Effect of Temperature Treatment on Peanut Vegetative and Fruit Growth[1]

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ABSTRACT

Two studies were conducted in growth chambers to evaluate the effects of temperature on the vegetative and reproductive growth phases of peanuts (*Arachis hypogaea* L., cv. Florigiant). Temperature regimes in the first study ranged from 34/30 to 18/14°C day/night and in the second from 34/30 to 22/18°C. The experiments were conducted for 61 and 110 days, respectively. In the first study, the plants were kept vegetative by clipping the pegs. Dry weights of leaflets, petioles and stems, leaf area, and number of flowers were measured. The same measurements plus fruit weights were made in the second study. Early growth, as determined by accumulation of top dry weight, was optimum at a weighted mean temperature of 27.5°C and essentially no growth occurred at 15.5°C. When plants were grown at the optimum temperature for four weeks and then subjected to different temperatures, the treatments had much less effect on top weight during subsequent growth and the optimum temperature decreased somewhat relative to that for early growth. Total fruit weight and individual pod weight were greatest at 23.5°C. Also, the rate of increase in pod weight was greatest at 23.5°C. During early growth the optimum temperatures for development of leaf area and for rate of flowering were above 28°C while in later stages the optimum for rate of flowering decreased to about 26°C.

Key Words: Leaf area, Modeling, Flowering, Leaflet/top ratio.

Temperature is a primary factor determining the growth and development of plants. In temperate regions the average daily temperature may vary over 10°C during the season. In tropical regions temperatures vary less during the season. Williams *et al.* (13) found that total dry matter accumulation of Makulu Red peanuts increased with increasing temperature over a range of 17.9 to 23.3°C, but that the yield of kernels was greatest at 20.1°C. Fortainer (8) studied development of the Schwarz 21 cultivar for 80 days in growth chambers. He noted a temperature optimum of about 30°C for dry matter gain during early growth, but this shifted to a lower average optimum temperature of about 26°C as the plants aged. Carlson *et al.* (3) found maximum dry matter accumulation of NC4 peanuts in phytotron studies at 28°C during early growth, whereas for older plants the maximum dry matter accumulation occurred at 32°C.

The growth and development of fruit is also temperature dependent. Ono *et al.* (10) found that the greatest fruiting percentage and the largest individual pods of Chiba-handachi peanuts were formed at a fruiting zone temperature of 31 to 33°C. These results may be contrasted with those of Williams *et al.* (13) which indicated that cooler air temperatures resulted in a more rapid rate of individual pod growth and larger fruit.

Studies have also been conducted on the effect of short term fluctuations in temperature. Wood (14) found the optimum temperature for the growth and development of Spantex peanuts during a 12-day period at early flowering to be near 25°C. He also noted that no daily (day/night) fluctuation in temperature was required. In fact, an extreme daily range was detrimental. This had also been reported by Fortainer (8).

There are a number of discrepencies in the observations to date. Some of these may be associated with differences in cultivars, but others may be based on different temperature optimums for the various growth stages or processes. The current studies were undertaken to evaluate the effect of temperature differences on the vegetative growth and fruit development of Florigiant peanuts. Growth is interpreted only as dry matter accumulation and is not meant to imply any particular plant process such as photosynthesis. The data will be used to support modeling efforts on peanut growth and development.

Materials and Methods

Florigiant peanut seeds were germinated in a chamber at 24°C. The day the seeds were moistened was considered as the first day of growth. On the third day, when the radicals were about 1 cm long, the germinated seed were transplanted to 20-cm diameter pots filled with a growth media consisting of 1/3 Redi-Earth (a peat vermiculite mixture from W. R. Grace & Co., Atlanta, GA) and 2/3 gravel by volume. The seeds were planted about 2 cm deep. They were then moved to one of five controlled environment rooms in the phytotron unit of the Southeastern Plant Environment Laboratories at North Carolina State University. The day/night treatment temperatures in these rooms were 34/30, 30/26, 26/22, 22/18, and 18/14°C. A combination of cool white fluorescent and incandescent lamps at a 10:3 input wattage ratio for a 9-hour day gave 680 μEM^{-2} sec^{-1} photosynthetically active radiation (PAR) and 18 wm^{-2} photomorphogenic radiation (PR). The night period was broken for three hours with PAR at 55 μEM^{-2} sec^{-1} and PR at 12 wm^{-2}. The relative humidity was maintained at near 70% and the pots were irrigated daily with a complete nutrient solution (6).

This experiment was conducted for 61 days. Two plants per treatment were sampled destructively about each five days after emergence. Emergence for the warmest to coolest temperature treatments occurred on day 7, 8, 9, 10 and 15, respectively. Measurements included leaf area, dry weights of leaflets, petioles and stems, and number of flowers. Developing fruit were clipped to maintain the plants in a vegetative state.

A second experiment was then conducted by planting germinated seed in 25-cm diameter pots and growing them at 30/26°C for 28 days. They were then transferred to four growth chambers at 34/30,

[1]Paper No. 5644 of the North Carolina Agricultural Research Service, Raleigh, N. C. 27650. Operation of the phytotron unit of the Southeastern Plant Environmental Laboratory at N. C. State University was supported in part by NSF Grant GI-28951. The use of trade names in this report does not imply endorsement by the N. C. Agricultural Research Service of the product nor criticism of similar ones not mentioned.

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30/26, 26/22 and 22/18°C and allowed to grow until day 110. In addition to the measurements made for the first experiment, the number and weight of fruit were determined. In this study a single plant was harvested each week.

Results and Discussion

The growth of young plants was markedly affected by the temperature treatments (Fig. 1). Dry weight accumulation of plants grown for 61 days was optimum at 30/26°C. Treatments 4°C above or below this temperature resulted in less dry weight. The reduction was about the same whether above or below by 4°C. After 61 days the weight of the 22/18 and 18/14°C treatments were only 36 and 2% that of the optimum, respectively.

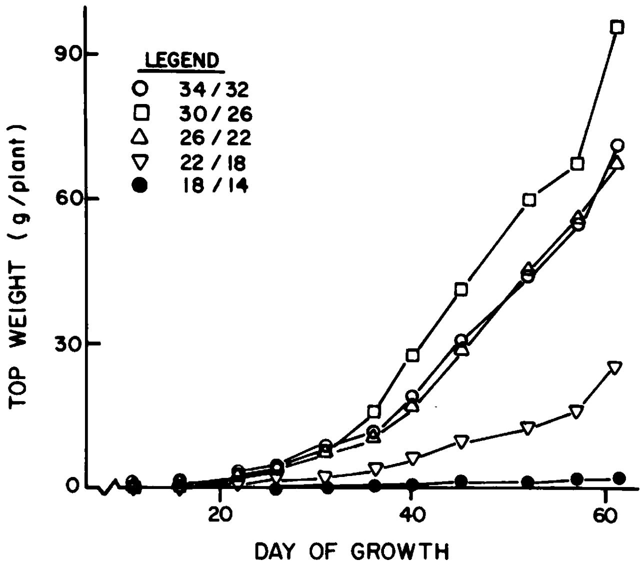

Fig. 1. The effect of five temperature treatments on the early growth of Florigiant peanuts. The LSD (P = 0.05) between the weights of any two treatments at a given time is 5 g/plant.

It was expected that little growth would occur at the lowest temperature treatment which had a weighted average of 15.5°C. Several workers have indicated that the lowest critical average temperature, the point at which growth ceases, is in the 13 to 14°C range (9, 7, 5). Because of the extremely small amount of growth, this treatment was not included in the second study.

The ratio of the weight of the leaflets to that of the entire above-ground portion of the plant was determined from the first experiment. It decreased from about 0.6 for seedlings to 0.45 for 50 g plants in a hyperbolic manner. This is similar to that reported earlier (4). If this relation is used when mathematically modeling the development of the peanut (15), the type function may apply but data should be collected from the field to calculate if for those conditions.

In the second study, after the plants had grown at a common temperature for 28 days, there were really no consistent differences in top weight among the four temperature treatments (Fig. 2). Development

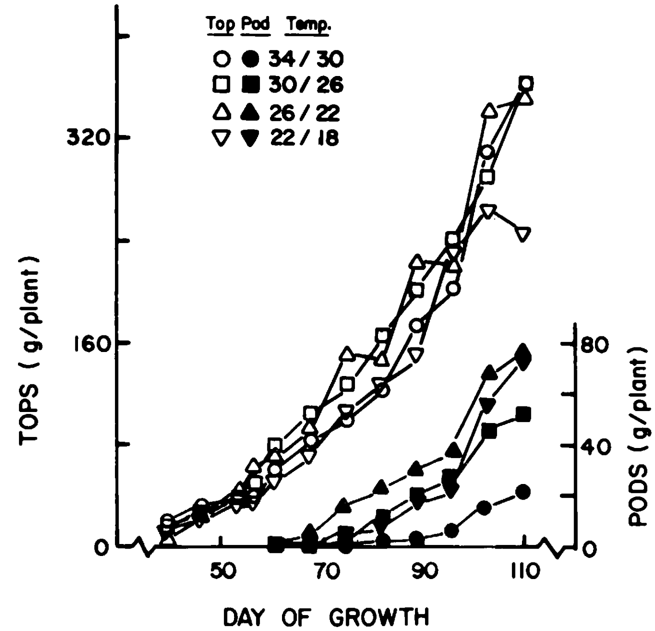

Fig. 2. The top and pod weight of Florigiant peanuts grown under four temperature treatments imposed on the 28th day of growth. The LSD (P = 0.05) for the top and pod weight differences between any two treatments at a given time were 47 and 13 g/plant, respectively.

of the peanut tops tended to be somewhat more rapid during the 60 to 90 day period for the 30/26 and 26/22°C treatments than for the 34/30 and 22/18°C treatments. For the 90 to 110 day period, top growth appeared to be less on plants grown under the 22/18°C treatment than under the others, but the difference was small.

It appears from this data that in later stages of growth the accumulation of dry weight by the tops is less sensitive to differences in temperature and the optimum temperature for top growth is less than that for earlier stages of growth. Fortanier (8) noted a similar response pattern in peanuts for stem length. Went (12) noted reduction in the optimum temperature of a number of species of plants as they aged. The reasons for the change in optimum temperature as plants age are not clear. The accumulation of dry weight is a combined function of carbon fixation, translocation, and its utilization in growth and respiration. At one age photosynthesis may be the most limiting process whereas at another, the limiting process may be the utilization of carbon in growth, especially leaf area development.

The optimum temperature for fruit development was lower than that of the tops, about 24°C (Fig. 2). Accumulation of dry weight by all the pods, regardless of their maturity, was slightly less at 30/26 and 22/18, but was markedly less at 34/30°C. Bolhuis and DeGroot (1) studied three varieties of peanuts and found that the optimum temperature for fruit development was greater than 24°C. The optimum temperatures for their varieties were about 26 to 28°C. Wood (14) found that the optimum temperature for a Spanish type cultivar at early flowering was about 25°C as determined by the effect of temperature at that time on subsequent pod development.

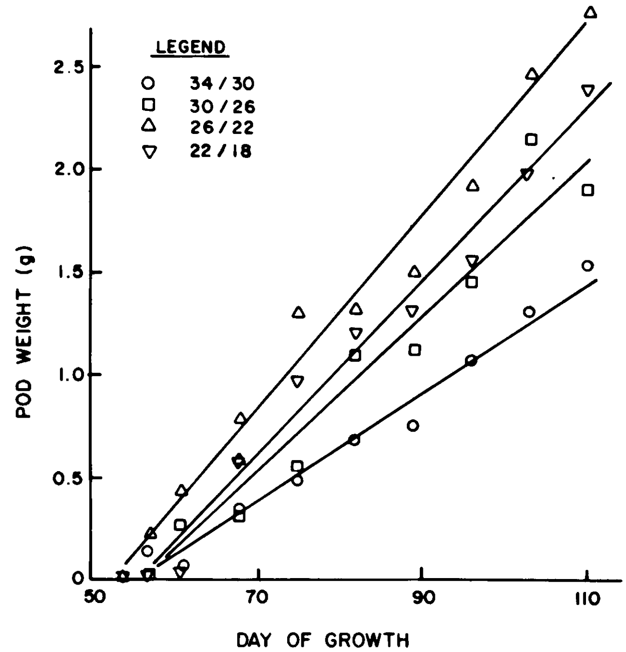

Fig. 3. The rate of dry matter accumulation by pods of Florigiant peanuts grown under four temperature regimes. The slopes of the lines in decreasing temperature order are 0.026, 0.038, 0.047, and 0.043 g/day and the LSB (P = 0.05) is 0.007 g/day.

The rate of development of an individual pod was determined by weighing the largest pod at each sampling time and assuming it was the first initiated. The effect of temperature on rate of pod development (Fig. 3) was similar to that just noted for overall pod production (Fig. 2). The rate of pod development during the period of measurement was essentially linear. A linear rate to near maturation has been reported by Boote (2) and seems to apply to the growth pattern observed by Schenk (11).

The pod development rate ranged from 0.026 g/day at 34/30°C to 0.047 g/day at 26/22°C (Fig. 3) which appears to be near the maximum in these studies. In the system that was used in the growth chamber, fruit number was restricted due to the limited soil surface for pegs to penetrate. It is likely, therefore, that the few fruit that did develop should have had adequate photosynthate to accumulate dry matter at their maximum rate.

The study was not continued long enough to note pod maturation by a reduction in the rate of pod growth. However, browning was occurring within the shells, especially in the warmer treatments. Pods grown at 34/30° weighed only 1.5 g whereas those grown at 26/22°C weighed 2.7 g at the end of the study. This indicates that there is dependence of pod size on temperature, too.

The mean kernel mass of Makulu Red peanuts grown at three altitudes reported by Williams *et al.* (13) also reflected responses of fruit growth to temperature. Under the coolest condition (about 18°C) they found the mean rate of kernel mass accumulation to be the most rapid. Also, it appeared that the ultimate size at that temperature was at least 0.7 g/kernel whereas under warmer conditions (about 23/24°C) it was less than 0.5 g/kernel.

Contrasting results were found by Ono *et al.* (10) with the Chiba-handachi cultivar when they altered the temperature of just the fruiting zone of the soil. Their results indicated most rapid development and largest pod size at a fruiting zone temperature of 31-33°C.

Flowering was also affected by the temperature treatments in my experiments. In the first study, in which no fruiting was allowed, the rate of flowering was greatest at 30/26°C, and the rate of the 34/30°C treatment was only slightly less (Fig. 4). The rate of flowering was quite restricted at temperatures less then 30/26°C.

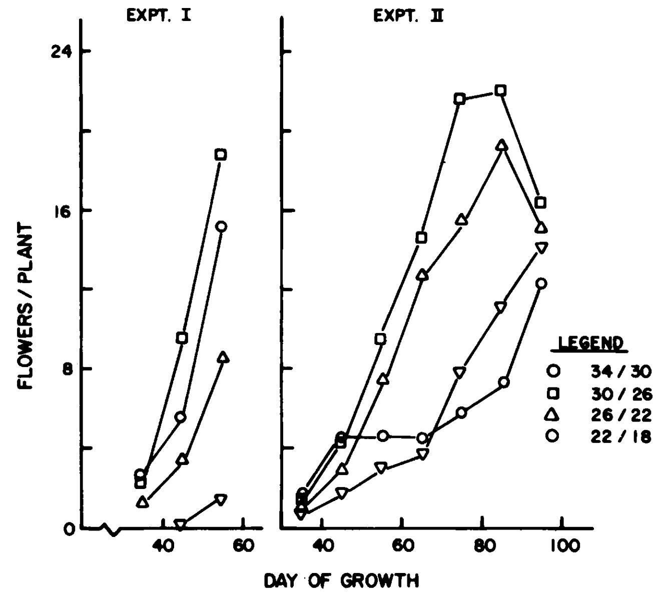

Fig. 4. The rate of flowering of Florigiant peanuts grown under four temperature regimes in the two experiments. The points are averages of several observations per 10 day period. The LSD (P=0.05) between any two treatments at a given time is 5 flowers/plant in each study.

In the second study the rate of flowering was again greatest at 30/26°C, but the rate of the 26/22°C treatment was only slightly less. The rates of the 34/30°C and 22/18°C treatments were markedly less in this experiment. The flowering rates in the two studies correspond reasonably well with the rates of dry weight accumulation (Fig. 1 & 2). Both measurements indicate that the optimum temperature may decrease as the plants age.

The flowering rate was lower in the second study, possibly because of developing fruit (Fig. 4). The 30/26°C treatment is comparable for the two experiments and its flowering rate in the second study is about half that which occurred in the first on the same day of growth during early flowering.

Wood (14) found that cooler temperatures favored the flowering of Spantex peanuts. A weighted average temperature was used and it was inversely related to the number of flowers formed during a 12-day treatment period. He also found that the net assimilation rate was correlated with temperature and hypothesized that flowering may be causally related to the level of photosynthesis.

Leaf area was measured in the first experiment. It was larger for the 34/30°C and 30/26°C treatments than for the other treatments. The optimum average temperature for maximum leaf area, therefore, was about 30°C. this was slightly higher than that for flowering and about 2°C above that for dry weight accumulation.

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Accepted November 25, 1978