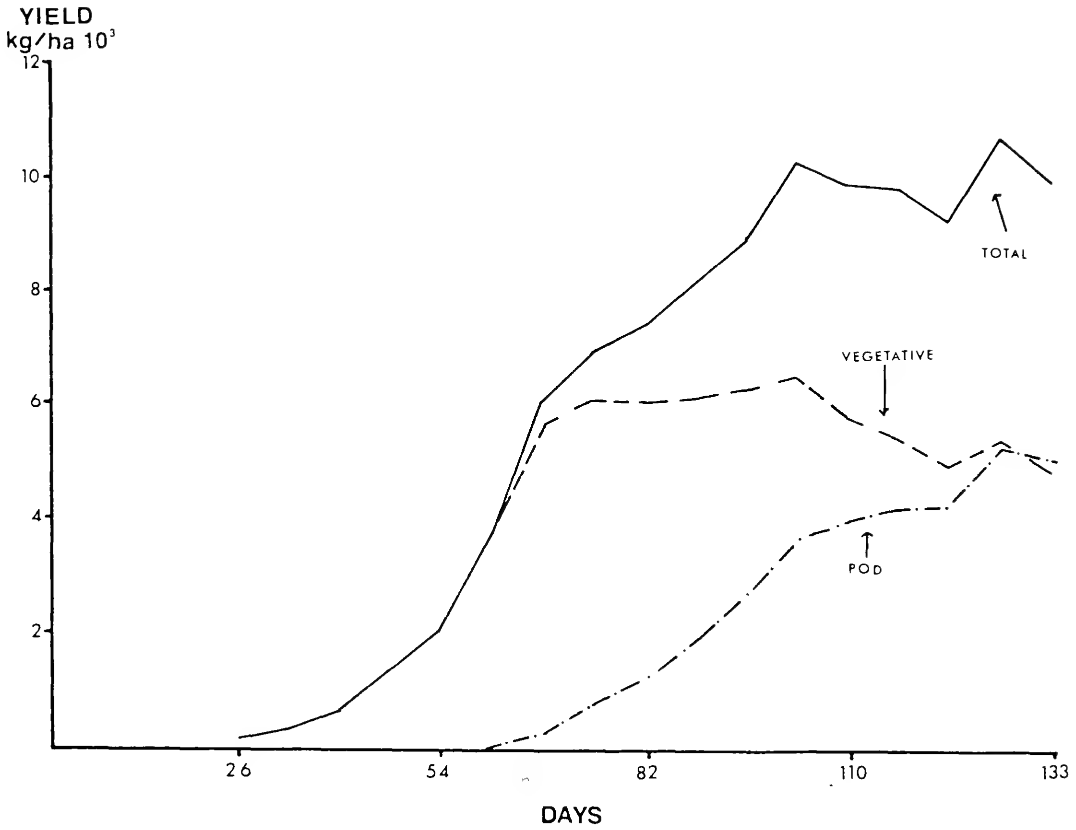

Figure 23. Total biomass dry weight partitioning into vegetative and pod components for Early Bunch peanuts during the 1976 growing season.

Table 12. Root, stem, leaf, and pod dry weight percentages for Early Bunch peanuts taken during the 1976 growing season.

Day	Root	Stem	Leaf	Pod
26	23.6	33.7	42.7	
33	18.8	29.3	51.9	
40	11.6	32.4	56.0	
47	9.1	38.7	52.2	
54	6.5	41.4	52.0	0.1
61	5.1	47.8	43.7	3.4
68	2.2	49.4	42.7	5.8
75	1.8	48.5	36.7	12.9
82	1.7	44.9	33.2	20.2
89	1.8	46.4	29.2	22.6
96	1.8	42.3	23.1	32.8
103	0.9	40.6	21.1	37.3
110	0.9	35.9	18.7	44.6
117	1.1	36.6	12.6	49.7
124	1.0	30.2	10.1	58.7
131	0.9	31.8	8.9	58.5
138	1.1	30.7	7.6	60.6

The period from day 40 to day 77 was during the linear growth phase and before significant seed development.

Early Bunch was the highest yielding of the Florida line of cultivars. When the seeds began to fill about day 75 (Table 5) and the plants began to partition photosynthate into the pod yield component, even less photosynthate was available for continued vegetative growth due to the high yield. The main difference between Early Bunch and Florunner in this respect was demonstrated by the stem elongation. Stem elongation ceased in Early Bunch about day 89 (Figure 24). Stem elongation ceased about day 98 for Florunner, day 103 for Early Runner, and began to slow in rate of elongation for Dixie Runner about day 112. The decline in LAI and flowering was similar for Early Bunch and Florunner.

The final growth phase covered the last four weeks. It was characterized by a decrease in the vegetative components of the plant. The pod growth rate continued to increase at a linear rate until harvest.

The pod growth rate calculated from day 75 to day 110 was 98.7 kg/ha/day (Table 9). The equation for this relationship was $Y = -6714 + 98.7X$ with a coefficient of determination of 0.985, a standard error of the Y-estimate of 176 kg/ha, and a standard error of the slope-estimate of 6.0 kg/ha/day. The final yield was 5377 kg/ha.

Spancross had a growth accumulation curve which followed a sigmoid pattern (Figure 25). The early geometric

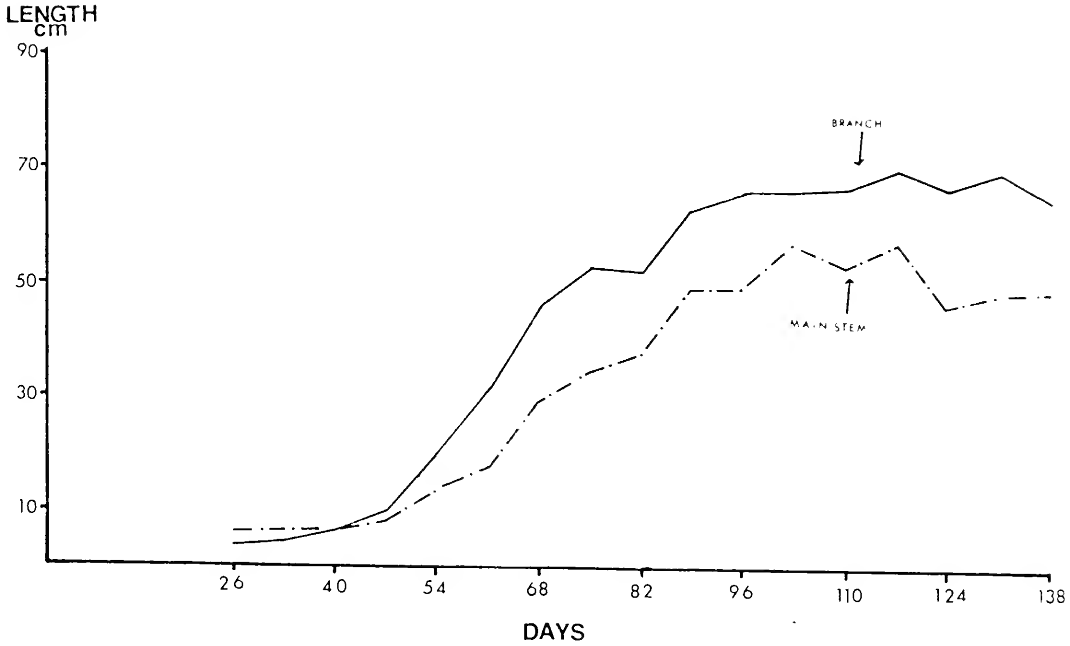

Figure 24. Length of the main stem and average length of the four longest branches of Early Bunch peanuts, measured weekly during the 1976 growing season.

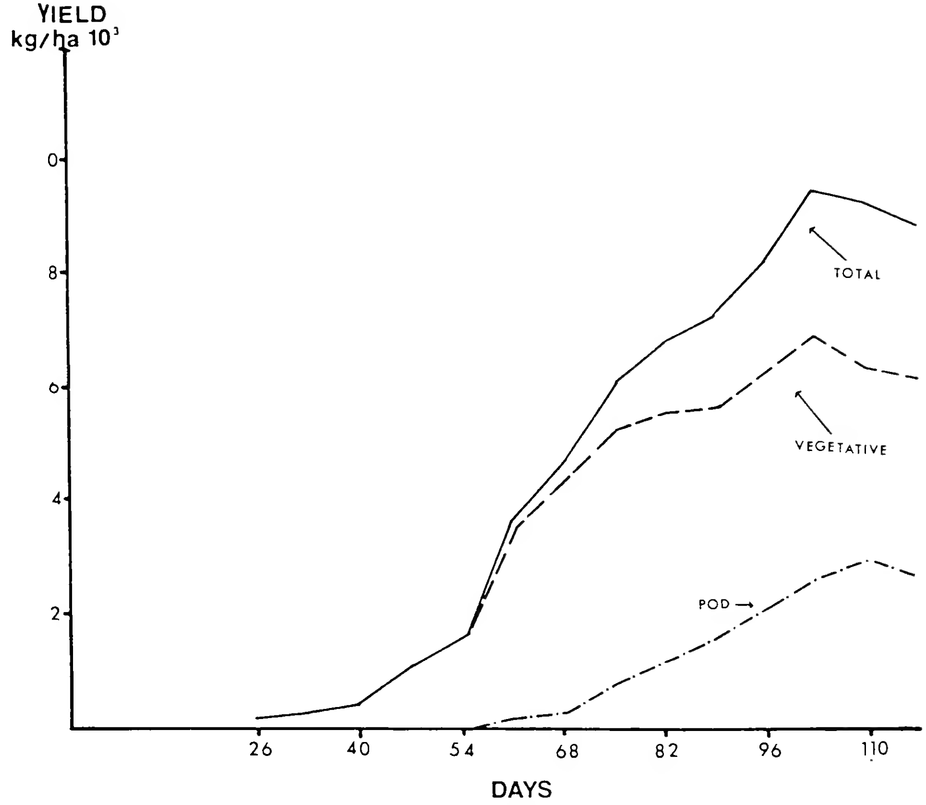

Figure 25. Total biomass dry weight partitioning into vegetative and pod components for Spancross peanuts during the 1976 growing season.

phase lasted about seven weeks. During this phase the leaf component was the largest in terms of percentage dry weight (Table 13). The stem component was 33.8% of the total plant weight and increased throughout this phase. The root component was initially 22.5% and decreased with time.

The linear growth phase began around day 47. The crop growth rate from day 47 to day 68 was 63.7 kg/ha/day (Table 9). The equation for this relationship was $Y = -7701 + 182X$ with a coefficient of determination of 0.966, a standard error of the Y-estimate of 379 kg/ha, and a standard error of the slope-estimate of 24 kg/ha/day. The period from day 47 to day 68 was during the linear growth phase and before significant seed development.

Spancross was not significantly different in yield from Dixie Runner (Table 9). It was also the shortest season cultivar grown. The final harvest for Spancross was at 110 days, about three to four weeks earlier than the other cultivars. The decline in growth of the vegetative components demonstrated in the higher yielding Florida peanut cultivars was not as evident in Spancross. Flowering never completely ceased (Figure 15). The LAI never decreased rapidly or dropped below that required for full ground cover (Figure 9). Stem elongation did cease two weeks prior to harvest (Figure 26). However, stem dry weight did not appear to decrease (Table 6).

Table 13. Root, stem, leaf, and pod dry weight percentages for Spancross peanuts taken during the 1976 growing season.

Day	Root	Stem	Leaf	Pod
26	22.5	33.8	43.7	
33	17.0	35.0	48.0	
40	9.7	36.4	53.9	
47	8.0	41.5	50.5	
54	5.3	45.3	47.2	2.2
61	4.6	47.8	44.1	3.5
68	2.6	47.7	40.7	9.0
75	1.7	45.1	36.1	17.1
82	1.6	43.7	33.0	21.7
89	1.6	40.8	28.1	29.4
96	2.2	42.1	26.9	28.0
103	1.7	43.4	23.5	31.4
110	1.8	45.4	18.9	33.9
117	1.6	47.0	16.8	34.6

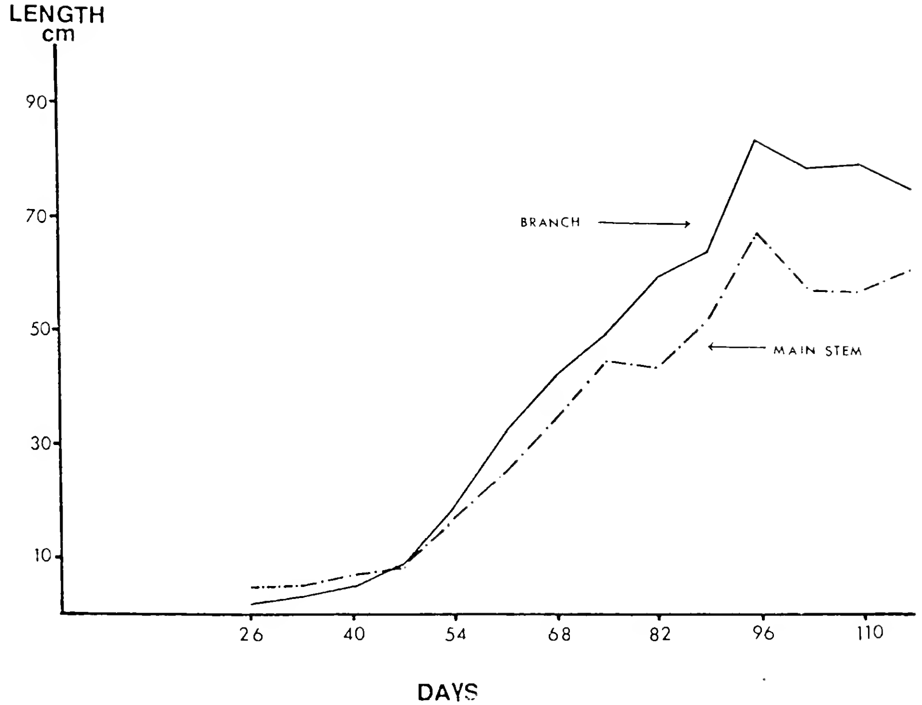

Figure 26. Length of main stem and average length of the four longest branches of Spancross peanuts, measured during the 1976 growing season.

The final growth phase lasted only one week. The pod growth rate remained linear until harvest. The pod growth rate calculated from day 68 to day 110 was 63.7 kg/ha/day. The equation for this relationship was $Y = -4033 + 63.7X$ with a coefficient of determination of 0.998, a standard error of the Y-estimate of 48 kg/ha, and a standard error of the slope-estimate of 1.3 kg/ha/day. The final yield was 2941 kg/ha.

The growth of Bragg soybeans was dissimilar to the peanut cultivars in some respects. The soybean plant responds to photoperiod to induce flowering but the peanut plants are day neutral. The soybean plants flowered and began to set fruit about two weeks after the peanut plants. The soybean is a determinate plant. Stem elongation ceased about day 63, one week after the formation of the first flowers (Figure 27). The cessation was long before photosynthate may have become limiting for vegetative growth resulting from the partitioning of photosynthate to the pods.

The growth accumulation curve followed the usual sigmoid pattern (Figure 28). The early geometric phase lasted the first seven weeks. At the initial sampling date, day 21, the root dry weight percentage was 51.3 of the total plant weight (Table 14). The root percentage decreased to 11.9 by day 77. The root dry weight percentage never dropped below 10 of the total plant dry weight before harvest on day 154. The root dry weight percentages

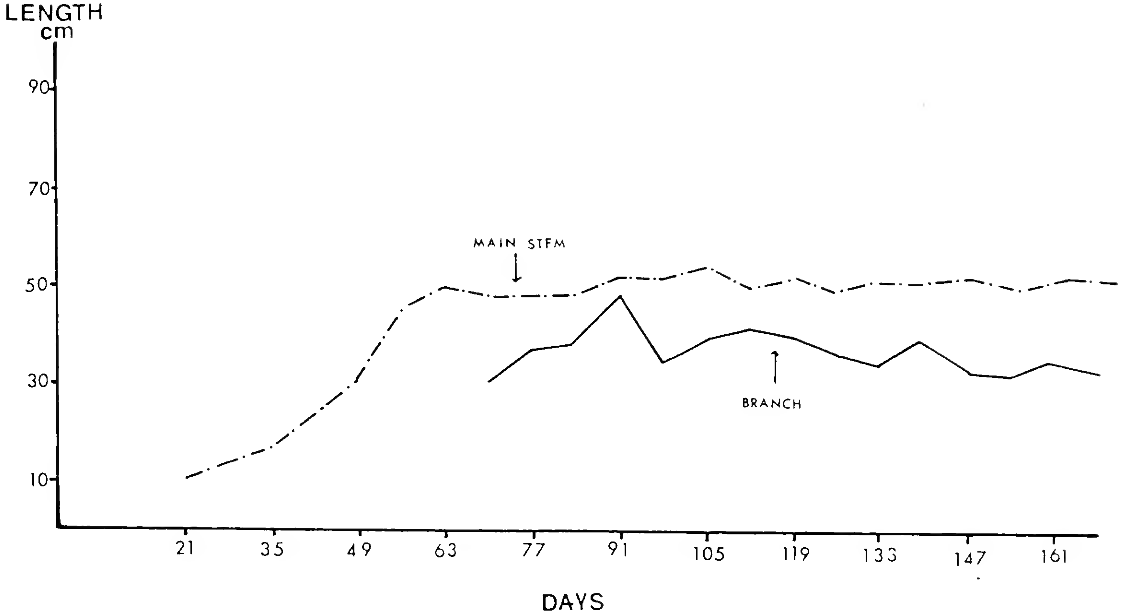

Figure 27. Length of the main stem and average length of the three longest branches of Bragg soybean, measured weekly during the 1976 growing season.

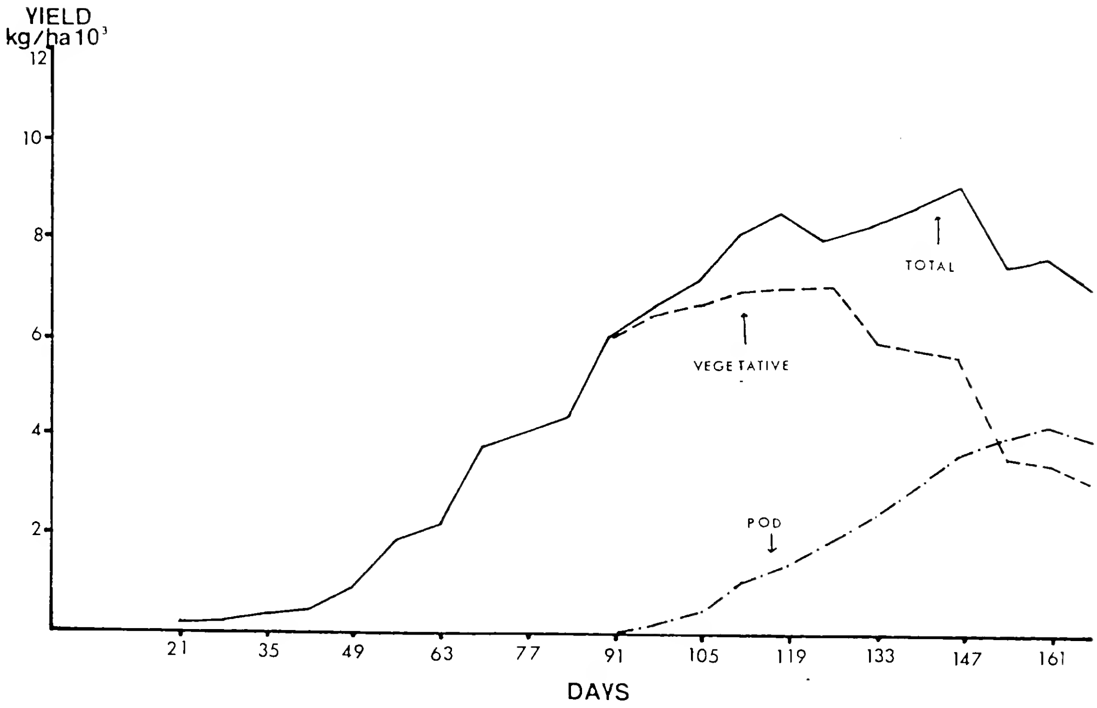

Figure 28. Total biomass dry weight partitioning into vegetative and pod components for Bragg soybean during the 1976 growing season.

Table 14. Root, stem, leaf, and pod dry weight percentages for Bragg soybean taken during the 1976 growing season.

Day	Root	Stem	Leaf	Pod
21	51.3	14.3	34.4	
28	34.8	22.9	42.3	
35	35.9	18.8	45.3	
42	22.4	30.3	47.3	
49	19.0	34.9	46.1	
56	18.1	40.5	41.4	
63	17.4	41.9	40.7	
70	20.5	43.6	35.9	
77	11.9	51.7	36.4	
84	20.9	47.0	32.1	
91	15.4	54.2	30.4	0.1
98	11.7	51.3	34.4	2.5
105	19.8	47.9	26.9	5.4
112	11.3	51.7	24.6	12.4
119	10.7	49.7	22.9	16.8
126	11.0	43.2	20.2	25.7
133	12.0	38.8	19.7	29.5
140	18.3	35.3	16.5	30.0
147	11.6	30.9	14.2	43.3
154	13.7	21.6	5.7	34.5
168	8.6	27.8	0.3	63.3

dropped below two for all the peanut cultivars. The leaf dry weight was 34.4% initially and increased to a high of 47.3% on day 42. The stem dry weight percentage was the lowest initially at 14.3, but increased to 54.2 of the total plant weight by day 91.

The linear growth phase began about day 49 (Figure 28). The crop growth rate from day 49 to day 91 was 116 kg/ha/day (Table 9). The equation for this relationship was $Y = -4698 + 116X$ with a coefficient of determination of 0.959, a standard error of the Y-estimate of 394 kg/ha, and a standard error of the slope-estimate of 11 kg/ha/day. The period from day 49 to day 91 was during the linear growth phase and before significant seed development.

The "self destruct" characteristic of soybeans was demonstrated by the canopy decline during the maturation phase of plant growth. The leaf dry weight reached a peak about day 93, then declined until harvest (Table 7). The vegetative growth curve (Figure 28) starts a rapid decline after about day 126. The decline corresponds with a start in the decline in the stem dry weight (Table 7). The LAI began a decline about seven weeks before harvest and dropped below that required for complete ground cover two weeks before harvest.

The pod growth rate increased linearly up to harvest (Figure 28). The pod growth rate from day 119 to day 147 was 79.3 kg/ha/day (Table 9). The equation for this relationship was $Y = -8049 + 79.3X$ with a coefficient of determination of 0.995, a standard error of the Y-estimate of 71 kg/ha, and a standard error of the slope-estimate of 3.2 kg/ha/day. The final yield for Bragg soybean was 4282 kg/ha.

Yield Aspects

The four Florida peanut cultivars differed significantly in pod yield (Table 9). The lowest yielding cultivar was Dixie Runner, the first cultivar released. It yielded 2472 kg/ha. Early Runner, the next cultivar released, yielded 55% more pods than Dixie Runner. Early Runner had a pod yield of 3823 kg/ha. Florunner, the cultivar grown most widely in the United States, yielded 12% more pods than Early Runner. Florunner yielded 4642 kg/ha. Early Bunch, the newest cultivar, out yielded Florunner by 16%. Early Bunch had a pod yield of 5377 kg/ha. The total yield increase from Dixie Runner to Early Bunch was 118%.

There are three possible major physiological explanations for this tremendous yield increase: 1) the photosynthetic output of the newer cultivars could have been increased, 2) the filling period of the newer cultivars could have been increased, and/or 3) the partitioning factor could have been increased in the newer cultivars. An increase in the overall photosynthetic efficiency of the plant did not account for the increased yield. The photosynthetic rates of the cultivars were estimated by the crop growth rates (Table 9). The crop growth rates were determined after the plants had reached full ground cover and the linear growth phase was reached, and before appreciable partitioning to the seeds. Partitioning to the seeds could effect the crop growth rate because of the higher requirement of photosynthate for production of oil and protein. The crop growth rates show that of the four Florida peanut cultivars, the highest yielding cultivar, Early Bunch had the lowest crop growth rate, 191 kg/ha/day. The highest crop growth rate was for the lowest yielder, Dixie Runner, at 222 kg/ha/day. Florunner was the second highest at 212 kg/ha/day with Early Runner third at 200 kg/ha/day. As the standard error of the slope-estimate was from 14 kg/ha/day for Early Runner to 20 kg/ha/day for Dixie Runner and Early Bunch, the crop growth rate data can be used to conclude that there was little difference in the crop growth rates between the cultivars. The difference was not sufficient to account for the 118% difference in yield among the four cultivars. This conclusion was reinforced by analysis of the total dry-matter produced by the plants. If an increased photosynthetic rate was responsible for the yield increase, one would expect the greatest total dry-matter to be produced by the plants with the highest photosynthetic rates. There was little difference in total dry-matter production of the four Florida peanut cultivars. The highest production was by Florunner which reached 11,162 kg/ha, and the lowest was Early Runner at 10,292 kg/ha. Early Bunch produced a maximum of 10,323 kg/ha, and Dixie Runner produced 10,780 kg/ha, which was well within the differential leaf drop among the cultivars. Thus, the increased yield potential resulting from the release of the Florida peanut cultivars cannot be explained by a difference in the photosynthetic rates.

Another possible explanation was an increased filling period. The four Florida peanut cultivars all began flowering at about the same time and all reached harvest at about the same time. The only exception was Dixie Runner which was about one week later in harvest. However, the newer higher yielding cultivars may have had a slightly longer filling period due to a more rapid initiation of pods. Dixie Runner reached a stable pod number about day 105, Early Runner about day 96, Florunner about day 84, and Early Bunch about day 75.

The apparent physiological aspect that was most responsible for the increased yield was an increase in the partitioning factor. The partitioning factor is a ratio of the amount of photosynthate partitioned to the yield component of the crop divided by the total amount of photosynthate available for crop growth. It can be estimated using the pod growth rate corrected for the increased oil and protein in the seed divided by the crop growth rate determined during the linear growth phase and before the seeds begin to fill (McGraw, 1977). The correction factor is different for peanuts and soybeans. Peanuts have more oil and protein than Bragg soybeans. Using equations from De Vries et al. (1974) and Hanson et al. (1960), a correction factor of 1.65 was calculated for peanuts and 1.41 for soybeans.

The partitioning factors for the four Florida cultivars were 0.85 for Early Bunch, 0.74 for Florunner, 0.61 for Early Runner, and 0.31 for Dixie Runner (Table 9). Spancross had a partitioning factor of 0.58 which was similar to the 0.61 partitioning factor of Early Runner which had a pod yield of 3823 kg/ha. The Early Runner pod yield was significantly higher than the 2941 kg/ha pod yield of Spancross. The reason for the difference was that Spancross was harvested at 110 days and Early Runner at 131 days. Even though Early Runner and Spancross partitioned about the same amount of their total photosynthate production into pod yield, Early Runner had a much longer filling period which resulted in a higher yield. Bragg soybean had a calculated partition factor of 0.96. Theoretically one would expect a partitioning factor of 1.00 since Bragg soybean is a determinate plant. In a determinate plant vegetative growth ceases prior to the fruit filling stage. As there is no vegetative growth, all the photosynthate should be utilized in reproductive growth. The partitioning factor may be greater than one if photosynthate produced and stored prior to the filling period was redistributed to the seeds.

Bragg soybean with a partitioning factor of about 0.96 and a high requirement for nitrogen demonstrated a decline in canopy toward the end of the season. Sinclair and De Wit

(1975) referred to this as a "self destruct" mechanism. Analysis of the Florida cultivars indicated that as the partitioning factor increased the vegetative growth declined and the crop canopy deteriorated late in the season. In the case of Early Bunch and Florunner the LAI declined below that required for full ground cover. Peanut breeding in Florida has produced cultivars which are functionally more determinate in growth habit. Even though the newer peanut cultivars do not end their vegetative growth in a reproductive node, as in a true determinate plant, very little vegetative growth occurs after the onset of a full pod load. With higher partitioning coefficients and higher yields which create greater demands for nitrogen, the newer cultivars are demonstrating "self destruct" characteristics similar to soybeans (see nutrient transfer study).

1977 Genotype Comparison

During the 1977 growing season 22 of the highest yielding genotypes from 11 different countries were analyzed (Table 1). The objective was to determine if they had similar physiological characteristics to the high yielding Florida cultivars, Florunner and Early Bunch, and whether the environment affected the physiological characteristics of the cultivars.

The genotypes studied had differences in yield, harvest date, and partitioning factor. The highest yielders were Early Bunch and Florunner (Table 15). The Florida

Table 15. Yields, harvest dates, pod growth rates, and partitioning factors for 1977 growth analysis data.

Genotype	Yield	Days to Harvest	PGR[a]	Partitioning Factor[b]
	kg/ha		$g/m^2/day$	
Early Bunch	5739 a	133	11.9 a	0.90
Florunner	5015 ab	133	9.7 abc	0.73
Shulamith	4733 ab	133	11.0 abc	0.83
Bachimba 74	4452 bcd	130	11.2 ab	0.84
Sellie	4131 bcd	116	10.0 abc	0.75
Giza-4	3932 cde	123	7.1 abc	0.53
47-10	3898 cde	123	9.8 abc	0.74
Manfredi 68	3861 cde	123	11.2 a	0.84
G-120-15	3840 cde	112	9.7 abc	0.75
Blanco Rio Segundo	3811 cde	112	9.5 abc	0.72
2938.71	3747 cdef	112	9.8 abc	0.74
Colorado Inadiado INTA	3703 def	112	8.8 abc	0.66
TS 32-1	3646 def	112	8.7 abc	0.66
NC-5	3535 defg	123	7.0 abc	0.53
Rojo Regional	3077 efgh	112	6.6 abc	0.50
Tatu Ca 34	3043 efgh	112	7.3 abc	0.55
Colorado Corrention INTA	2971 efghi	112	5.9 bc	0.44
Egret	2757 fghi	154	3.5 c	0.26
Valencia R2	2629 ghi	109	6.7 abc	0.51
Apollo	2515 hi	154	4.0 bc	0.30
Roxo 80-1	2318 hi	112	8.3 abc	0.63
Makula Red	2030 i	158	3.5 c	0.26

[a] Duncan's Multiple Range Test, alpha = .05.

[b] Based on an overall CGR of 219 kg/ha/day.

cultivars were probably the highest yielders due in part to their being bred for cultivation in this environoment. The lowest yielding genotype was Makula Red. Makula Red yielded only 2030 kg/ha compared to 3739 kg/ha for Early Bunch. However, when Makula Red is grown in Rhodesia where it it adapted to high elevation and cooler temperatures, it has produced yields higher than 9,000 kg/ha. Due to the problems associated with testing peanuts in areas where they may not be well adapted, absolute statements are not possible about particular genotypes in regard to their maximum yield potential or partitioning factor.

Three genotypes, Makula Red, Egret, and Apollo, all from Rhodesia, appeared to be poorly adapted to the Florida environment. These genotypes never appeared to mature. In a personal communication, Dr. J. H. Williams (Crop Breeding Institute, Salisbury, Rhodesia) theorized that the Florida cultivars may have been bred for uniform pod formation while the Rhodesian cultivars have not. There were always unfilled pods and pegs even at final harvest. The pods which matured early in the filling period were lost due to weakened peg attachments. The plants were left in the field for over 150 days, but the rate of increase of new pods filled was offset by the loss of old filled pods.

The crop growth rates for the genotypes were calculated from samples taken at two different dates after full ground cover was reached and before a full pod load was established. The crop growth rate data indicated a high variability. Several factors attributed to the high variability. First, the plots were not as uniform as the plots were in the 1976 experiment. The plots were located on a slope in the corner of a field, and those along the edge of the field were sandier than the plots located up the slope. Second, the study followed a corn investigation in which atrazine herbicide was used. The plants at the edge of the field appeared to suffer from residual effects of the herbicide where the tractor turned and a possible double application was applied.

Third, the weather was drier and hotter than in 1976. There was only 301 mm of precipitation during the 133 days of the 1977 growing season (Figure 3). Over one-half of this, 178 mm, came in the last three weeks after many of the genotypes were mature and their final harvests taken. In the 133 days of the 1976 growing season 771 mm of precipitation was received and this was more evenly distributed (Table 2). In 1977, overhead irrigation was applied. However, because of the light soil and problems in obtaining access to the irrigation equipment, the field suffered from periodic droughts. The maximum temperature averaged 1.5° C higher in 1977 than 1976.

Thus, the combined effects of using genotypes adapted to many areas of the world which may not have been well adapted to the Florida environment, the nonuniform field, the abnormally hot dry weather, and the possible residual effects of the herbicide all contributed to a high variation in the crop growth rate data. Thus, it was not possible to measure the crop growth rates precisely enough to separate the cultivars, and a pooled crop growth rate was used. It was calculated from the two blocks which were at the top of the slope which were not as affected by the adverse conditions. An overall crop growth rate of 219 kg/ha/day was calculated. The combined crop growth rate for Florunner and Early Bunch in 1976 was 202 kg/ha/day, so I believe this approach was valid.

The pod growth rates were calculated from samples taken on two different dates after a full pod load was reached and before maturity. The pod growth rate data was significant at the alpha = 0.01 level (Table 15).

The partitioning factors were calculated using the overall crop growth rate of 219 kg/ha/day. The lowest partitioning factors were calculated for the Rhodesian cultivars (Table 15). As these cultivars are very high yielding when grown in Rhodesia, the low partitioning factors may have been the result of poor adaptation to the Florida climate. Makula Red is an old cultivar and Apollo and Egret represent the beginning of peanut yield improvement in Rhodesia. It is possible that these cultivars have an inherently low partitioning factor. As they are grown in a cool climate and have a very long growing season in Rhodesia, they may have been bred for a low seed filling rate.

Florunner had the same partitioning factor, 0.73, as was calculated in 1976. Early Bunch had a slightly higher partitioning factor, 0.90 as compared to 0.84 in 1976. The partitioning factor was positively and significantly correlated to yield. The correlation coefficient partitioning factor versus yield was 0.813, with a coefficient of determination of 0.662, and a standard deviation of 905 kg/ha.

The harvest date ranged from 109 days for Valencia R2 to 133 days for the three highest yielding cultivars, Early Runner, Florunner, and Shulamith. As the three Rhodesian cultivars appeared to never really mature, they are not included in the discussion of the harvest date data. As all the genotypes began to flower at approximately the same time, the harvest date was a good indication of the amount of time the pods were filling. The harvest date was positively and significantly correlated to yield. The correlation coefficient for harvest date versus yield was 0.818, with a coefficient of determination of 0.669, and a standard deviation of 844 kg/ha.

A multiple linear regression was calculated for harvest date and pod growth rate versus yield. The Rhodesian cultivar data were not included. The model was significant at the Alpha = 0.01 level with a correlation coefficient of 0.885. Both factors were positively and significantly correlated to yield. The correlation coefficient of the harvest dates and pod growth rate was 0.818 and 0.757 respectively.

The study indicates that in some of the cultivars yield may be increased by increasing the filling period and/or partitioning factor. Although increasing the length of the filling period may increase yields, it also requires a climate with a long enough growing season to accommodate the increase. In an area where the growing season is short, as in a climate where the growing season is shortened by a severe dry season, a short growing cultivar may be advantageous even though it is potentially lower yielding.

1978 Nutrient Transfer Study

Foliar Analysis

The results of the 1976 growth analysis indicated that peanut cultivars with the highest partitioning factors demonstrated a marked decline in vegetative growth toward the final phase of the filling period. The decline is similar to the phenomenon in soybeans termed "self destruction." It is thought that the decline in the vegetative portion of the plant characterized by a decline in LAI and the cessation of stem elongation, may be the result of the remobilization of nutrients from the vegetative portion of the plant to the seeds. In cultivars with a high partitioning factor and high yield, the demand for nitrogen and possibly other nutrients may be so great that the demand must be met by remobilizing nutrients already assimilated in the vegetative portion. Possibly in the cultivars with a low partitioning factor and low yield, the demand for nutrients is low enough to be met by the daily uptake of nutrients from roots and nodules and nutrients are not remobilized to as great an extent. In an effort to test this hypothesis, the leaf characteristics of Florunner, a high yielding cultivar with a high partitioning factor, and Dixie Runner, a low yielding cultivar with a low partitioning factor, were compared. The leaves of Florunner and Dixie Runner were analyzed for specific leaf weight (SLW), percent nitrogen content, and percent starch content.

The leaves were sampled at the beginning of the filling period before one would expect the plants to be transferring large quantities of nutrients from the leaves and at final harvest when one would expect the greatest amount of nutrients to have been transferred from the leaves. New leaves with the highest SLW and the old yellow leaves about to abscise were taken for analysis from each cultivar. To determine which leaves to analyze as the new leaf sample, the SLWs of leaves beginning with the first partially expanded leaves at the apex of the stem down to the oldest leaf on the stem were analyzed. The SLW was found to increase from 3.53 mg/cm^2 for the first partially expanded leaf (leaf position number one) to a high of 5.01 mg/cm^2 at leaf position number four (Figure 29). After reaching a maximum at leaf position number four the SLW declined at a linear rate until abscission.

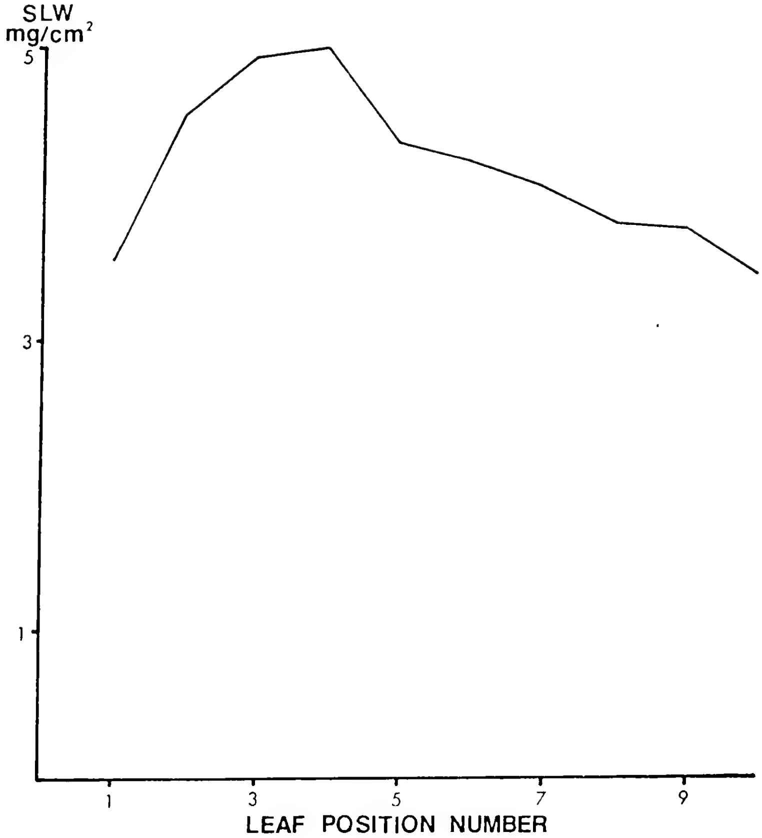

Figure 29. Change in specific leaf weight depending on the position of the leaves on the stem.

At the beginning of the filling period (day 91) both cultivars exhibited a difference in SLW, percent nitrogen, and percent starch between the new and old leaf samples (Table 16). The new leaves had a higher SLW, percent nitrogen, and percent starch than the older leaves.

The older leaves for both cultivars did not differ at the beginning of the filling period. The SLW, percent nitrogen, and percent starch were all similar. Also, there were no real differences between the two cultivars at the beginning of the filling period for the new leaf samples. The SLW for Florunner was 5.25 ± 0.13 mg/cm^2, and for Dixie Runner it was 4.13 ± 0.11 mg/cm^2. The percent starch was 4.99 ± 1.47% for Florunner and 2.51 ± 0.80% for Dixie Runner. The percent nitrogen was similar for the two cultivars at the beginning of the filling period (Table 16).

At the end of the filling period, when one would expect remobilization to have effected the nutrient content of the leaves, there was very little difference between the two cultivars (Table 16). The old leaf samples did not appear to be different just as in the beginning of the filling period. There was a change in the new leaf samples. At the beginning of the filling period Florunner had a higher SLW and a higher percent starch content than Dixie Runner. At the end of the filling period they were similar indicating a greater loss in SLW and percent starch for Florunner (Table 16). The percent nitrogen was similar for the two cultivars at the beginning of the filling period; however,

Table 16. Specific leaf weights, percent nitrogen of leaves, and percent starch of leaves taken at the beginning of pod fill and at harvest for shaded and unshaded treatments.

Cultivar	Sample	Day	SLW ± S.D. mg/cm^2	% N ± S.D.	% Starch ± S.D.
Florunner	New Leaf	91	5.25 ± 0.13	3.83 ± 0.17	4.99 ± 1.47
Florunner	Old Leaf	91	3.84 ± 0.16	2.57 ± 0.05	1.87 ± 0.23
Dixie Runner	New Leaf	91	4.13 ± 0.11	4.26 ± 0.29	2.51 ± 0.80
Dixie Runner	Old Leaf	91	3.71 ± 0.23	2.26 ± 0.11	1.67 ± 0.22
Florunner	New Leaf	133	4.39 ± 0.10	3.43 ± 0.13	2,87 ± 0.41
Florunner	Old Leaf	133	4.00 ± 0.09	2.37 ± 0.11	1.95 ± 0.20
Florunner Shade	New Leaf	133	3.76 ± 0.10	3.29 ± 0.23	2.04 ± 0.18
Florunner Shade	Old Leaf	133	3.80 ± 0.18	2.19 ± 0.15	2.18 ± 0.25
Dixie Runner	New Leaf	133	4.17 ± 0.09	4.19 ± 0.11	2.56 ± 0.49
Dixie Runner	Old Leaf	133	3.62 ± 0.33	2.37 ± 0.08	2.07 ± 0.21
Dixie Runner Shade	New Leaf	133	3.23 ± 0.09	4.82 ± 0.15	2.09 ± 0.34
Dixie Runner Shade	Old Leaf	133	3.16 ± 0.27	2.76 ± 0.11	1.75 ± 0.22

at the end, Florunner appeared to lose more nitrogen than Dixie Runner. The comparison of the two cultivars at the beginning and end of the filling periods suggests that Florunner remobilized more nutrients from the leaves during the filling period than Dixie Runner. The old leaf samples did not differ for either cultivar at the beginning or end of the filling period. Apparently both cultivars lose nutrients to a constant level before leaf senescense. However, at the end of the filling period the new leaf samples of Florunner demonstrated greater losses in SLW, percent nitrogen, and percent starch.

An analysis of the changes in SLW, percent nitrogen, and percent starch within each cultivar supports the conclusion that Florunner transfers more nitrogen and starch from its leaves during the filling period than Dixie Runner. The filling period had little effect on the SLW, nitrogen, and starch contents of the leaves of Dixie Runner (Table 16). The SLW for Dixie Runner increased from 4.13 ± 0.11 mg/cm^2 at the beginning to 4.17 ± 0.09 mg/cm^2 at the end of the filling period for the new leaf samples. The old leaf samples decreased from 3.71 ± 0.23 mg/cm^2 to 3.62 ± 0.33 mg/cm^2. Thus, there was very little change in the SLW over the filling period for Dixie Runner. The percent nitrogen for Dixie Runner decreased from 4.26 ± 0.29% to 4.19 ± 0.11% for the new leaf samples. The old leaf samples increased from 2.26 ± 0.11% to 2.37 ± 0.08% nitrogen. The percent nitrogen and starch for Dixie Runner demonstrated very little change as a result of the effect of the filling period. The percent starch increased from 2.51 ± 0.08% to 2.56 ± 0.49% for the new leaves and decreased from 1.67 ± 0.22% to 2.07 ± 0.21% for the old leaves. Dixie Runner, the low yielding cultivar which partitions only about 31% of its daily photosynthate production to the pods during the filling period, does not appear to show an effect on the nitrogen and starch content of the leaves as a result of remobilization from the leaves during the filling period.

Florunner, the high yielding cultivar which partitions about 73% of its daily photosynthate production to the pods, does show a decline in nitrogen and starch content in the leaves during the filling period. The old leaves do not appear to change over the filling period. The SLW for the old leaves increased slightly from 3.84 ± 0.11 mg/cm^2 to 4.00 ± 0.09 mg/cm^2. The percent nitrogen decreased from 2.57 ± 0.29% to 2.37 ± 0.11%. The percent starch increased from 1.87 ± 0.80% to 1.95 ± 0.20%. As the old leaves for both cultivars were the yellow leaves just ready to abscise, the constant values at the beginning and end of the filling period and the similarities between the cultivars indicate that peanut leaves may lose nitrogen and starch to a constant value before loss of physiological activity and senescence. The newer leaves of Florunner did show differences. The SLW declined from 5.25 ± 0.13 mg/cm^2 to 4.39 ± 0.10 mg/cm^2 at the end of the filling period.

Similarly, the percent nitrogen decreased from 3.83 ± 0.17% to 3.43 ± 0.13%. Also, the percent starch declined from 4.99 ± 1.47% to 2.87 ± 0.41%. It was believed that these losses in Florunner are the result of the high partitioning of photosynthate and nutrients to the pods which cannot be met by daily uptake and must be remobilized from already existing vegetative tissues.

A series of leaf samples were taken to insure that each succeeding sample was comprised of leaves which were approximately two weeks older. The leaf sampling began at day 91 and continued every two weeks until harvest. The objective was to determine if the SLW, percent nitrogen, and percent starch decreased linearly with time during the filling period. Each sample was comprised of five measurements. The SLW for Florunner decreases significantly (alpha = 0.01) with leaf age during the filling period (Figure 30). The correlation coefficient between SLW versus days from planting was -0.726, with a coefficient of determination of 0.527, and a standard deviation of 0.349 mg/cm^2. The SLW for Dixie Runner is shown in Figure 31. The correlation coefficient between SLW versus days from palnting was -0.386, the coefficient of determination was 0.149, and the standard deviation was 0.167 mg/cm^2. Even though the data does show a decrease in SLW, the SLW of Dixie Runner did not decrease significantly with age.

The percent starch data for Florunner are shown in Figure 32. The correlation coefficient for percent starch

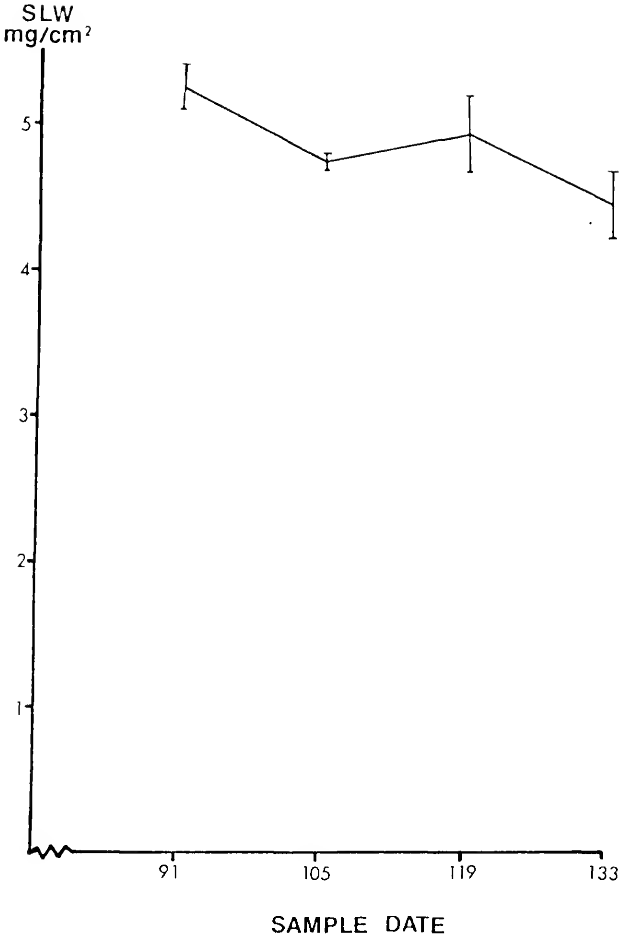

Figure 30. Specific leaf weight (± standard deviation) of Florunner leaves as a function of leaf age.

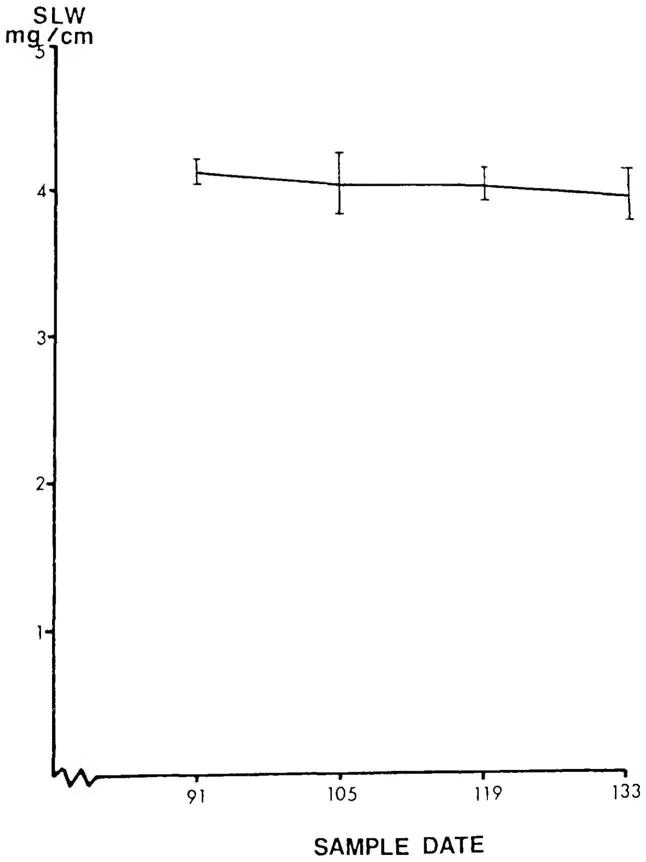

Figure 31. Specific leaf weight (± standard deviation) of Dixie Runner leaves as a function of leaf age.

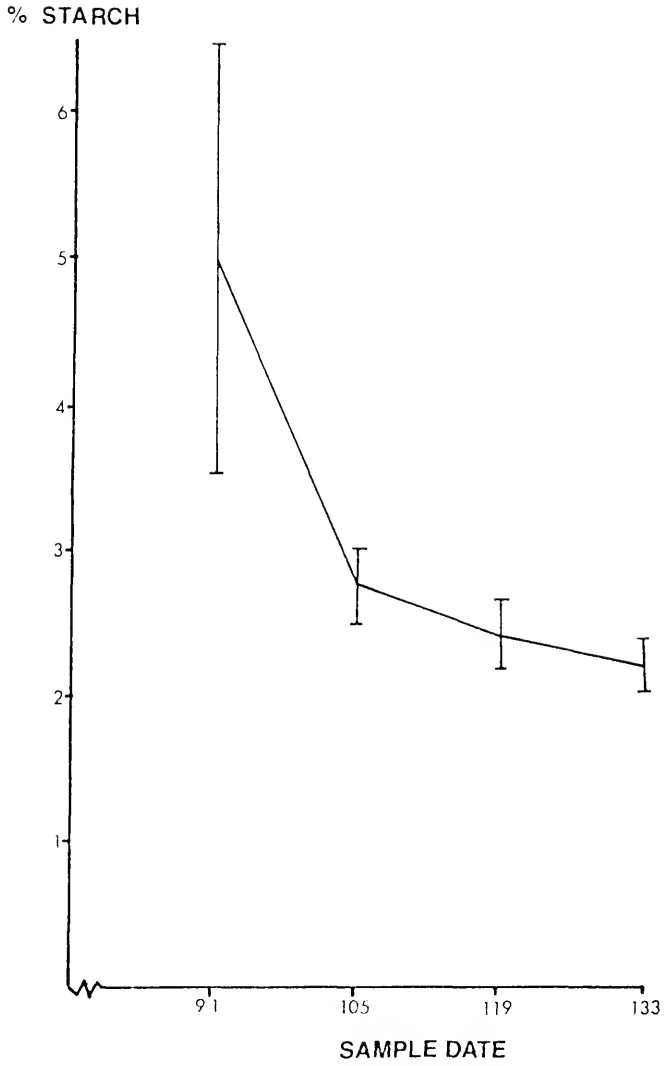

Figure 32. Starch content (± standard deviation) of Florunner leaves as a function of leaf age.

versus days from planting was -0.742, the coefficient of determination was 0.550, and the standard deviation was 1.35%. These data show a significant (alpha = 0.01) decrease in percent starch content of the leaves as the leaves age during the filling period. The percent starch data for Dixie Runner are presented in Figure 33. The correlation coefficient for percent starch versus days from planting was -0.552, and the coefficient of determination was 0.305, and the standard deviation was 0.583%. The decrease in percent starch is not significant in Dixie Runner.

Figure 34 gives the percent nitrogen data for Florunner and Figure 35 the percent nitrogen data for Dixie Runner. Both had a significant (alpha = 0.01) decrease in percent nitrogen as the leaves aged during the filling period. The correlation coefficient for Florunner for percent nitrogen versus days from planting was -9.935, the coefficient of determination was 0.875, and the standard deviation was 0.566%. The correlation coefficient for Dixie Runner for percent nitrogen versus days from planting was -0.869, the coefficient of determination was 0.756, and the standard deviation was 0.397%.

The data for the SLW, percent nitrogen, and percent starch content of the leaves as they aged during the filling period, indicate that the values decreased for both cultivars. However, only Florunner had a significant decrease in all three. Florunner also had a greater negative slope

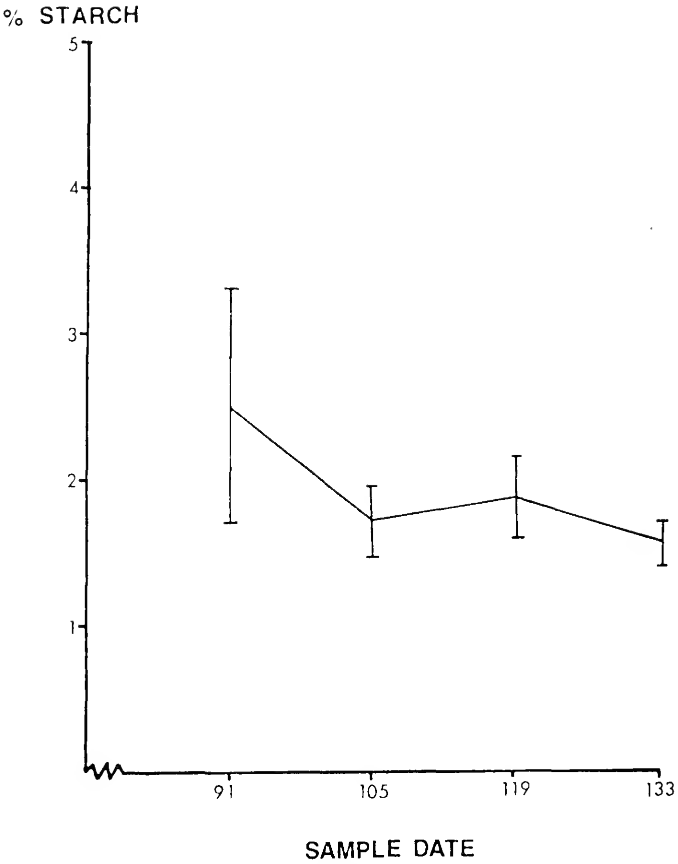

Figure 33. Starch content (± standard deviation) of Dixie Runner leaves as a function of leaf age.

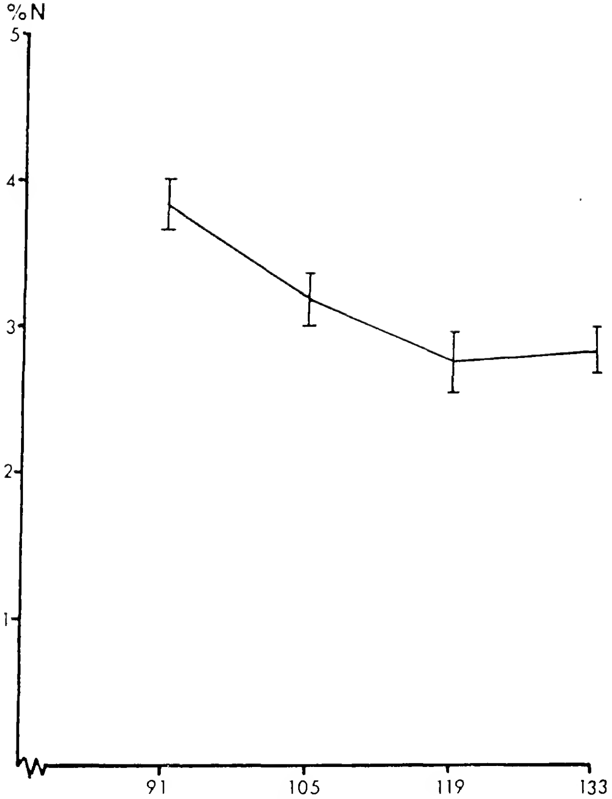

Figure 34. Nitrogen content (± standard deviation) of Florunner leaves as a function of leaf age.

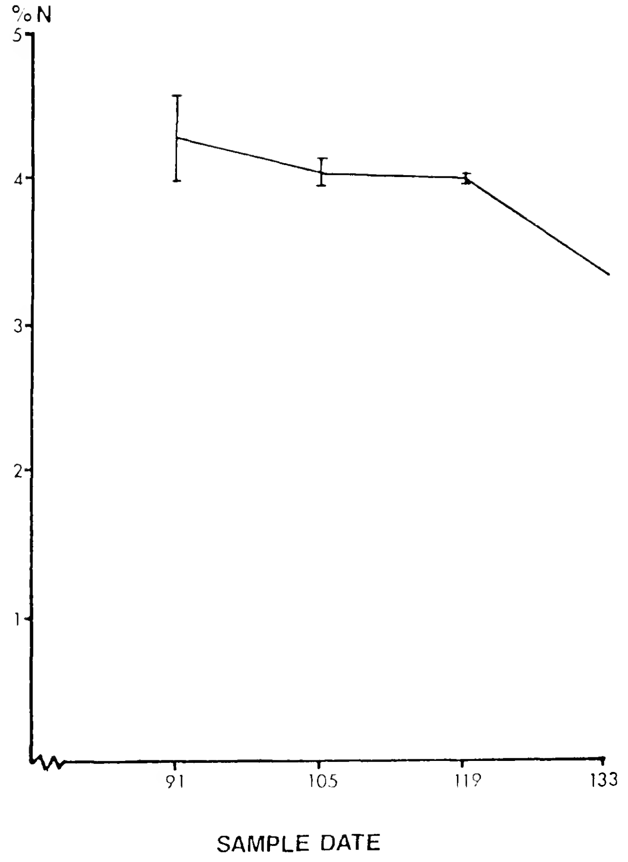

Figure 35. Nitrogen content (± standard deviation) of Dixie Runner leaves as a function of leaf age.

and a higher coefficient of determination of percent nitrogen than Dixie Runner, providing further evidence that the higher yielding, high partitioning factor cultivar, Florunner, remobilizes more nitrogen and starch from its leaves as they age during the filling period than the low yielding low partitioning cultivar, Dixie Runner.

The amount of nitrogen that may be remobilized from the leaves to the pods in Florunner during the filling period was estimated. Florunner averaged about 20.4 g/plant of leaf dry weight on day 91. As the stems stop elongation about this time very little new leaf tissue should develop after this time (Figure 36). At harvest only 4.0 g/plant of leaf dry weight remained. During the filling period about 16.4 g/plant of leaf material was lost. The average leaf at day 91 in 1978 contained about 3.55% nitrogen. A senescing Florunner leaf contains about 2.47% nitrogen (average of old leaf samples at the end and beginning of the filling period). Thus, about 1.08% of the leaf dry weight is removed from the leaf as nitrogen during senescence. Assuming there were no losses due to insect attack or disease which would result in material not translocated, about 0.18 g/plant of nitrogen is remobilized from the leaves to the pods during pod filling. At the density used in this experiment, this converts about 22.9 kg/ha of nitrogen which may be remobilized from the leaves to the pods. Even more nitrogen may be removed if stems are included.

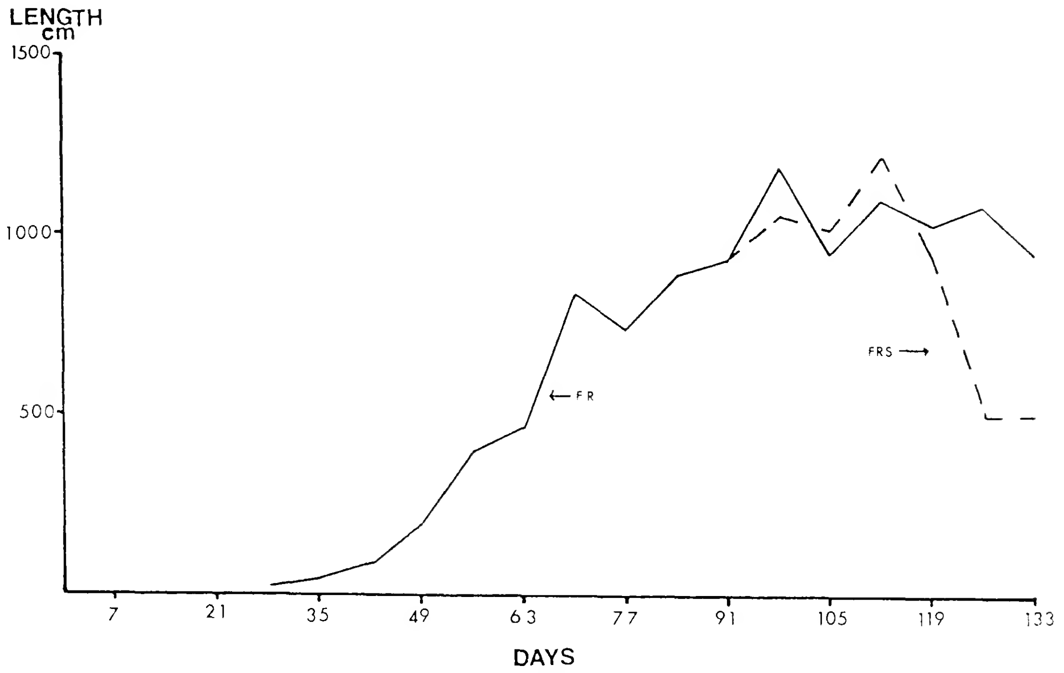

Figure 36. Total stem lengths for Florunner (FR) and Florunner under 75% shade (FRS) for the 1978 growing season.

Shading Study

If high yielding peanut cultivars such as Florunner remobilize nutrients from the vegetative tissues to the pods, then the pods must have some kind of priority over the vegetative tissue. In order to test this hypothesis, shades were placed over the two cultivars to reduce the photosynthate output of the leaves. It was theorized that a reduction in the photosynthetic output below that which is naturally partitioned to the pods would increase the remobilization of nutrients from the vegetative tissues to make up for the loss in photosynthate production. Shades that restricted 75% of the light were placed over the two cultivars on day 91. Day 91 was after a full pod load had been established and maximum partitioning was achieved. Shades of 75% were used to insure a significant reduction below that required for Dixie Runner which partitioned approximately 31% of its daily production of photosynthate to the pods and 69% to the vegetative tissue.

Problems occurred in the shaded treatment for Dixie Runner. It began to rain almost every day from the time the shades were placed on the plants at day 91. It rained 25 of the next 31 days. A total of 362 mm of rain fell during that time period. Dixie Runner which partitions about 69% of its photosynthate into vegetative growth had a dense canopy. The LAI had reached 7.5 by day 91 (Figure 37). The average total stem length per plant was 1450 cm (Figure 38). The dense canopy coupled with the extremely

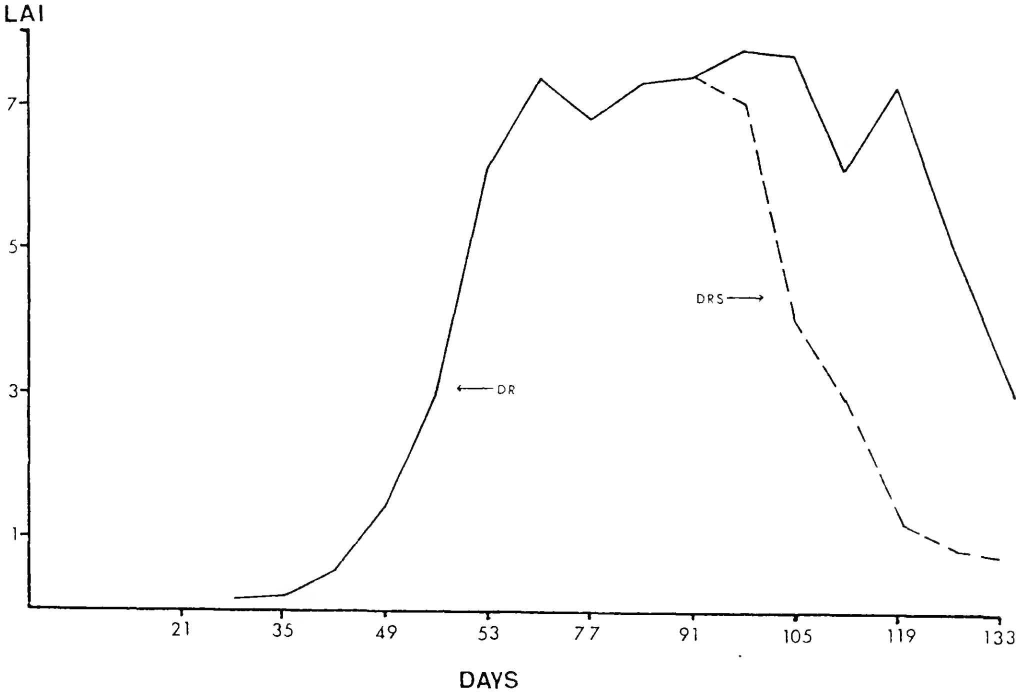

Figure 37. Leaf area index for Dixie Runner (DR) and Dixie Runner under 75% shade (DRS) for the 1978 growing season.

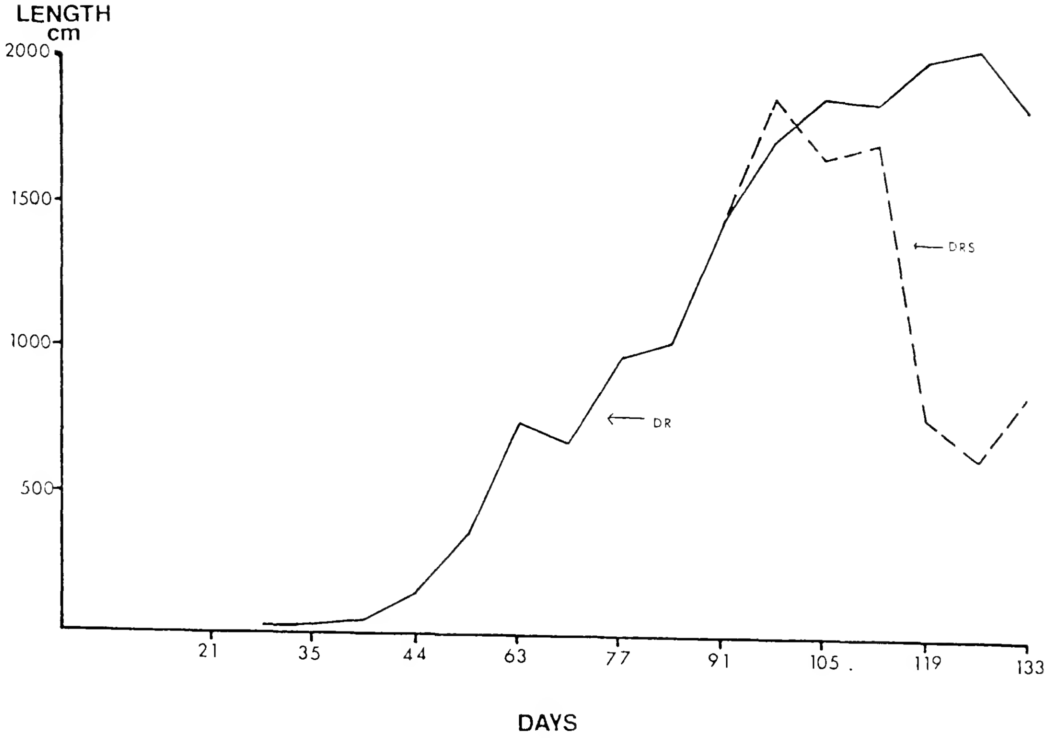

Figure 38. Total stem lengths of Dixie Runner (DR) and Dixie Runner under 75% shade (DRS) for the 1978 growing season.

wet conditions and the 75% shade created ideal conditions for fungal diseases. Cercospora leafspots, white mold or stem rot (Sclerotium rolfsii Saccardo), and a variety of other diseases decimated the shaded Dixie Runner plants. By the final harvest the yield was only 215 kg/ha and a majority of the plants was dead. The LAI dropped drastically to less than one (Figure 37). The specific leaf weight decreased from an average of 4.12 mg/cm^2 for the control of 3.59 mg/cm^2 for the shaded treatment for that period (Figure 39). The total stem length decreased from a high of 1878 cm one week after shading to a low of 624 cm one week before harvest (Figure 38). The peg and pod rates were drastically reduced (Figures 40 and 41). As it was impossible to separate the effects of shading from the effects of the disease, any analysis of these data in relation to nutrient transfer and partitioning would not be meaningful.

Florunner did not appear to be as affected by the diseases as Dixie Runner. The shaded Florunner treatment had a final yield of 2570 kg/ha, or 76% of the unshaded control which was 3389 kg/ha. The yield of the shaded treatment was remarkably high considering the plants received 75% less light during the final 42 days of the growing season when the majority of the pod filling was taking place. The reason the final yield for the unshaded treatment was so high in relation to the control was believed to be the result of the pods having priority for

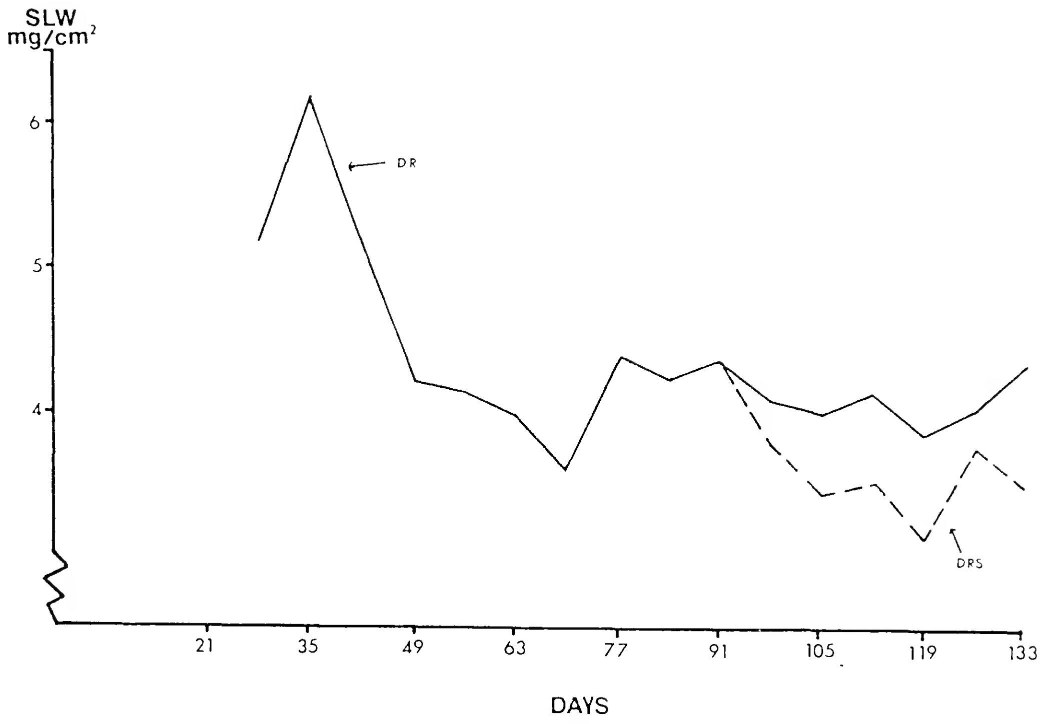

Figure 39. Specific leaf weights for Dixie Runner (DR) and Dixie Runner under 75% shade (DRS).

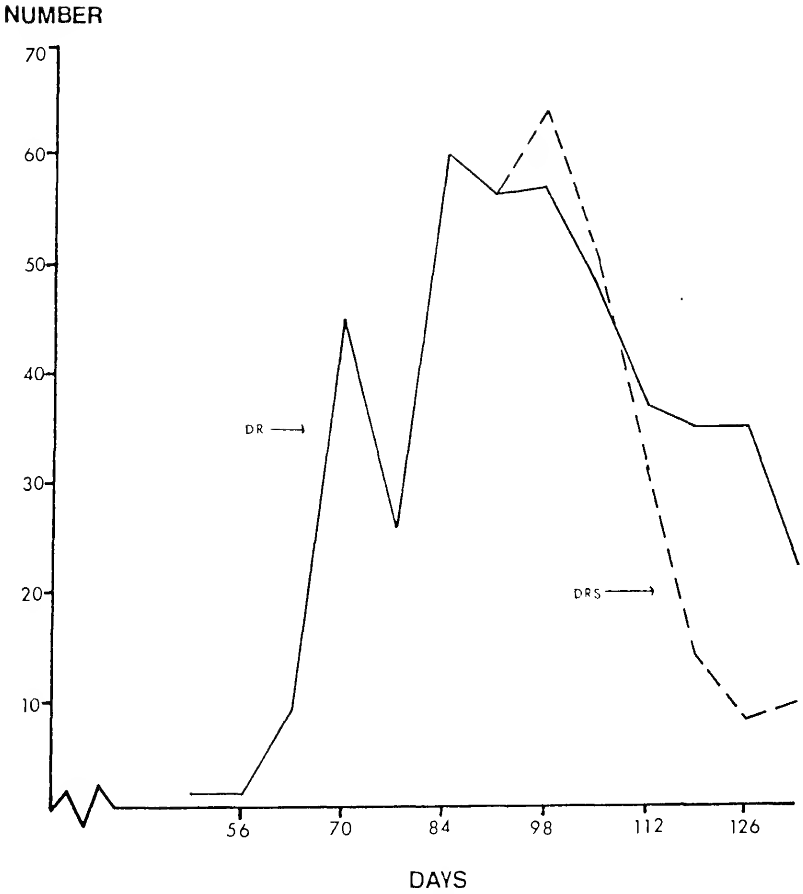

Figure 40. Peg numbers for Dixie Runner (DR) and Dixie Runner under a 75% shade (DRS). Shade was applied on day 91.

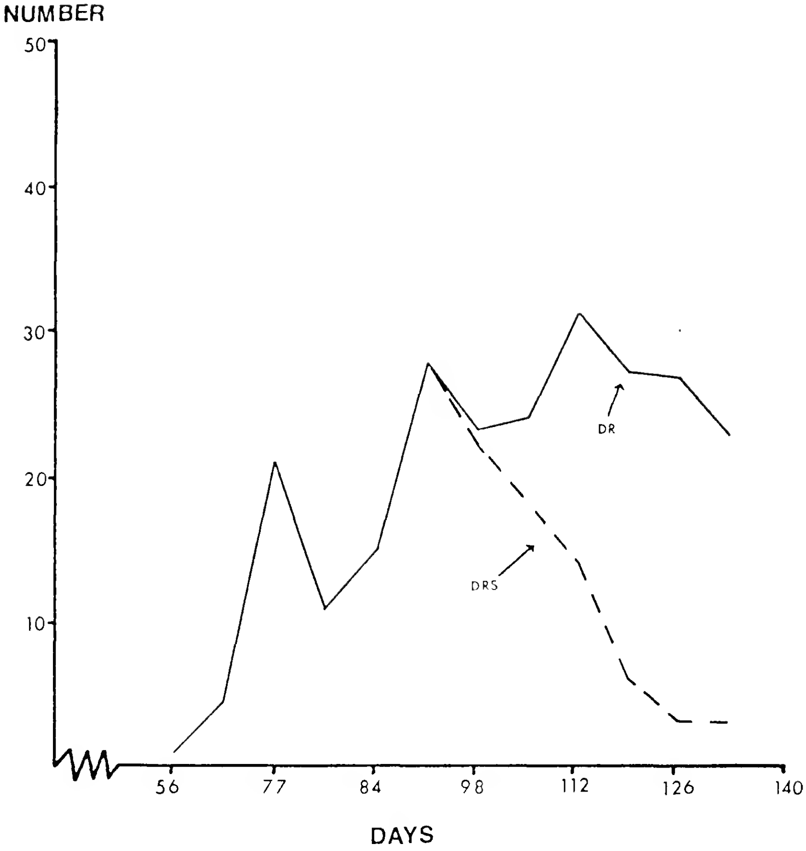

Figure 41. Pod numbers for Dixie Runner (DR) and Dixie Runner under 75% shade (DRS). Shade was applied on day 91.

the nutrients and photosynthate that were available and an increased remobilization of materials from the vegetative portion of the plant.

The belief that there was an increased mobilization of nutrients from the vegetative portion of the plants was supported by the increased decline in the crop canopy. The LAI of the shaded treatment decreased more than the control (Figure 42). The shaded treatment averaged about one LAI lower each week than the control. At harvest, the LAI of the shaded treatment was only 0.19, and the LAI of the control was 1.17. The stem elongation was similar for the shaded treatment and the control up to day 119 (Figure 36). Both treatments demonstrated little evidence of stem elongation during this time. After day 119 the shaded treatment began to decrease in total stem length while the control remained approximately the same. The decrease in total stem length for the shaded treatment was a result of rotted stems. The stem deterioration was believed to be hastened by the nutrient transfer from the stems to the pods.

Analysis of the SLW, nitrogen, and starch content of the leaves also supported the theory that shading may have increased remobilization from the vegetative portions of the plants. The SLW for the unshaded Florunner plants fluctuated between 5.96 mg/cm^2 and 4.13 mg/cm^2 prior to the onset of the pod filling period. During the filling period the SLW was very consistent averaging 4.42 ± 0.07 mg/cm^2

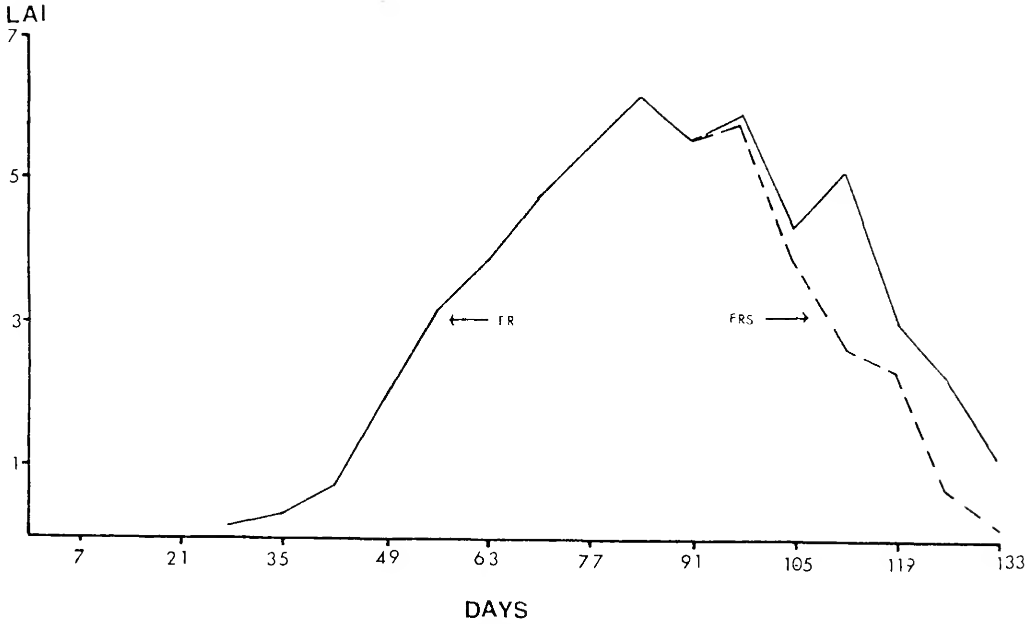

Figure 42. Leaf area index for Florunner (FR) and Florunner under 75% shade (FRS) for the 1978 growing season.

(Figure 43). The SLW for the shaded Florunner treatment averaged 4.05 ± 0.28 mg/cm^2.

The new and old leaves for the shaded treatment were also analyzed for percent starch, nitrogen, and SLW (Table 16). The old leaf samples taken at harvest failed to show much difference between the shaded and unshaded treatments. The SLW was 4.00 ± 0.09 mg/cm^2 for the unshaded and 3.80 ± 0.18 mg/cm^2 for the shaded treatment. The percent nitrogen was 2.37 ± 0.11% for the unshaded and 2.19 ± 0.20% for the shaded. The percent starch was 1.95 ± 0.20% for the unshaded and 2.04 ± 0.19% for the shaded treatment. The lack of real difference was consistent with the hypothesis that peanut leaves may lose nitrogen and starch to a constant value before loss of physiological activity and senescence. The new leaf sample analysis taken at harvest showed a difference in the SLW and percent starch between the shaded and unshaded treatments. The unshaded treatment had a SLW of 4.39 ± 0.10 mg/cm^2 and the shaded treatment 3.76 ± 0.10 mg/cm^2. The percent starch for the unshaded treatment was 2.87 ± 0.41% and 2.18 ± 0.25% for the shaded treatment. The nitrogen content of the leaves did not show any real difference even though the shaded treatment was lower. The percent nitrogen for the unshaded treatment was 3.43 ± 0.13% and 3.29 ± 0.23% for the unshaded treatment.

The increased transferring of nutrients from the leaves and stems to maintain pod filling in the shaded treatment was believed to be responsible for the differences in LAI

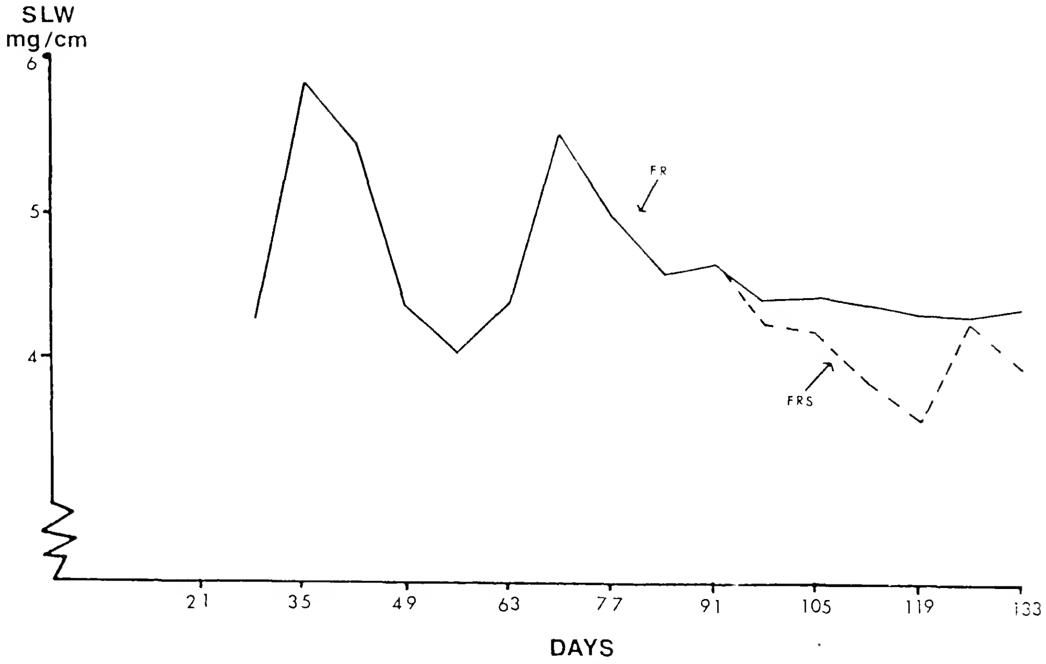

Figure 43. Specific leaf weights for Florunner (FR) and Florunner under 75% shade (FRS).

and stem elongation rates between the shaded and unshaded treatments. By the time the shades were placed over the plants, the pods had been set and they had priority over the vegetative portion for photosynthate and nutrients. This priority was believed to be not only for photosynthate and nutrients produced during the filling period but also for material already stored in the vegetative tissues. Florunner had set pods at day 91 based on the solar radiation received prior to shading and a partitioning factor of about 74%. When the shades were placed over the plants restricting the incoming solar radiation and thus the daily photosynthate production, the plants began to remobilize nutrients at an increased rate compared with the control in order to fill as many pods as possible. If there was not an increased transfer of nutrients from the vegetative portion of the plant to the pods, it would be difficult to account for the comparatively high yield of the shaded plants.

The peg number was not greatly affected by the shading treatment until the last two weeks (Figure 44). The large decrease in peg number corresponds to the decrease in total stem length which also occurred during the last two weeks (Figure 38). The pod number was affected by shading from the first week (Figure 45). At day 91, the pod number had reached 34.8 ± 8.8 pods per plant, then began to plateau at approximately 38.4 ± 6.8 pods per plant. The pod number for the shaded treatment began to decrease with the greatest

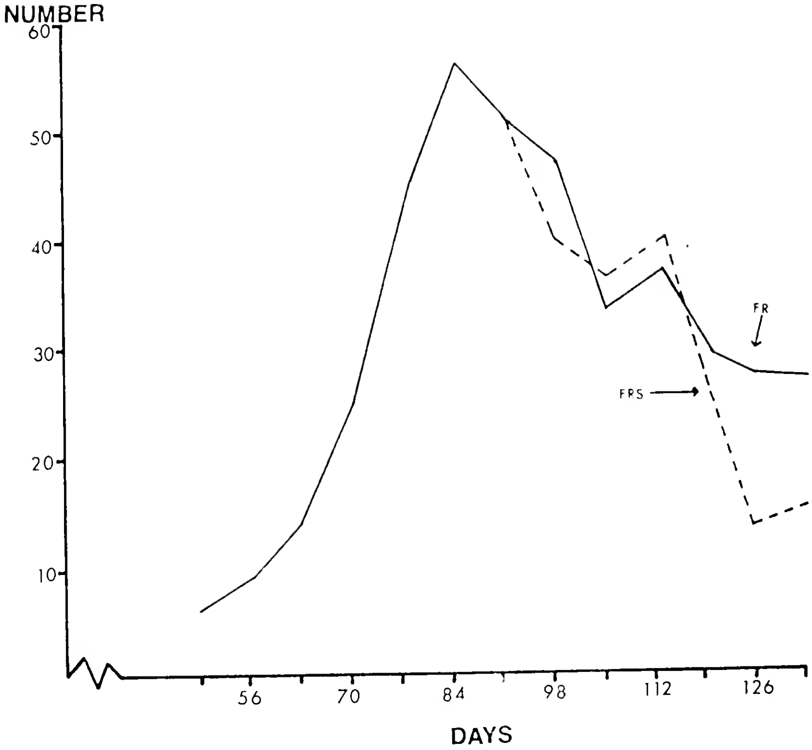

Figure 44. Peg numbers for Florunner (FR) and Florunner under 75% shade (FRS). Shade was applied on day 91.

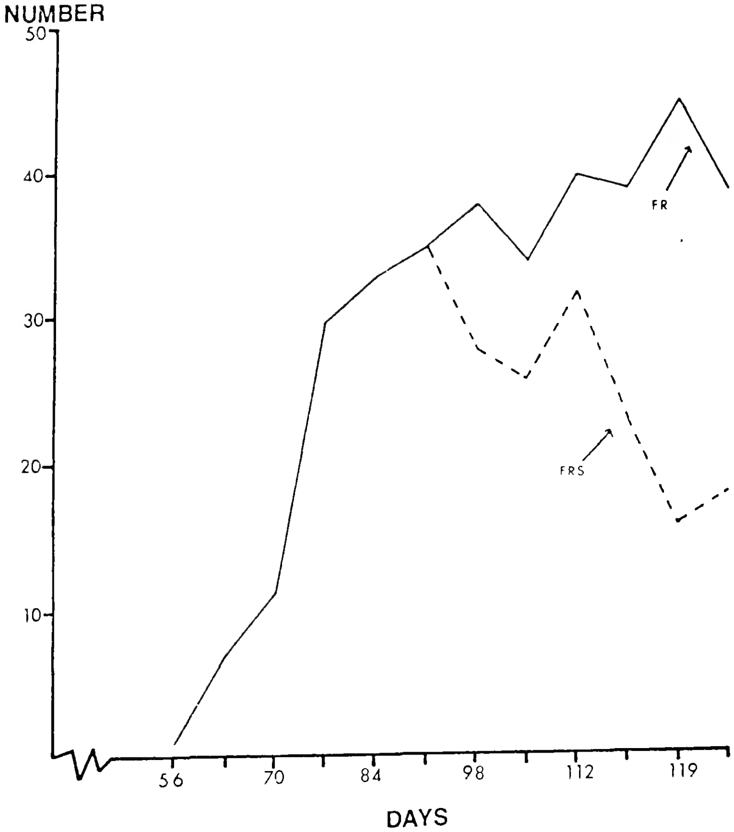

Figure 45. Pod numbers for Florunner (FR) and Florunner under 75% shade (FRS). Shade was applied on day 91.

loss the last three weeks before harvest. The final pod number was 17.8 ± 4.4 pods per plant. The shelling percentage was higher, 73%, for the shaded treatment than the unshaded treatment, 67%. The lower shelling percentage for the unshaded treatment results from the immature, unfilled pods. The unshaded treatment continued to add a few pods during the filling period which were put on too late in the season to allow complete filling before harvest. These pods had unfilled seeds which passed through the shelling machine and were not included in the seed weight. The shaded plants could not continue to fill all the pods set due to the lack of photosynthate. It was theorized that they continued to fill at the same rate only those pods which could be filled from the available photosynthate plus that remobilized. Thus, the harvest date was approximately the same and the pods were filled in the shaded treatment but there were fewer pods produced. The pods that were not filled were probably the last pods set and these were lost due to rotted peg attachments.

SUMMARY AND CONCLUSIONS

During the 1976 growing season, growth analysis was conducted on five peanut and one soybean cultivars. Four of the peanut cultivars (Dixie Runner, Early Runner, Florunner, and Early Bunch) were the result of nearly 50 years of peanut breeding at the University of Florida. With the release of each new cultivar the potential yield from Dixie Runner to Early Bunch was determined to be 118%. The four cultivars were all developed in the same environment, using standardized methods developed early in the program, and using closely related breeding lines. The development of these cultivars led to a unique opportunity to determine the physiological changes that had occurred which led to increased yield. The other peanut cultivar, Spancross, was analyzed for comparison to a Spanish type cultivar. The soybean, Bragg, was analyzed for comparison with an intensively studied legume.

The growth analysis indicated several differences between the cultivars. The higher yielding peanut cultivars and the soybean showed greater canopy deterioration late in the season. Spancross, the low yielding Spanish peanut cultivar, did not have a marked decline in LAI late in the season. Dixie Runner and Early Runner, the two older peanut cultivars, had a marked decline in LAI about three weeks before harvest. Florunner and Early Bunch, the newer peanut cultivars, began a decline in LAI about five weeks before harvest. The LAI was below that required for full ground cover the last two weeks before harvest. Bragg soybean, a determinate plant, began to decline in LAI about seven weeks before harvest. The decline was much more complete than for the peanut cultivars.

The cultivars also showed marked differences in flowering. Dixie Runner and Spancross, the lowest yielding cultivars, continued to flower until harvest. Early Runner ceased to flower about day 103, Florunner about day 91, and Early Bunch at approximately the same time as Florunner. Bragg soybean ceased flowering about day 112, but it also began flowering much later than the peanut cultivars. Bragg soybean, Florunner and Early Bunch peanuts all flowered for approximately nine weeks.

The time when the stem elongation rate declined or ceased also varied between the cultivars. The stem elongation rate decreased in Dixie Runner about day 112. Early Runner appeared to cease stem elongation about day 103, Florunner about day 98, and Early Bunch about day 89. Spancross appeared to cease stem elongation about day 96, only two weeks before harvest. Bragg soybean, a determinate cultivar, ceased stem elongation when the first blooms appeared.

The new higher yielding cultivars appeared to become functionally determinate in their growth habit. Early Bunch resembled the determinate soybean cultivars more closely than did Dixie Runner. The so-called "self destruct" mechanism found in soybeans, characterized by a deterioration of the canopy late in the season, appeared to be occurring in the high yielding peanut cultivars. However, the deterioration was much more evident in the soybean cultivar.

There were two major physiological aspects that were responsible for most of the yield increase resulting from the release of the newer peanut cultivars. The newer cultivars had a longer filling period as a result of earlier initiation of pods. Dixie Runner reached a stable pod number about day 105, Early Runner about day 96, Florunner about day 84, and Early Bunch about day 75.

The major physiological change which accounted for the majority of the potential yield increase in peanuts was the higher partitioning factor in the newer cultivars. Dixie Runner, the lowest yielding cultivar, was found to have a partitioning factor of 0.31. Early Runner had a partitioning factor of 0.61, Florunner was 0.74, and Early Bunch, the highest yielding cultivar, was 0.85.

There was no evidence to indicate that an increase in photosynthetic rate was responsible for the increased yields of the newer cultivars.

In 1977, 22 of the highest yielding peanut cultivars from 11 different countries were analyzed. The objective was to determine if they had similar physiological characteristics to the high yielding Florida cultivars. The environment was found to effect the physiology of the plant. The effect of the environment was most evident in the Rhodesian cultivars. Makula Red, when grown in Rhodesia where it is adapted to high elevation and cool temperatures had produced record yields of over 9,000 kg/ha. In this experiment, Makula Red yielded only 2030 kg/ha and had a very low partitioning factor.

The partitioning factor was found to be positively and significantly correlated to yield. Partitioning factors ranged from 0.26 for the low yielding Rhodesian cultivars to 0.90 for Early Bunch. The harvest date, which was used as an indication of the length of the filling period, was also positively and significantly correlated to yield. The harvest dates ranged from 109 days for Valencia R2 to 133 days for the three highest yielders, Early Bunch, Florunner, and Shulamith. The Rhodesian cultivars were excluded as they never appeared to completely mature. The study indicates that yield in some of the cultivars may be increased by increasing the filling period and/or partitioning factor.

In 1978, Florunner and Dixie Runner were analyzed to determine if the canopy deterioration demonstrated by the high yielding cultivars late in the season may be the result of remobilization of assimilates and nutrients from the canopy to the pods. The newest fully developed leaves and the oldest yellow leaves were analyzed for SLW, percent starch, and percent nitrogen at the beginning and end of the filling period. The new leaves were found to be higher in SLW, percent starch, and percent nitrogen than the old leaves for both cultivars indicating that these materials are removed from the leaves before senescence. The old leaves were found to have a similar SLW, percent starch, and percent nitrogen for both cultivars at the beginning and end of the filling period. The uniform loss supports the belief that peanut leaves may lose nitrogen and starch to a constant value before loss of physiological activity and senescence.

Dixie Runner had similar values for SLW, percent nitrogen, and percent starch for new leaves in the beginning and end of the filling period. The remobilization of nutrients from the leaves of Dixie Runner did not appear to be increased due to pod filling. Florunner had lower values of SLW, percent nitrogen, and percent starch for new leaves at the end of the filling period than at the beginning. The decreases for Florunner indicate that the high yielding, high partitioning cultivar remobilized materials from the leaves to a greater extent at the end of the filling period. The increased canopy deterioration may be due to the removal of materials from the vegetative portion of the plant in the high partitioning cultivars.

Leaf samples were also taken so that each succeeding sample was comprised of leaves which were approximately two weeks older. The SLW, percent nitrogen, and percent starch were found to decrease for both cultivars as the leaves aged. However, only Florunner showed a significant decrease in all three. Dixie Runner had a significant decrease in percent nitrogen but the decrease was at a slower rate and had a lower correlation coefficient than that for Florunner. As the samples were taken during the filling period this supports the conclusion that the high yielding high partitioning peanuts remobilize materials to a greater extent during the filling period.

A shading study was conducted on Florunner to determine if the pods had priority for materials already assimilated in the vegetative portion of the plant. Shades that reduced solar radiation by 75% were placed over the plants after the full pod load was set and maximum partitioning was in effect. The shaded plants had a greater canopy deterioration and a greater decrease in SLW and percent nitrogen and starch at the end of the filling period than the unshaded control. The shaded Florunner plants yielded 76% of the unshaded control despite the 75% shades over the last 42 days of the filling period. The greater canopy deterioration, loss of nitrogen and starch from the leaves, and relatively high pod yield of the shaded treatment indicated that the pods may have priority for assimilates and nutrients being produced and already stored in the vegetation portion.

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APPENDIX

1-A: Nitrogen Determination Procedure

1. Weigh 0.1 g of dried ground plant material and place in 200mm test tube.
2. Add 3.40 g of catalyst-salt mixture (1 part $CuSO_4$ to 2 parts K_2SO_4) to each tube.
3. Add 2 or 3 boiling chips to each tube.
4. Pipette 10 ml concentrated H_2SO_4 to each tube and vortex until clumps leave sides of tubes.
5. Pipette 0.5 ml H_2O_2 in each tube. Repeat. Adjust pipette to 1.0 ml and add 1.0 ml to each tube (Total: 2.0 ml H_2O_2 to each tube).
6. Place tubes onto digestion block. Set block at 375° C for 6.5 hours.
7. After tubes are cool vortex and add distilled H_2O straight into bottom of vortex until vortex disappears.
8. Bring each tube up to volume (75 ml), using Technicon Block Digestion Tubes. Transfer to storage bottles.
9. Read nitrogen concentrations on a Technicon Auto-Analyzer.

1-B: Starch Determination Procedure

1. Weigh 0.1 g of ground leaf and put in a 15ml centrifuge tube. Add 8 ml of 80% ethanol. Heat tube at 80° C for 30 minutes and then put in refrigerator over-night.

2. Repeat step one.
3. Repeat step one except that instead of refrigerating over-night, place tubes in centrifuge at 15,000 RPM for 30 minutes. Pour off liquid then refill with 80% ethanol. Repeat centrifuging procedure twice more, then place tubes in dryer until dry.
4. Add 5 ml of Acetate Buffer to test tubes and shake.
5. Add 5 ml of Amyloglucosidase solution to test tubes and stopper. Place in osilating water bath at 41° C for 48 hours.
6. Remove from bath, centrifuge at 15,000 RPM. Pour off liquid and save liquid for starch determination.
7. Take 0.2 ml of sample (from step 6) and place in 10ml scored test tube.
8. Add 1.0 ml of Alkaline Reagent and shake. Heat in boiling bath for 30 minutes. Remove.
9. Add 1.0 ml of Arsenomolybdate Reagent and fill to scored 10ml line with deionized water.
10. Read on colorimeter with a blank solution as zero and a green filter. Use set of glucose standards prepared with same procedure for correlation.

Reagents

Acetate Buffer: Mix 3 parts of 0.2 N acetic acid and 2 parts of 0.2 N Sodium acetate. Add a few crystals of thymol to prevent microorganism growth.

Amyloglucosidase solution: Add 5 g of amyloglucosidase to one liter of distilled water. Add thymol to prevent microorganism growth.

Alkaline Reagent: Add 25 g of Sodium Carbonate, 25 g of Potassium Sodium Tartrate, 20 g of Sodium Bicarbonate, and 200 g of Anhydrous Sodium Sulfate to 700 ml of distilled water then dilute to one liter. Dissolve 6 g of Cupric Sulfate in 40 ml of distilled water followed by one drop of concentrated sulfuric acid. Combine the two solutions.

Arsenomolybdate Reagent: Dissolve 25 g of Ammonium Molybdate Tetrahydrate in 450 ml of distilled water, then add 21 ml of concentrated sulfuric acid. In separate solution dissolve 3 g of Disodium Arsenate in 25 ml of distilled water. Combine the two solutions.

BIOGRAPHICAL SKETCH

Robert Luther McGraw was born January 31, 1948, to Frank William and Mary Jean Head McGraw. The first years of his life were spent on the move as his father was a career officer in the United States Army. Born in Yokohama, Japan, he then lived in California, Florida, Germany, and Virginia before moving back to Florida at the age of nine.

He attended P. K. Yonge Laboratory School from the seventh grade until graduation from high school. Then he enrolled in the University of Florida in 1966 and received a Bachelor of Science in Secondary Education in 1970. He majored in biological science and graduated with honors and was elected into Phi Kappa Phi national honorary and Kappa Delta Pi Honor Society in Education.

After graduation from college he spent four years as an officer in the United States Air Force. In the service he graduated from Communications Electronics School and was a Communications Electronics Systems Officer at Eglin Air Force Base for 3 years. After separation he enrolled in the University of Florida for a program in Agronomy. He received a Master of Science degree in March 1977. He was elected to Gamma Sigma Delta Honor Society in Agriculture.

Mr. McGraw expects to receive a degree of Doctor of Philosophy in December 1979.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

D.E. McCloud

D. E. McCloud, Chairman
Professor of Agronomy

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

W. G. Duncan
Professor of Agronomy

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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