Photoperiodic Response of Peanut Species [1]

H. T. Stalker* and J. C. Wynne[2]

ABSTRACT

Many *Arachis* species collections do not produce pegs in North Carolina even though they flower profusely. To investigate reasons for the failure of fruiting, nine wild peanut species of section *Arachis* and three *A. hypogaea* cultivars representing spanish, valencia and virginia types were evaluated for response to short and long-day treatments in the North Carolina State Phytotron Unit of the Southeastern Environmental Laboratories. The objective of this investigation was to determine the flowering and fruiting responses of *Arachis* species to short and long-day photoperiods. Plant collections grown under a 9-hour short-day treatment were generally less vigorous, but produced more pegs than corresponding plants grown in long-day treatments which were produced by 9 hours of light plus a 3-hour interruption of the dark period. Annual species produced significantly more flowers and pegs than perennial species during both long and short days. The total number of flowers produced ranged from 0 during short days for *A. correntina* to more than 300 for *A. cardenasii* in long-day treatments. Only one plant of each species *A. chacoense* and *A. villosa,* and no plants of *A. correntina,* flowered in short days. Total numbers of pegs produced in short-day treatments were generally greater than in long-day treatments and the ratio of total number of pegs/total number of flowers was consistently greater during short-day treatments. A general trend was observed for more flowers produced in long-day treatments, but more pegs produced in short days. This study indicated that photoperiod can be manipulated to increase the seed set of some species and the success rate of obtaining certain interspecific hybrids. Furthermore, introgression from wild to cultivated species may possibly alter the reproductive capacity of *A. hypogaea* to photoperiod.

Key Words: *Arachis,* flowering, photoperiod, pegging.

Developing high yielding cultivars with uniform maturity has been a primary goal of peanut breeders. The indeterminate growth habit of peanuts results in several maturity groups on the same plant at harvest (6). Among the factors affecting maturity is photoperiodic response. Although Smith (8) and Fortainer (4) reported no correlation between photoperiod and flowering, several other investigators concluded that cultivated peanuts are affected by photoperiod. Umen (9) found that while photoperiod did not affect flowering at constant temperatures, variable temperatures did affect flowering. Peanut plants perform similarly in 9+3-hour photoperiods and in long days (10). Long days generally promote vegetative growth while short days enhance pegging and fruiting (3, 7, 11). Short days have also been shown to enhance heterotic responses for fruit yield (7, 10). Wynne and Emery (10) reported reciprocal differences to photoperiod among intraspecific hybrids of cultivated peanuts which had a specific spanish line in the pedigree. Superior types were recovered when this spanish genotype was used as the female parent. Radiation levels can also affect flowering response where increased amounts of light result in greater numbers of fruits (1,7). If photoperiod responses in peanuts are under genetic control (10), maturity could possibly be altered by hybridizing diverse *Arachis hypogaea* L. cultivars or by introgression from the wild *Arachis* species. Manipulation of photoperiodic responses has potential applications for increased seed production, maintenance of germplasm resources, analyzing cross-compatibility results in hybridization programs and possibly to alter the reproductive system of the cultivated peanut.

The objectives of this investigation were to determine the flowering and fruiting responses of *Arachis* species to short and long-day photoperiods. Members of section *Arachis* will hybridize with cultivated peanuts and the plant materials were thus limited to this group.

Materials and Methods

Eight diploid species of section *Arachis* were used in this investigation as follows: *A. villosa* (PI 210554) from Colonia, Uruguay, *A. stenosperma* Greg. et Greg. *nom. nud.,* coll. 410 HLK (PI 338280) from Porto Dom Pedro II, Parana, Brazil; *A. duranensis* Krap. et Greg. *nom. nud.* 7988 K (PI 219823) from Salta, Argentina; *A. batizocoi* Krap. et Greg. 9484 K (PI 298639) from Parapeti, Bolivia; *A. cardenasii* Krap. et Greg. *nom. nud.* 10017 GKP (PI 262141) from Roboré, Bolivia; *A. spegazzinii* Greg. et Greg. *nom. nud.* 10038 GKP (PI 262133) from Salta, Argentina; *A. chacoense* Krap. et Greg. *nom. nud.* 10602 GKP (PI 276235), and *A. correntina* (Burk) Krap. et Greg. *nom. nud.* 9548 GKP cultivated at Manfredi, Argentina, but most likely originally collected along the Paraguay River in Corrientes, Argentina. One tetraploid wild species, *A. monticola* Krap. et Rig. 7264 K from Yala, Jujuy, Argentina, was also observed (Fig. 1).

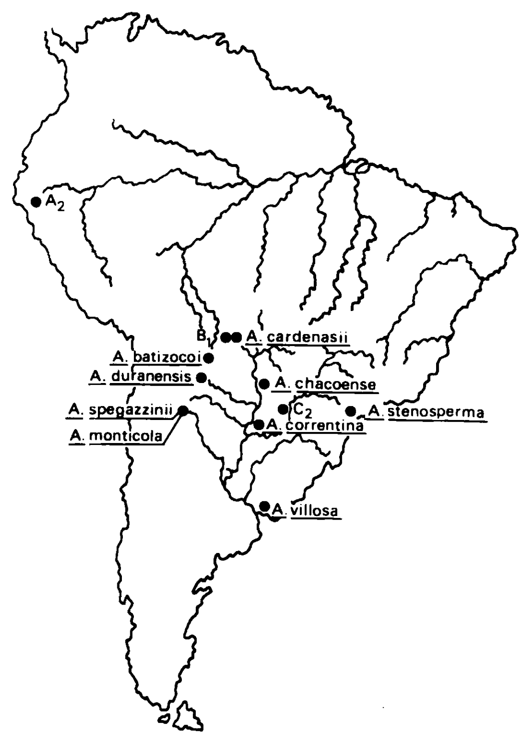

Fig. 1. Map of South America illustrating the location of *Arachis* in their native habitat which were evaluated for photoperiod sensitivity.

[1]Paper number 8754 of the journal series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7629.

[2]Associate Professor and Professor, respectively, Department of Crop Science, North Carolina State University, Raleigh, NC 27695-7629.

Peanut Science (1982) 10:59-62

Three *A. hypogaea* lines representing different botanical varieties also were used in this investigation. The lines have been extensively evaluated by Wynne *et al.* (10,11) and Emery *et al.* (3). A_2 (NC Ac 17090) belongs to subsp. *fastigiata* var. *fastigiata* (valencia) and was collected from about 8° south latitude in Peru. B_1 (PI 262090) belongs to subsp. *hypogaea* var. *hypogaea* (virginia) and was collected at about 17° south latitude in Bolivia. C_2 (PI 262000) was collected at about 25° south latitude in Paraguay and is classified as subsp. *fastigiata* var. *vulgaris* (spanish) (Fig. 1).

Seeds from each entry were germinated in 25-cm plastic pots filled with a growth medium composed of one-third peat-lite and two-thirds gravel and supplemented with a nutrient solution (2). Each collection was represented by a single plant plot replicated three times within each photoperiod treatment. Daily flower records were kept. The number of pegs per plant was counted for the first 50 days and every 10 days thereafter. Mainstem height, length of cotyledonary laterals and plant weight were recorded at harvest.

The experiment was conducted in the North Carolina State University Phytotron Unit of the Southeastern Plant Environment Laboratory (2). The short days were programmed for 9 hours light plus 15 hours dark. Long day treatments had 9 hours of light and 15 hours dark interrupted by 3 hours of low intensity light from incandescent lamps. Temperatures were maintained at 30 C during light phase and 26 C during the dark phase. Carbon dioxide levels were held at approximately 400 ppm.

Results and Discussion

Entries grown under short-day conditions generally produced fewer flowers, more pegs and were vegetatively less vigorous than corresponding plants grown under long-day conditions (Table 1). A few exceptions to the trend were observed. For example, *A. batizocoi* produced longer mainstem and lateral branches in short-day conditions and correspondingly greater plant weight (Table 1). However, even though a reduced daylength resulted in increased dry matter accumulation, *A. batizocoi* had approximately the same number of pegs under both photoperiods. *Arachis duranensis, A. spegazzinii,* and *A. cardenasii* had less vegetative growth but slightly increased plant weight when grown under short-day conditions. *Arachis villosa* was the only species which had more pegs produced in the long rather than short-day treatments.

The total number of flowers produced under long days in *Arachis* species ranged from 96 for *A. villosa* to more than 300 for *A. cardenasii* and the *A. hypogaea* cultivars, A_2 and C_2. For short-day treatments the range was from 0 to 334. *Arachis chacoense, A. correntina,* and *A. villosa* had few or no flowers produced under short-day conditions. Six species had significantly more flowers when grown in long days (*A. batizocoi, A. chacoense, A. cardenasii, A. correntina, A. villosa,* and C_2), three collections had no flowering response to daylength (*A. monticola, A. stenosperma,* and C_2), and three had a de-

Table 1. Response of *Arachis* species to short and long photoperiods.

Species/ cultivar	Habit*	Day-length**	Avg no. per plant Flowers	Pegs	Pegs/ flower	Days to first Flower	Peg	Avg main stem height (cm)	Avg lateral length (cm)	Avg plant weight (g)
A. batizocoi	A	L	237	121	0.51	25	35	94	120	14
		S	183	126	0.69	28	32	107	128	23
A. duranensis	A	L	228	120	0.52	22	27	47	118	19
		S	334	302	0.90	21	26	33	108	22
A. spegazzinii	A	L	104	72	0.69	21	27	135	123	15
		S	160	138	0.86	20	25	132	115	17
A. cardenasii	P	L	304	1	0.00	28	70	20	120	14
		S	103	3	0.02	38	60	9	100	15
A. chacoense	P	L	107	0	0.00	34	--	45	48	10
		S	7	0	0.00	40	--	22	33	8
A. correntina	P	L	284	0	0.00	30	50	32	70	11
		S	0	0	0.00	--	--	11	20	4
A. stenosperma	P	L	106	4	0.04	27	33	70	104	23
		S	98	60	0.61	26	29	51	104	16
A. villosa	P	L	96	15	0.15	33	39	77	96	9
		S	3	1	0.25	65	70	21	30	4
A. monticola	A	L	215	50	0.23	25	40	83	98	32
		S	217	164	0.75	24	28	60	81	25
A_2 (valencia)	A	L	309	92	0.29	24	29	57	65	62
		S	261	167	0.64	24	28	51	71	54
B_1 (virginia)	A	L	176	60	0.33	25	31	49	54	77
		S	288	114	0.80	25	28	45	53	72
C_2 (spanish)	A	L	397	133	0.33	24	28	62	63	98
		S	279	141	0.50	21	27	50	46	69
LSD (.05)			35	50	0.13	11	11	14	15	13
LSD (.01)			50	71	0.19	16	15	19	21	18

*A = annual, P = perennial.

**L = long day, S = short day.

crease in the number of flowers (*A. duranensis, A. spegazzinii*, and B_1) when grown under long versus short days. In most species the average flower production per day increased until a leveling-off occurred at about 45 to 50 days, at which time the number of flowers per day remained constant. However, *A. chacoense* and *A. cardenasii* continued to produce more flowers per day during successive weeks throughout the experiment. Under short-day conditions the rate of flowering for five species (*A. batizocoi, A. cardenasii, A. spegazzinii, A. stenosperma,* and *A. monticola*) was initially less than in long days, but at approximately day 50 the rate of flowering in short days increased over the rate in long-day conditions. Differences were not observed in the rate of flowering in short or long days for *A. duranensis*. Among the species analyzed, most are similar in flowering responses to the cultivars belonging to subspecies *fastigiata* (A_2 and C_2); and only the species *A. duranensis* and *A. spegazzinii* had similar flowering responses to a subspecies *hypogaea* genotype (B_1). Three patterns of responses to daylength were: (1) more flowers are produced in long-day treatments than in short-day treatments, (2) equal numbers of flowers are produced in long and short days, and (3) flowering is greater in short days than in long-day treatments (Table 1).

As an estimate of reproductive efficiency, the total number of pegs per plant was counted daily for 50 days and subsequently at 10-day intervals. Pegs were observed for all genotypes grown under long-day conditions except for species *A. chacoense* and for all species grown under short-days except *A. chacoense* and *A. correntina*. The first pegs observed on a plant were usually produced 4 to 6 days after the first flower (Table 1). Exceptions existed in long-day treatments for *A. batizocoi, A. cardenasii, A. correntina,* and *A. monticola*, where pegging was delayed for 10 to 20 days. Short-day treatments also delayed pegging for the species *A. cardenasii* and *A. stenosperma* (Table 1). A correlation between the total number of flowers and pegs does not exist among species for long or short days.

Both annual and perennial species were evaluated in this test. The annuals of section *Arachis (A. batizocoi, A. monticola, A. hypogaea, A. duranensis,* and *A. spegazzinii)* produced significantly more pegs than the perennial species. Peg production for the perennial species *A. cardenasii, A. chacoense,* and *A. correntina* was less than five per plant during both long and short days. Greater numbers of pegs were observed for the perennial species *A. villosa* and *A. stenosperma*, which averaged 15 and 60 pegs during long and short days, respectively. Typical illustrations shown in Fig. 2 include four patterns of responses to daylength which were: (1) numerous flowers were produced in long but not in short days and plants did not produce pegs, (2) numerous flowers were produced in long and short days but no pegs were produced, (3) numerous flowers and pegs were produced in both daylengths, and (4) numerous flowers were produced in both long and short days but more pegs were produced in short days (Fig. 2).

When the number of pegs per flower was calculated, a trend for greater peg production under short-day conditions was observed for all collections (Table 1). Similar results were observed by Emery *et al.* (3) and Wynne

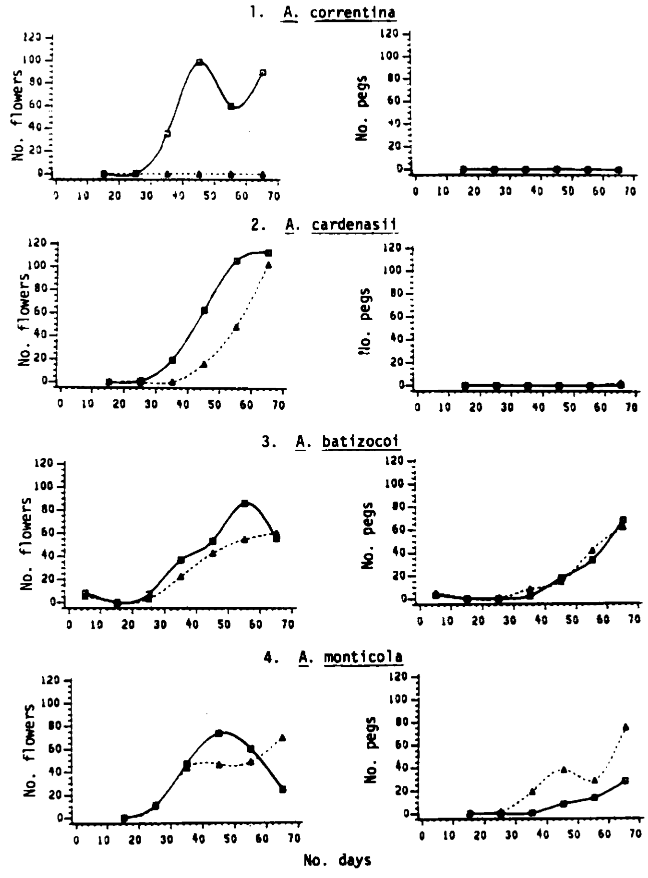

Fig. 2. Representative flowering and pegging patterns of *Arachis* species where plants (1) flower in long days, but no pegs are produced in long or short days; (2) flower in both long and short days, but no pegs are produced; (3) flower and peg in both long and short days and (4) flower in both long and short days, but peg better in short days (— long days; - - - short days).

et al. (11) for varieties of *A. hypogaea*. In their native habitat, short days had apparently promoted pegging and fruiting.

The results in this investigation of pegging compare favorably to field tests where the species have been grown for seed increases. In North Carolina, the annual species *A. batizocoi, A. duranensis, A. monticola,* and *A. spegazzinii* produce numerous seeds while the perennials *A. cardenasii, A. chacoense, A. stenosperma,* and *A. villosa* are more difficult to maintain through seed production. Photoperiodic responses are probably not totally responsible for the observed variation because the annual species had more pegs per plant than perennial ones during both long and short days. Greater seed production on annual versus perennial plants is generally observed, in large part, because of natural selection for immediate reproduction. However, when seeds are difficult to obtain, daylength can apparently be manipulated to increase pegging for at least some species, such as *A. stenosperma, A. villosa,* and *A. cardenasii.*

The results of this investigation may also have implications for interpreting reciprocal cross differences in interspecific hybridization programs. Although most section *Arachis* species will hybridize (5), the frequency of successful reciprocal hybrids can vary greatly. For example, in a recent hybridization program when *A. corren-*

tina x *A. batizocoi* were crossed, no hybrids were produced after 228 pollinations; but the cross *A. batizocoi* x *A. correntina* had a 25.3% success rate. Similar results were obtained when *A. batizocoi* was crossed with *A. stenosperma, A. chacoense,* or *A. cardenasii.* Artificial manipulation of photoperiod or making crosses during months when pegging conditions are ideal could possibly increase the rate of successful hybridization.

Several of the species analyzed had very few or no flowers under short-day conditions, including *A. chacoense, A. correntina,* and *A. villosa.* If genes conditioning failure of flowering in short days were transferred from wild species to *A. hypogaea,* then in some environments cultivated peanuts could produce most of their fruit during a limited time span and thus act like a determinant plant in response to photoperiod. This could be useful for developing plant types which produce a crop with uniform maturity. The overall quality of the crop should also improve if a uniform product is obtained. However, determinate plant types may be more susceptible to environmental stresses, and the trait may be undesirable where adequate water and pest controls are not available.

In an indeterminate plant such as peanuts many more flowers are produced than pegs. Increasing yields of cultivated peanuts would appear to be more dependent on inducing peg formation than stimulating flowering. Several species of *Arachis* had very high peg/flower ratios, and genes conditioning greater number of pegs per plant could possibly be introgressed from the wile to cultivated species.

Literature Cited

1. Cox, F. R. 1978. Effect of quality of light on the early growth and development of the peanut. Peanut Sci. 5:27-30.
2. Downs, R. J., and V. P. Bonaminio. 1976. Phytotron procedural manual for controlled research at the Southeastern Plant Environmental Laboratories. North Carolina Exp. Stn. Tech. Bull. 244.
3. Emery, D. A., M.E . Sherman, and J. W. Vickers. 1981. The reproductive efficiency of cultivated peanuts. IV. The influence of photoperiod on the flowering, pegging, and fruiting of spanish-type peanuts. Agron. J. 73:619-623.
4. Fortanier, E. J. 1957. Control of flowering in *Arachis hypogaea* L. Mededel. Landgouwhogesch. Wageningen 57:1-116.
5. Gregroy, M. P., and W. C. Gregry. 1979. Exotic germ plasm of *Arachis* L. interspecific hybrids. J. Heredity 70:185-193.
6. Gupton, C. L., D. A. Emery, and J. A. Benson. 1968. Reproductive efficiency of virginia type peanuts. III. Relating the time of peg placement to the branching pattern of the plant. Oleagineux 23:247-250.
7. Ketring, D. L. 1979. Light effects on development of an indeterminate plant. Plant Physiol. 64:665-667.
8. Smith, B. W. 1954. *Arachis hypogaea.* Reproductive efficiency. Amer. J. Bot. 41:607-616.
9. Umen, D. P. 1933. Biology of peanut flowering. Lenin. Acad. Agr. Sci., Inst. Sci. Res. Oil Cult. Krasnudar. No. 6, pp. 1-57 (cited from Pl. Br. Abstr. 5:60).
10. Wynne, J. C., and D. A. Emery. 1974. Response of intersubspecific peanut hybrids to photoperiod. Crop Sci. 14:878-880.
11. Wynne, J. C., D. A. Emery, and R. J. Downs. 1973. Photoperiodic response of peanuts. Crop Sci. 13:511-514.

Accepted June 16, 1983