Field Crops Research, 12 (1985) 347—361
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

YIELD, COMPONENTS OF YIELD AND QUALITY RESPONSES OF GROUNDNUT CULTIVARS (*ARACHIS HYPOGAEA* L.) AS INFLUENCED BY PHOTOPERIOD AND A GROWTH REGULATOR

A. WITZENBERGER[1], J.H. WILLIAMS[2] and F. LENZ[1]

[1] *Institut für Obstbau und Gemüsebau, Universität Bonn, Auf dem Hügel, Bonn (Fedral Republic of Germany)*
[2] *International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, P.O., Andhra Pradesh 502324 (India)*

ICRISAT Journal Paper No. 395

(Accepted 24 April 1985)

ABSTRACT

Witzenberger, A., Williams, J.H. and Lenz, F., 1985. Yield, components of yield and quality responses of groundnut cultivars (*Arachis hypogaea* L.) as influenced by photoperiod and a growth regulator. *Field Crops Res.*, 12: 347—361.

In a field experiment conducted during the winter/spring (post-rainy irrigated season) of 1982/83 at ICRISAT (Hyderabad, India) six cultivars of groundnuts representing the two subspecies of *Arachis hypogaea* L. were investigated for their responses to photoperiod and a growth regulator, Kylar (succinic acid 2,2-dimethylhydrazide = SADH). The short-day treatment was the normal winter/spring day at Hyderabad (latitude 17° N). Long-day conditions were achieved by extending the days to 22.00 h. Kylar was applied at the rate of 1 kg/ha a.i. at early pod-set.

Cultivar variability for photoperiod responses was found in both subspecies for pod yield. While four cultivars achieved greater pod yields (38—106%) under short-day conditions, TMV-2 and Robut 33-1 had slightly increased yield in long days. Kylar decreased the differences in yield created by the two daylengths.

Change in the proportion of large (> 19/64 × 3/4"; > 7.5 × 19 mm) seeds was the main factor responsible for the yield differences resulting from the photoperiodic treatments. The Kylar-treated plants produced more large kernels.

Generally, the shelling percentages were increased by the Kylar short-day treatments. Only TMV-2 had a significantly increased shelling percentage under long-day conditions.

At final harvest all cultivars, except for TMV-2, had accumulated higher levels of vegetative dry matter in the long-day treatment. Kylar, again excepting TMV-2, increased vegetative weights/m^2 at final harvests in both photoperiods.

INTRODUCTION

Early research on the responses of groundnuts (*Arachis hypogaea* L.) to photoperiod indicated that there were negligible effects within the cultivar investigated (Fortanier, 1957). More recent research by Wynne et al. (1973),

0378-4290/85/$03.30

Wynne and Emery (1974) and Ketring (1979) with potted plants in phytotrons has shown that while the phenological development was not greatly influenced by photoperiod, the reproductive process was, and that large differences in flower efficiency and yield depended on exposure to short days (SD) or long days (LD). In a series of experiments by Emery et al. (1981) the phase of growth most sensitive to photoperiodic influence was determined to be from 36 to 72 days after seedling emergence.

Few statistically unconfounded field studies have been conducted on photoperiod responses of groundnuts because of the difficulties of manipulasting daylength (DL) on a field scale. Former field experiments (see, for example, Tetenyi, 1957) were carried out in natural LD, whereby SD conditions were achieved by covering the plants; a treatment likely to result in simultaneous changes in temperature and humidity. These factors are known to influence the reproductive development of groundnuts (Bolhuis and De Groot, 1959; De Beer, 1963; Wood, 1968; Lee et al., 1972).

For practical purposes the breeder in a region usually has a fixed pattern of photoperiods to work with and is only concerned about the relative performance of his material within that one environment. However, with the establishment of a crop improvement program with international responsibilities at ICRISAT, the implications of possible photoperiodic effects assumed major importance.

At ICRISAT (lat. 17°N) the temperatures are just high enough to grow a winter/spring crop in the shortest DL possible for commercial groundnut production. This photoperiod could be readily extended to provide a DL comparable to the DL at the highest latitudes (± 45°) in which the crop is grown, without the confounding effects of temperature. This approach has been used for other crops of tropical origin, such as maize (Francis et al., 1970).

Since Wynne et al. (1973) and Emery et al. (1981) found stimulated vegetative growth under LD, and N'Diaye (1980) reported that the use of SADH (Kylar) could increase the yields of low yield potential groundnut cultivars by influencing growth distribution, it was thought worthwhile to investigate the effects of this growth inhibitor on any photoperiodic response that might be detected.

The effects of LD or SD and a growth regulator on the growth and development of six cultivars was studied by growth analysis techniques in the winter/spring of 1982/83. This paper describes the yield and quality response of these cvs. to two daylengths and growth regulator application.

MATERIALS AND METHODS

The experiment was located on a medium deep Alfisol following pearl millet (*Pennisetum americanum* (L.) Leeke) in the crop rotation. Prior to fertilizer application the field was chisel-ploughed and after distribution of a basal fertilizer dose of 100 kg/ha diammonium phosphate, it was disced and

TABLE 1

Meteorological data for ICRISAT, Hyderabad, December 1982 to April 1983

	Dec. 1982	Jan. 1983	Feb. 1983	Mar. 1983	Apr. 1983
Max. temp. (°C)	28.2	28.8	32.3	36.5	38.5
Min. temp. (°C)	13.2	13.1	17.0	19.0	23.0
R.H. (07.17 h)	92.2	85.8	75.1	61.1	56.7
R.H. (14.17 h)	40.3	33.4	26.6	22.5	22.1
Wind (km/h)	6.4	6.6	8.3	8.2	9.8
Sunshine (h)	9.4	10.0	10.1	10.3	10.4
Solar radiation (MJ m^2)/day	16.5	18.7	20.8	22.5	24.2
Rainfall (mm)[a]	0.0	0.0	0.0	12.5	0.0
Evaporation (mm)[a]	149.2	169.9	210.5	303.9	374.1
Mean duration of daylight (h)	11.1	11.2	11.4	12.0	12.3
Mean photoinductive daylength (h)[b]	11.4	11.4	12.0	12.3	12.6

[a]Rainfall and evaporation data are totals, not means.
[b]Calculation for photoinductive daylengths has been done as described by Francis (1970).

harrowed. To insure an adequate supply of calcium during pod enlargement, gypsum (67.2% $CaSO_4$) was applied at a rate of 500 kg/ha alongside the rows 81 days after sowing (DAS).

The experiment was hand-sown on 6 December 1982. The treatments were arranged in a split-plot design with three replications, DL treatments forming the main plots and factorial combinations of Kylar* × cv. treatments as subplots. Subplots were 4.5 × 9.0 m arranged in three 1.5-m wide beds. In every bed four rows of groundnuts were sown with 30 cm between rows and 10 cm between plants in the row.

After sowing, 4 l/ha Alachlor (Lasso*) was applied. Further weed control was done by hand as necessary. Intensive insect pest control and irrigation were provided as needed to insure that pests and soil moisture were not limiting factors during the growing season.

Daylength was varied to provide one SD and one LD treatment. The SD was the normal winter/spring day at Hyderabad which varied by about 1.5 h during the crop season (Table 1). Long-day conditions were achieved by extending the days to 22.00 h using 100 W incandescent lamps, suspended 1.5 m above the crop at 4 × 4.5 m intervals. The light intensity generated by the lamps was measured with a Licor* photometer (Model, LI-185 B) and varied in the following manner: directly under a lamp, 100—110 lx; between two lamps in a row, 50—60 lx; between two lamps of adjacent power lines, 37—39 lx; in the centre of four lamps, 30—33 lx.

*Use of a trade name does not constitute endorsement by ICRISAT and does not imply its approval to the exclusion of other products that also may be suitable.

TABLE 2

Classification and origin of cultivars investigated for photoperiodic response

Cultivar	Origin	Classification
Robut 33-1	India	*A. hypogaea* subsp. *hypogaea* var. *hypogaea* (Virginia bunch)
S 7-2-13	Sudan	*A. hypogaea* subsp. *hypogaea* var. *hypogaea* (Virginia bunch)
M-13	India	*A. hypogaea* subsp. *hypogaea* var. *hypogaea* (Virginia runner)
TMV-2	India	*A. hypogaea* subsp. *fastigiata* var. *vulgaris* (Spanish bunch)
Krapovickas St. 16	Argentina	*A. hypogaea* subsp. *fastigiata* var. *fastigiata* (Valencia)
NCAc 17090	Peru	*A. hypogaea* subsp. *fastigiata* var. *fastigiata* (Valencia)

The LD treatment was started on 17 January 1983, at the beginning of flowering.

Previous investigations at ICRISAT (unpublished data) have shown that an incandescent light intensity of about 20 lx was sufficient to induce a photoperiodic response in groundnuts.

On 23 February 1983 (79 DAS), at early pod-set, Kylar was applied at a rate of 1 kg/ha a.i. with hand sprayers. The six groundnut cultivars used in the experiment are listed in Table 2.

At final harvest an experimental area of 1.5 × 8.0 m for each subplot was dug by hand, the number of plants recorded and the pods removed. All detached mature pods were also collected. After 3 days of drying in the sun the total vegetative plant weight was recorded, and a subsample of 20 plants selected at random. From these, the total pod weight was measured and a

TABLE 3

Grading screen used for the separation of the kernels

Classes	Screen sizes (inches)[a]
I	< 15/64 × 3/4 (6.0 × 19)
II	> 15/64 × 3/4 (6.0 × 19)
III	> 16/64 × 3/4 (6.4 × 19)
IV	> 17/64 × 3/4 (6.7 × 19)
V	> 18/64 × 3/4 (7.1 × 19)
VI	> 19/64 × 3/4 (7.5 × 19)
VII	> 20/64 × 3/4 (7.9 × 19)

Figures in parentheses are sizes in mm.

subsample of 1 kg of pods was taken. All subsamples were weighed, dried to constant weight at 105°C and the dry weights recorded. The pods were then counted. After shelling by hand the kernels were weighed, separated into seven classes of kernel sizes (Table 3), and the kernels of each class were weighed and counted with an electronic seed counter.

The data were analysed according to standard statistical methods and the results expressed on a unit area basis.

RESULTS

The meteorological data for the crop season are presented in Table 1. The effective photoinductive DL (20 lx) was calculated using the values for civil twilight as described by Francis (1970).

TABLE 4

Mean pod weights (g/m^2) for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	230.3	287.3	258.8	270.6
	LD	264.2	300.4	282.3	
S 7-2-13	SD	190.6	229.8	210.2	180.5
	LD	118.4	183.1	150.8	
M-13	SD	202.7	138.5	170.6	143.8
	LD	98.4	135.6	117.0	
TMV-2	SD	245.4	221.2	233.3	242.3
	LD	269.8	232.8	251.3	
Krapovickas St. 16	SD	204.4	221.6	213.0	191.9
	LD	148.5	192.9	170.7	
NCAc 17090	SD	297.7	277.7	287.7	247.7
	LD	207.2	208.2	207.7	
S.E.		±27.72		±18.85	±14.37
(DL × Kylar)					
Mean	SD	228.5	229.4	228.9	
	LD	184.4	208.8	196.6	
S.E.		±8.95		±3.35	
Kylar					
Mean		206.5	219.1		
S.E.		±8.30			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

Reproductive characters

Pod dry weight/m^2, pod number/m^2, kernel dry weight/m^2 and kernel number/m^2 were significantly influenced by the DL treatments. Higher values for these characters occurred under SD conditions. Significant differences also occurred between the cultivars.

In the short photoperiod the cvs. S 7-2-13, M-13, Krapovickas St. 16 and NCAc 17090 produced pod dry weights/m^2 which were 61, 106, 38 and 44% greater than the respective LD values. In terms of absolute values these differences were 72.2, 104.3, 55.9, 90.5 g/m^2, respectively (Table 4). However, in each subspecies one cultivar (Robut 33-1 (subsp. *hypogaea*) and TMV- 2 (subsp. *fastigiata*)) showed a slight (non-significant) increase in pod weight/m^2 under LD conditions.

The Kylar application did not change the qualitative response to photo-

TABLE 5

Mean kernel weights (g/m^2) for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	156.8	201.4	179.1	184.8
	LD	174.0	207.0	190.5	
S 7-2-13	SD	121.7	150.4	136.1	116.3
	LD	71.5	121.3	96.4	
M-13	SD	111.1	78.2	94.7	75.3
	LD	42.5	69.5	56.0	
TMV-2	SD	159.9	144.2	152.0	165.2
	LD	192.5	164.3	178.4	
Krapovickas St. 16	SD	98.8	112.3	105.6	93.1
	LD	68.2	93.0	80.6	
NCAc 17090	SD	168.6	164.0	166.3	141.4
	LD	114.8	118.4	116.6	
S.E.		±19.31		±13.16	±9.99
(DL × Kylar)					
Mean	SD	136.2	141.7	139.0	
	LD	110.6	128.9	119.8	
S.E.		±6.34		±2.62	
Kylar					
Mean		123.4	135.3		
S.E.		±5.76			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

period, since all those cultivars in which the pod yield was varied by photoperiod still responded to photoperiod when Kylar was applied, but the photoperiod response was decreased relative to that of the no-Kylar treatments. The Kylar effect was greatest in the LD treatment but this effect was not statistically significant.

The kernel yields were also influenced by the treatments (Table 5), but in the SD treatments the four photosensitive cultivars had more increase in kernel yield than was observed in pod (70, 160, 45, 47% for cvs. S 7-2-13, M-13, Krapovickas St. 16 and NCAc 17090, respectively).

The pod number/m^2 and kernel number/m^2 were influenced in the same manner as the pod and kernel weights. Data on pod numbers are provided in Table 6, the kernel numbers/m^2 are presented, with the quality data, in Table 7.

TABLE 6

Mean pod numbers (number/m^2) for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	281.2	341.5	311.3	327.8
	LD	340.0	348.6	344.3	
S 7-2-13	SD	248.3	286.5	267.4	220.6
	LD	127.8	220.0	173.9	
M-13	SD	172.7	145.1	158.9	144.4
	LD	124.2	135.7	130.0	
TMV-2	SD	358.2	330.7	344.5	351.2
	LD	389.8	325.9	357.8	
Krapovickas St. 16	SD	159.5	197.6	178.5	167.1
	LD	129.7	181.5	155.6	
NCAc 17090	SD	320.4	252.0	286.2	251.1
	LD	207.4	224.7	216.1	
S.E.		±33.64		±22.87	±17.45
(DL × Kylar)					
Mean	SD	256.7	258.9	257.8	
	LD	219.8	239.4	229.6	
S.E.		±10.82		±3.95	
Kylar					
Mean		283.3	249.1		
S.E.		±10.07			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

TABLE 7

Kernel size distribution (number/m^2) for six cultivars of groundnuts as influenced by daylength and growth regulator treatments

Kernel-size	Day-length	Without growth regulator						With growth regulator					
		Cultivar[a]						Cultivar[a]					
		1	2	3	4	5	6	1	2	3	4	5	6
A. Class I + II	SD	138	118	106	208	198	253	106	191	76	271	222	166
	LD	102	95	55	203	144	166	130	139	90	193	178	165
B. Class III + IV + V	SD	114	122	95	220	70	179	119	142	69	210	98	146
	LD	128	71	32	273	55	151	114	123	56	231	80	157
C. Class VI + VII	SD	159	102	58	113	34	100	244	124	51	90	27	135
	LD	198	52	20	133	18	47	253	110	40	122	28	43
Class VII	SD	107	61	35	41	18	46	178	75	29	30	10	69
	LD	129	27	12	40	7	10	187	58	29	41	13	11
Total No. of kernels	SD	410	342	259	541	302	532	469	457	196	571	347	447
	LD	428	218	107	609	218	364	497	372	186	546	286	365

Standard errors

Effects	Influenced characters				
	Class I + II	Class III + IV + V	Class VI + VII	Class VII	Total No. of kernels
DL	14.8	8.6	3.9	1.8	5.3
K	7.4	6.0	5.7	3.7	14.2
Cv.	12.9	10.4	9.9	6.4	24.5
DL × K	16.5	10.5	6.9	4.2	14.6
DL × Cv.	22.2	16.0	13.4	8.5	32.0
K × cv.	18.2	14.8	14.0	9.1	34.7
DL × K × cv.	28.8	21.8	19.4	12.5	47.2

A = Small, shrivelled and damaged kernels; B = medium size kernels; C = large and extra large kernels.
[a]Cvs. 1—6 = Robut 33-1, S 7-2-13, M-13, TMV-2, Krapovickas St. 16, NCAc 17090, respectively.

Quality effects

All the treatments had statistically significant effects on kernel quality (Table 7). Major differences occurred in the kernel size distribution between the *hypogaea* and *fastigiata* subspecies, with the former having most kernels in the largest kernel fraction (> 20/64 × 3/4"; > 7.9 × 19 mm) while the bulk of seeds from the *fastigiata* group was smaller.

Generally this distribution pattern was not altered by the DL and Kylar treatment, except in cv. NCAc 17090, where an interaction between DL and Kylar occurred. When Kylar was applied to this cultivar under SD conditions, relatively more kernels were in the largest size group (> 20/64 × 3/4"; > 7.9 × 19 mm), while under LD with Kylar a greater proportion of the kernels was very much smaller (> 17/64 × 3/4"; > 6.7 × 19 mm). Without Kylar there were no comparable responses to DL.

Both DL and Kylar did not have any effect on the number of small, shrivelled or damaged kernels (Classes I + II), but these varied with cultivar.

In medium-sized kernels (Classes III + IV + V) a significant DL × cv. interaction was found only in Class IV. Expressed as a percentage of the total number of kernels/m², cultivars of the subsp. *hypogaea* tended to have a higher percentage of medium-sized kernels in SD, while the *fastigiata* cultivars produced more kernels of this category under LD conditions. Kylar did not change this tendency.

The strongest responses to DL and Kylar treatments were obtained in the economically most interesting large-kernel fraction (Classes VI + VII). The DL × cv. interaction in Class VI and Kylar × cv. interactions in Class VI were statistically significant ($P \geqslant 0.5$), revealing variability in response to these treatments amongst the cultivars. The responses of the cvs. to daylength was similar to those reported for the pod and kernel yield. Kylar increased the number of large kernels for the cvs. Robut 33-1, S 7-2-13, M-13 and NCAc 17090, and decreased it for cvs. TMV-2 and Krapovickas St. 16.

TABLE 8

Mean shelling percentages for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	67.5	70.2	68.8	68.3
	LD	66.5	68.9	67.7	
S 7-2-13	SD	63.1	65.5	64.3	63.6
	LD	59.9	66.0	63.0	
M-13	SD	53.9	56.3	55.1	49.7
	LD	39.4	49.2	44.3	
TMV-2	SD	64.8	65.2	65.0	67.9
	LD	71.3	70.4	70.9	
Krapovickas St. 16	SD	46.2	50.2	48.2	47.7
	LD	46.0	48.5	47.3	
NCAc 17090	SD	56.3	59.1	57.7	56.7
	LD	55.1	56.2	55.7	
S.E.		±2.63		±1.78	±1.36
(DL × Kylar) Mean	SD	58.6	61.1	59.9	
	LD	56.4	59.9	58.1	
		±0.83		±0.28	
Kylar Mean		57.5	60.5		
S.E.		±0.79			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

The shelling percentage (Table 8) was generally increased under SD conditions but only for the cv. M-13 was the difference significant. The shelling percentage for cv. TMV-2 was significantly higher in the long photoperiod, which resulted in a significant DL × cv. interaction. Kylar did improve the shelling percentage in all cultivars.

Vegetative weight and total biomass

Statistically significant differences in the vegetative dry weight/m^2 resulted from all three treatments (Table 9). The Virginia and Valencia type groundnuts produced similar vegetative weights, but the Spanish bunch cv. TMV-2 produced less than the others.

Plants exposed to LD accumulated more vegetative dry matter/m^2 than plants in SD. Only cv. TMV-2 had the same vegetative dry weight/m^2 in the

TABLE 9

Mean vegetative weights (g/m^2) for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	379.4	450.7	415.0	448.7
	LD	477.3	487.3	482.3	
S 7-2-13	SD	426.9	510.3	468.6	498.3
	LD	502.4	533.5	528.0	
M-13	SD	431.0	389.4	410.2	469.6
	LD	557.0	500.8	528.9	
TMV-2	SD	293.4	334.4	313.9	312.8
	LD	288.4	334.9	311.6	
Krapovickas St. 16	SD	375.2	445.2	410.2	432.8
	LD	436.2	474.4	455.3	
NCAc 17090	SD	404.5	447.2	425.9	474.8
	LD	470.9	576.5	523.7	
S.E.		±41.05		±28.10	±21.17
(DL × Kylar)					
Mean	SD	385.1	429.5	407.3	
	LD	455.4	487.9	471.6	
S.E.		±13.85		±6.53	
Kylar					
Mean		420.2	458.7		
S.E.		±12.22			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

two photoperiod environments, both with and without Kylar. Although Kylar is known to decrease the vegetative growth of groundnuts, it increased the vegetative weight/m^2 (except for cv. M-13) at final harvest. The leaves of the plants in Kylar-treated plots were still dark green, whereas the canopy in untreated plots showed a yellow-brownish colour and defoliation had already started.

The energy content of the pods was adjusted by using the method of Duncan et al. (1978) before computing total biomass at final harvest (Table 10). DL and Kylar did not significantly influence total biomass accumulation but cultivars did accumulate different amounts of biomass.

An estimation of the biological efficiency is provided by the ratio of kernel to plant top weight (Table 11). A significant DL × cv. interaction for this parameter indicated that the cultivars did not perform consistently in different daylengths. While for most cvs. this ratio was increased in the SD,

TABLE 10

Mean total biomass (g/m^2) after energy adjustment (pod weight × 1.65) for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	759	925	842	895
	LD	913	983	948	
S 7-2-13	SD	741	889	815	796
	LD	698	856	777	
M-13	SD	765	618	692	707
	LD	719	724	722	
TMV-2	SD	698	699	699	713
	LD	734	719	726	
Krapovickas St. 16	SD	713	811	762	749
	LD	681	793	737	
NCAc 17090	SD	896	905	901	883
	LD	813	920	866	
S.E.		±74.2		±50.7	±38.3
(DL × Kylar)					
Mean	SD	762	808	785	
	LD	760	832	796	
S.E.		±24.9		±11.4	
Kylar					
Mean		761	820		
S.E.		±22.1			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

TABLE 11

Kernel/plant top weight ratios for six cultivars of groundnuts as influenced by daylength and Kylar treatments

Cultivar	Day-length	Kylar		(DL × cv.) mean	Cultivar mean
		Without	With		
Robut 33-1	SD	0.43	0.46	0.44	0.42
	LD	0.37	0.42	0.39	
S 7-2-13	SD	0.28	0.30	0.29	0.24
	LD	0.15	0.22	0.18	
M-13	SD	0.26	0.21	0.23	0.17
	LD	0.08	0.13	0.10	
TMV-2	SD	0.54	0.43	0.49	0.54
	LD	0.68	0.50	0.59	
Krapovickas St. 16	SD	0.26	0.25	0.26	0.22
	LD	0.16	0.20	0.18	
NCAc 17090	SD	0.43	0.37	0.40	0.31
	LD	0.24	0.20	0.22	
S.E.		±0.048		±0.033	±0.025
(DL × Kylar)					
Mean	SD	0.37	0.34	0.35	
	LD	0.28	0.28	0.28	
S.E.		±0.015		±0.005	
Kylar					
Mean		0.32	0.31		
S.E.		±0.014			

44 d.f. for the body of the Table.
SD = short day; LD = long day; DL = daylength; cv. = cultivar.

it was decreased for the cv. TMV-2. Kylar decreased the differences between the DL treatments as observed for the reproductive parameters.

DISCUSSION

While Wynne et al. (1973), Wynne and Emery (1974), and Ketring (1979) have shown that the groundnut does have photoperiodic responses which affect reproductive efficiency and yields, they have not shown these effects to be of practical significance to the adaptation of groundnuts. The treatments involved (usually 15-h nights with or without a 3-h interruption) do not occur naturally within the geographical limits of groundnut production. Attempts to examine the effect of photoperiod in field conditions have been made, for example by Tetenyi (1957), but these treatments have relied on shortening the day by covering the crop with opaque covers without controlling the temperature or humidity under the covers. These treatments could well have confounded the results obtained by invoking decreased flower efficiencies, particularly if temperatures rose above those necessary to interfere with pollen viability (De Beer, 1963).

This experiment varied DL within the full range possible for commercial groundnut production, and the strong effects of these treatments on yield show clearly that photoperiod plays an important role in determining yields and also that some cultivars are relatively insensitive to this effect.

The results achieved in this experiment differ considerably in magnitude to those reported from the phytotron studies at North Carolina State University (Wynne et al., 1973; Wynne and Emery, 1974; Emery et al., 1981) where the interrupted night treatments resulted in many-fold decreases in yield. Here the largest decrease in yield in response to LD occurred in the cv. M-13 while in cvs. TMV-2 and Robut 33-l yield was not influenced by the photoperiod. Although the same cultivars as used by Wynne et al. (1973), Wynne and Emery (1974), and Ketring (1979) have not been studied here, differences in magnitude of photoperiodic effects are large enough to suggest that the extent of the photoperiodic response may also be varied by the duration of day or night. This possibility is being investigated to establish a fuller understanding of the responses of groundnut to photoperiod.

The implications of the photoperiod × cv. interaction to the adaptability of cultivars across regions is obvious. Those lines which are photoperiod "insensitive" should be more likely to be adapted over a wider range of latitudes than those that are not. Conversely, material selected at ICRISAT for high yield will have unpredictable performances when moved into regions with greater DL. There is an obvious need to include photoperiodic responses in the information gathered to characterize germplasm and cultivars.

Vegetative growth was also influenced in most cultivars by the photoperiod treatments. All cvs. examined, except for TMV-2, had greater vegetative dry matter accumulation in LD. This result is also consistent with the responses observed in the phytotron (Wynne et al., 1973; Wynne and Emery, 1974; Ketring, 1979; Emery et al., 1981) but, as for yield, the magnitude of the effects were smaller in this field experiment.

Kylar is used in groundnut cultivation to decrease stem growth and under some circumstances has resulted in increased yield (Bockelee-Morvan and Gillier, 1973; Brown and Ethredge, 1974; Daughtry et al., 1975). However, these yield increases have often been inconsistent across years. In this experiment Kylar was applied to see if it would reverse the anticipated effects of LD by limiting stem growth. Although yield was not significantly increased by Kylar treatments it did have a consistent effect of partially counteracting the effects of LD on pod yields. Kylar also had a large effect on the accumulated vegetative dry matter, since it was observed that, although Kylar decreased stem elongation, Kylar-treated plants retained most of their leaves while untreated plants did not. This differential defoliation was not apparent in M-13, a later maturing cultivar.

The cultivar and subspecies influences on kernel size distribution are not unexpected. The different yields in response to daylength noted and discussed earlier were mainly due to changes in number and proportion of large kernels.

Although the differences in quality cannot be manipulated by photoperiod directly for commercial purposes, it is important that breeders consider both the quality and yield aspects of cultivars introduced from other photoperiodic environments. However, it seems that if there are sufficient other reasons (for example the production of two crops within a year as in India and China) to use cultivars which are not specifically adapted to the photoperiod regime, agronomic investigation of the use of growth regulators to counter these difficulties seems justified.

ACKNOWLEDGEMENTS

This investigation was made possible by a contribution from the International Agricultural Research Funds of GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit). Furthermore, we should like to express thanks to the Heinrich Hertz Stiftung (Foundation), Düsseldorf, and the Fritz ter mer Stiftung (Foundation), Leverkusen, for their additional financial support of this study.

REFERENCES

Bockelee-Morvan, A. and Gillier, P., 1973. Action d'un regulateur de croissance sur l'arachide au Senegal. Oleagineux, 28 (10): 457—460.

Bolhuis, G.G. and De Groot, W., 1959. Observations on the effect of varying temperatures on the flowering and fruit set in three varieties of groundnut. Neth. J. Agric. Sci., 7: 317—326.

Brown, R.H. and Ethredge, W.J., 1974. Effects of succinic acid 2,2-dimethylhydrazide on yield and other characteristics of peanut cultivars. Peanut Sci., 1(1): 20—23.

Daughtry, C.S., Brown, R.H. and Ethredge, W.J., 1975. Effect of time of application of succinic acid 2,2-dimethylhydrazide on yields and associated characters of peanuts. Peanut Sci., 2(2): 83—86.

De Beer, J.F., 1963. Influences of temperature on *Arachis hypogaea* L. with special reference to its pollen viability. Versl. Landbouwkd. Onderz. Nr. 69.2, Wageningen, 81 pp.

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

Emery, D.A., Sherman, M.E. and Vickers, J.W., 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.

Fortanier, E.J., 1957. Control of flowering in *Arachis hypogaea* L. Meded. Landbouwhogesch. Wageningen, 57(2): 1—116.

Francis, C.A., 1970. Effective day lengths for the study of photoperiod sensitive reactions in plants. Agron. J., 62: 790—792.

Francis, C.A., Sarria, D.V., Harpstead, D.D. and Cassalett, C.D., 1970. Identification of photoperiod insensitive strains of maize (*Zea mays* L.) II. Field tests in the tropics with artificial lights. Crop Sci., 10: 465—468.

Lee, T.A., Jr., Ketring, D.L. and Powell, R.D., 1972. Flowering and growth response of peanut plants (*Arachis hypogaea* L. var. Starr) at two levels of relative humidity. Plant Physiol., 49: 190—193.

Ketring, D.L., 1979. Light effects on development of an indeterminate plant. Plant Physiol., 64: 665—667.

N'Diaye, O., 1980. Physiological aspects of peanut (*Arachis hypógaea* L.) yield as affected by diaminozide. Ph. D. Thesis, University of Florida, Gainesville, FL.

Tetenyi, P., 1957. The phases of development of the peanut. Acta Agron. Acad. Sci. Hung., 7(3): 201—216.

Wood, I.M.W., 1968. The effect of temperature at early flowering on the growth and development of peanuts (*Arachis hypogaea*). Aust. J. Agric. Res., 19: 241—251.

Wynne, J.C. and Emery, D.A., 1974. Response of intersubspecific peanut hybrids to photoperiod. Crop Sci., 14: 878—880.

Wynne, J.C., Emery, D.A. and Downs, R.J., 1973. Photoperiodic response of peanuts. Crop Sci., 13: 511—514.