Effect of Gibberellic Acid on Pegging and Seed Set of *Arachis* Species[1]

H. T. Stalker*, M. H. Seitz and P. Reece[2]

ABSTRACT

Many species of *Arachis* fail to produce seeds after self- or cross-pollination. A primary barrier to seed production is pegging for many genotypes; therefore, the effect of applying GA_3 (gibberellic acid) to flowers was investigated. Species of *Arachis* were treated with 0, 88, 176, or 352 ppm GA_3 daily for 30 days and the number of flowers and pegs recorded. The species *A. chacoense* Krap. et Greg. *nom. nud., A. villosa* Benth., *A. correntina* (Burk) Krap. et Greg. *nom. nud., A diogoi* Hoehne, *A. stenosperma* Greg. et Greg. *nom. nud.*, and *A.* sp. coll. GK 30006 had a linear response in peg formation to increased levels of GA_3. However, *A.* sp. coll. GKPSc 30108 had a quadratic response. *Arachis cardenasii* Krap. et Greg. *nom. nud.* had a cubic response to GA_3 levels. The species *A. helodes* Mart. ex. Krap. et Rig., *A.* sp. coll. GK 30008, *A.* sp. coll. GK 30011, *A.* sp. coll. GK 30017, *A. glabrata* Benth and *A. hypogaea* did not have a significant peg response to application of GA_3. Flowering was suppressed on all species by 352 ppm GA_3. Application of either 88 or 176 ppm GA_3 resulted in increased numbers of pegs for all species except *A. hypogaea, A.* sp. coll. GK 30017 and *A.* sp. coll. GK 30011. In another experiment, plants of *A. chacoense, A. cardenasii, A. villosa, A. helodes,* and *A. diogoi* were treated with 176 ppm GA_3 and pegs were allowed to mature but no seeds were recovered. A crossing program using NC 4 in reciprocal with five species resulted in a significant increase in seeds when GA_3 applications were applied, but only for hybrid combinations which are normally successful without GA_3. Parthenocarpic development is believed to account for increased numbers of pegs. Because pegging is mandatory before seeds can be obtained in *Arachis,* applications of GA_3 will add significantly toward overcoming a reproductive barrier in *Arachis.* However, application of additional growth regulators will be necessary to stimulate development of the embryo.

[1]Paper No. 10632 of the Journal Series of the North Carolina Agriculture Research Service, Raleigh, NC 27695-7601. The work was funded in part by SEA-CR grant no. 83-CRCR-1-1334 and by AID Peanut CRSP Grant DAN-4048-G-SS-2065-00.

[2]Associate Professor, former Research Associate and Graduate Assistant, Department of Crop Science, North Carolina State University, Raleigh, NC 27695.

Peanut Science (1987) 14:21-25

Key Words: Gibberellin, *Arachis hypogaea,* parthenocarpy, wild species, germplasm.

Peanut *(Arachis hypogaea* L.) is a member of the Leguminosae, tribe Aeschynomeneae. Only members of the genus plus species *Trifolium subterraneum* L. and *Vigna subterranea* (L.) Verdc. flower aerially but develop fruits underground (2). In *Arachis,* a meristem proximal to the basal ovule becomes active 2 to 3 days after fertilization and a structure, commonly called a peg, elongates geotropically. The embryo of *A. hypogaea* initially divides, but development is arrested during the time of rapid peg elongation (11). Upon soil penetration the peg ceases to elongate and swells at the tip to form a pod. The embryo then initiates a rapid growth phase and develops into a seed. Peg initiation and subsequent elongation and embryo development are influenced by photoperiod (12, 14, 15) and a physical response to soil penetration, which may be correlated to moisture (11, 13). Pod formation inhibits pod development on pegs initiated later in the growing season (10).

Wild *Arachis* species have a similar reproductive development to *A. hypogaea* except peg elongation usually continues after soil penetration (5). Pegs of many species will elongate to a length of a meter or more underground. On the other hand, many *Arachis* species rarely produce pegs when artificially propagated under greenhouse or field conditions. More than 40% of 290 species collections have never produced pegs or seeds in North Carolina. Lack of pegging is believed to be conditioned by a combination of environmental factors related to photoperiod, endogenous levels of growth regulators, and plant stresses.

Because many *Arachis* species neither produce seeds

upon selfing nor serve as female parents in hybridization programs, methods to stimulate seed production are greatly needed for germplasm maintenance and utilization. Gibberellic acid is generally accepted as conditioning fruit development and seed maturation in many plants. This growth promoter has been used experimentally to enhance embryo development in a number of species (8), but GA_3 can also inhibit ovule development as in *Nigella sativa* L. (7). Amir (1) found that gibberellic acid (GA_3)-treated pegs were significantly longer than nontreated pegs. Sastri and Moss (9) and Mallikarjuna and Sastri (6) used several growth regulators, including kinetin (Kn), 1-naphthalene-acetic acid (NAA), and GA_3 to increase the frequency of peg production and elongation and to enhance embryo development of interspecific hybrids by applying these substances to reproductive structures. Use of growth regulators thus appears to present a possible way of increasing seed production in *Arachis*. The objectives of this investigation were (a) to evaluate the effects of GA_3 on peg elongation of peanut species and (b) to determine whether GA_3 will increase the percentage of hybrid seeds after pollination in the greenhouse.

Materials and Methods

Sixteen *Arachis* accessions were grown in 10-cm pots in the greenhouse during the summer of 1985 at Raleigh, NC (Table 1). Two cuttings each of accessions GK 30005 (*A. diogoi* Hoehne), GK 30031 (*A. helodes* Mart. ex. Krap. et Rig.), GKPSc 30108 (*A.* sp.), and GKP 9634 (*A. glabrata* Benth) were placed in the 10-cm pots at the time seeds of other accessions were planted. Cultivar NC 4, *A. hypogaea* subsp. *hypogaea,* and cv. Argentine, *A. hypogaea* subsp. *fastigiata,* were used as cultivated checks. All species accessions were members of section *Arachis* except *A. glabrata,* which is a perennial taxa of section *Rhizomatosae*. A factorial arrangement of treatments was used with four replications, four GA_3 concentrations, and 16 species accessions arranged in randomized complete blocks. Two plants per accession were in each replication. Approximately 30 days after seeds germinated, plants initiated flowering. Flowers were then removed from plants before 8:00 AM daily to prevent self-fertilization and pegging prior to initiation of the study. Fourteen days after the first flowers appeared, application of GA_3 was initiated, at which time flowers ceased to be removed. Concurrently, 2.3 mL of 0, 88, 176, or 352 ppm GA_3 plus 1 mL/L Tween 80 were applied to each respective plant receiving a specific GA_3 treatment daily with an atomizer bottle for 30 days during the experiment. Flowers were counted daily and pegs were counted once every 5 days between day 10 and day 35. Since pegs usually are observed on selfed plants of *Arachis* between 5 and 8 days after fertilization, peg counts at day 10 were assumed to result from flowers borne on plants during days 1-5. Additional pegs at day 15 were from flowers of days 6-10, etc. throughout the experiment. Main stems and longest lateral branches were measured 35 days after initiation of the treatment.

The responses of *Arachis* species to GA_3 application for increasing seed production in an interspecific hybridization crossing program were next evaluated. NC 4 was crossed in reciprocal with five accessions: Argentine, *A. duranensis* Krap. et Greg. *nom. nud.* (coll. K 7988), *A. chacoense* Krap. et Greg. *nom. nud.* (coll. GKP 10602), *A. correntina* (Burk) Krap. et Greg. *nom. nud.* (coll. GKP 9530), and *A. diogoi* (coll. GK 30005). A factorial arrangement of treatments was used with two replications, three GA_3 combinations of 0 ppm GA_3, 176 ppm GA_3 + 1 mL/L Tween 80 applied by wrapping saturated cotton around the base of the hypanthium, or 176 ppm GA_3 + 1 mL/L Tween 80 applied as a spray at a rate of 7.66 mL/plant every day of pollination. Pollinations began July 16 and continued for aproximately 20 days until 50 pollinations per cross per treatment (totaling 3000 pollinations in the experiment) were completed. Nonpollinated flowers were removed by 8:00 AM daily to avoid selfing. Pegs were counted on all plants 10 days following the final pollination and seeds were harvested 50 days later.

Table 1. Species of *Arachis* used in GA_3 and hybridization experiments and habits.

Species	Collector[a]	Accession no./cultivar	PI	Habit	Seeds/plant[b]
A. diogoi Hoehne	GK	30005	468142	Perennial	None
A. helodes Mart ex Krap. et Rig.	GK	30031	468146	Perennial	None
A. sp.[c]	GKPSc	30108	468356	Perennial	None
A. glabrata Benth.	GKP	9634	262836	Perennial	None
A. chacoense Krap. et Greg. nom. nud.	GKP	10602	--	Perennial	Very few
A. cardenasii Krap. et Greg. nom. nud.	GKP	10017	262141	Perennial	Very few
A. correntina (Burk) Krap. et Greg. nom. nud.	K	7830	--	Perennial	Very few
A. correntina	GKP	9530	--	Perennial	Very few
A. villosa Benth.	B	22585	298636	Perennial	Few
A. stenosperma Greg. et Greg. nom. nud.	HLK	410	338280	Perennial	Many
A. sp.	GK	30006	468150	Perennial	Many
A. sp.	GK	30008	468152	Perennial	Many
A. sp.	GK	30011	468154	Annual	Many
A. sp.	GK	30017	468159	Perennial	Many
A. hypogaea L. subsp. hypogaea	--	NC 4	--	Annual	Many
A. hypogaea subsp. fastigiata	--	Argentine	--	Annual	Many

[a]Abbreviations of collectors' names: G = W. C. Gregory, K = A. Krapovickas, P = J. R. Pietrarelli, Sc = A. Schinini, H = R. O. Hammons, L = W. R. Langford and B = A. Burkart.

[b]None = 0, very few = 1-5, few = 5-15 and many = 25 or more seeds per plant during an average growing season.

[c]All unnamed accessions are believed to represent unique species.

Because the GA_3 applications to species only indicated pegging and not seed production, another test was conducted to evaluate the effect of GA_3 on seed production. Two plants each of *A. cardenasii* Krap. et Greg. *nom. nud., A. chacoense, A. diogoi, A. helodes,* and *A. villosa* Benth were planted into three boxes (total six plants of each species) and allowed to self-pollinate. Applications of 0, 88, and 176 ppm GA_3 were made to plants in respective boxes of each species daily at a rate of 7.66 mL/plant. Daily flower counts were taken for 21 days, after which the number of pegs were counted. Plants were harvested 60 days later, which corresponded to the time of normal seed maturity. Floral nodes of *A. chacoense* and *A. cardenasii* with and without 176 ppm GA_3 treatment were also tagged and subsequently harvested at 1 and 5 days after fertilization. Peg tips at each collection date were fixed in 90 pt. 70% ethyl alcohol: 5 pt. acetic acid : 5 pt formalin, dehydrated, embedded into paraffin, sectioned to 10 μ, mounted on slides, stained with Safranin-O/Fast Green/Orange-G, and observed under the microscope.

Data from the experiments were analyzed by the general linear model procedure of the Statistical Analysis System (SAS). Because interactions between treatments and entries were significant for several variables, single degree of freedom contrasts of the linear, quadratic, and cubic effects of treatments were computed.

Results

The number of flowers produced on plants among *Arachis* species was significantly ($p = 0.01$) different. Because similar trends in flowering were observed throughout the experiment for each 5-day interval, only the total number of flowers for the entire study is reported (Table 2). The least number of flowers was produced on NC 4 while, at the other extreme, *A.* sp. coll. 30017 had more than 200 flowers. Application of 352 ppm GA_3 significantly ($p = 0.05$) decreased the number of flowers per plant when compared to 0 ppm GA_3. A small increase in flower number was found when 88 ppm GA_3 was applied. GA_3 apparently had a significant inhibitory effect on duration of flowering. The experimental plants were not discarded until nearly a month after GA_3 treatments were completed. At that time, only the 0 ppm GA_3 control plants continued flowering at the same rate as when the experiment was in progress. All plants of species which had been treated with GA_3 at 88, 176, or 352 ppm had either completely stopped flowering or produced only a very few flowers daily.

GA_3 enhanced the numbers of pegs in most peanut accessions studied, and varying effects were observed

Table 2. Number of flowers produced in *Arachis* species after 30 days of treatments at four GA_3 levels*.

Species	ppm GA_3 0	88	176	352
	No.			
A. chacoense	82ab	108bc	114de	78abc
A. cardenasii	143def	181e	141ef	114cde
A. villosa	167ef	90ab	114de	97bc
A. correntina (GKP 9530)	105a-d	131b-e	139ef	146def
A. correntina (K 7830)	94abc	143cde	110cde	90abc
A. diogoi	115bc	112bc	109cde	113cde
A. helodes	86abc	83ab	65abc	53a
A. stenosperma	121bc	113bc	90bc	76abc
A. sp. 30108	110bc	84ab	49ab	78abc
A. sp. 30006	178ef	249f	177ef	186fg
A. sp. 30008	128cde	162cde	107cde	154ef
A. sp. 30011	127cde	125bc	115de	106cd
A. sp. 30017	261g	278f	251g	221g
A. glabrata	87abc	83ab	48ab	82abc
A. hypogaea (NC 4)	62a	48a	37a	55ab
A. hypogaea (Argentine)	98abc	118bc	106cde	92abc

*Means followed by the same letter for each GA_3 treatment not significantly different at p = 0.05 as determined by Duncan's multiple range test.

Table 3. Number of pegs produced in *Arachis* species after 30 days of treatments at four GA_3 levels.*

Species	ppm GA_3 0	88	176	352
	No.			
A. chacoense	1a	37b	36b	41b
A. cardenasii	4a	53b	46b	75b
A. villosa	5a	6a	23b	36b
A. correntina (GKP 9530)	0a	15ab	29ab	41b
A. correntina (K 7830)	1a	9ab	20b	42c
A. diogoi	0a	10ab	19b	41c
A. helodes	0	4	9	7
A. stenosperma	49	51	60	60
A. sp. 30108	1a	2a	8a	35b
A. sp. 30006	26a	59b	47ab	61b
A. sp. 30008	28a	47b	46b	52b
A. sp. 30011	66	61	56	68
A. sp. 30017	46	43	49	52
A. glabrata	0	0	1	3
A. hypogaea (NC 4)	32b	32b	21a	27ab
A. hypogaea (Argentine)	31	37	38	32

*Means followed by the same letter for each species not significantly different at p = 0.05 as determined by Duncan's multiple range test.

which resulted in significant interactions between entries and treatments. Pegging was first recorded after 10 days when 11 of 16 species treated with GA_3 averaged at least one peg per plant; species not pegging included *A. correntina, A. helodes, A. glabrata, A. hypogaea* (cv. NC 4), and *A.* sp. coll. GKPSc 30108. After day 10, an increase in the numbers of pegs were observed for all species except *A. glabrata,* which only averaged 0.7 pegs per GA_3-treated plant for the entire experiment.

The numbers of pegs increased from 1.0 to 37, 4 to 75, 0 to 10, and 0 to 15 pegs per plant for the species *A. chacoense, A. cardenasii, A. diogoi,* and *A. correntina,* respectively, when the 0 ppm GA_3 was compared to 88 ppm GA_3 after 30 days (Table 3). Even when species normally produced many pegs without GA_3 application (for example, *A.* sp. coll. GK 30006 and *A.* sp. coll. GK 30008), significant increases from 26 to 59 and 28 to 47 pegs per plant, respectively, were observed for 88 ppm GA_3 treatments. Several other species did not have a significant increase in the number of pegs until 176 ppm GA_3 was applied — for example, *A. villosa, A. helodes,* and *A. correntina* (coll. K 7830). The one section *Rhizomatosae* species tested, *A. glabrata,* produced pegs on only one plant in the four replications at 176 ppm treatments but averaged 2.8 pegs per plant at 352 ppm GA_3 application rates. GA_3 had very little effect on the species *A. hypogaea, A.* sp. coll. GK 30017, or *A.* sp. coll. GK 30011. Although no significant increases in peg numbers at any one treatment level existed for *A. stenosperma* Greg. et Greg. *nom. nud,* a linear response to increased GA_3 concentrations for peg production was observed.

Because of the significant differences in numbers of flowers among species, data were expressed as pegs per flower to obtain estimates of reproductive efficiency. Significant linear effects for GA_3 treatments were observed for *A. chacoense, A. villosa, A. correntina, A. diogoi, A. stenosperma,* and *A.* sp. coll. GK 30006. A significant quadratic effect was observed for *A. sp. coll. GKPSc 30108 and a significant cubic effect was observed for A. cardenasii.* No significant treatment effects were seen for the other species. However, this was generally because the 0 or 88 ppm GA_3 treatments had similar effects on peg production for individual species rather than a lack of overall increase in pegging at higher rates. The reproductive efficiency for pegging was highest at the 352 ppm GA_3 treatment level where most species averaged between 30 and 50% of flowers with pegs. *Arachis glabrata* was the lowest at 2.9% flowers with pegs, while 79.8% of *A. stenosperma* flowers produced pegs at the highest GA_3 treatment.

Plants of five species were planted in boxes to determine if pegs produced after GA_3 applications would produce pods and seeds (Table 4). When 0 ppm GA_3 was applied, no pegs were observed on any of the species even though nearly 1300 flowers were borne on the plants. At 88 ppm GA_3, pegging was still not observed on *A. cardenasii* or *A. helodes,* and *A. villosa* had only one peg. Although 30 and 50 pegs were produced on *A. diogoi* and *A. chacoense,* respectively, for 88 ppm GA_3 application, no pods formed. Pegs were produced at a higher frequency on *A. chacoense* and *A. cardenasii* when 176 ppm GA_3 was applied, but pods were still not observed (Table 4). Abortion mechanisms are thus only partially overcome by hormone application.

Embryos were collected 1 and 5 days after self-pollination for GA_3-treated and nontreated flowers of *A. cardenasii and chacoense.* All histologically examined materials at day 1 had one to two cells. Nineteen 5-day-old reproductive tissues were sectioned for *A. cardenasii* with 16.7 and 42.8% possessing developing embryos for GA_3-treated and nontreated flowers, respectively. Comparisons of 1- and 5-day-old embryos of *A. chacoense* to which GA_3 was applied showed that fertilization had occurred, but the embryos started to abort by day 5.

Reciprocal hybrids were made between *A. hypogaea* cv. NC 4 and five other accessions including *A. hypogaea* cv. Argentine, *A. duranensis, A. chacoense,*

Table 4. Flowering and pegging responses for *Arachis* species after GA_3 treatments.

Species	0 ppm			88 ppm			176 ppm		
	Flowering	Peg	Pod	Flowering	Peg	Pod	Flowering	Peg	Pod
	No.								
A. cardenasii	239	0	0	119	0	0	154	17	0
A. chacoense	177	0	0	226	50	0	102	64	0
A. diogoi	597	0	0	333	30	0	217	25	0
A. helodes	132	0	0	219	0	0	236	0	0
A. villosa	150	0	0	31	1	0	18	1	0

A. diogoi, and *A. correntina* to evaluate the effect of GA_3 on hybrid production. In previous crossing experiments, cv. Argentine and *A. duranensis* hybridized with NC 4 when used as either the male or female parent at approximately the same frequencies of 25-30%. This is significantly less than most *A. hypogaea* x *A. hypogaea* crosses for which 80 to 95% of pollinations result in hybrids. *Arachis chacoense, A. diogoi,* and *A. correntina* usually cross with *A. hypogaea* at a much higher frequency when used as the male parent. In this study, Argentine and *A. duranensis* were hybridized with NC 4 as either male or female parents and at the relatively low frequencies of 20-27% (Table 5). *Arachis chacoense* averaged 7.0% success when used as a female parent and 23% success when used as a male parent without GA_3. *Arachis diogoi* and *A. correntina* could only be hybridized with NC 4 as male parents when GA_3 was not applied (Table 5).

Application of 176 ppm GA_3 was made to female parents of the same crosses either as a cotton application to the flower at the time of pollination or as a spray application to the whole plant. Significantly ($p = 0.01$) more pegs were observed with GA_3 applications than without treatments. A general trend for spray treatments producing greater numbers of pegs than cotton-applied treatments was observed (Table 5). When NC 4, Argentine, or *A. duranensis* was used as a female parent, significantly more pods and seeds were recovered when GA_3 was applied. For reciprocal crosses between the *A. hypogaea* cultivars NC 4 and Argentine, both cotton and spray applications resulted in nearly the same percentages of pods and seeds (Table 5). However, for reciprocal hybrids involving *A. duranensis,* cotton applications resulted in significantly more pods and seeds than did spray applications. This superiority of cotton over spray application was also observed when *A. diogoi* was used as a male parent, while *A. correntina* males had nearly equal results for either application type. A slight enhancement effect was observed for spraying when *A. chacoense* was used as the male (Table 5). Although hybrids were obtained when *A. chacoense* females were used without GA_3 applications, and an average of 33.0 and 49.5 pegs per plant were observed for cotton and spray applications, respectively, no pods or seeds were found after GA_3 was used (Table 5). Numerous pegs were also observed when applied either as cotton or spray treatments to *A. diogoi* or *A. correntina* females, but only one pod and seed was recovered from an *A. correntina* cross (Table 5).

Table 5. Average number pegs, pods, and seeds produced per 50 pollinations after GA_3 treatment for 10 *Arachis* hybrids.

Hybrid	Pegs			Pods			Seeds		
	0 ppm	176 ppm Cotton	176 ppm Spray	0 ppm	176 ppm Cotton	176 ppm Spray	0 ppm	176 ppm Cotton	176 ppm Spray
	No.								
NC 4 x Argentine	9.5*	23.5	29.5	8.0	13.5	17.0	12.0	22.5	28.0
Argentine x NC 4	12.0	38.0	43.0	7.5a	17.5b	17.5b	13.5a	29.0b	27.5b
NC 4 x A. chacoense	6.0a	24.5b	25.5b	6.0a	18.5ab	25.0b	11.0	31.5	36.0
A. chacoense x NC 4	3.5a	33.0b	49.5c	3.5	0.0	0.0	3.5	0.0	0.0
NC 4 x A. diogoi	11.5a	30.5ab	37.0b	5.0a	20.0b	13.5b	9.5a	37.0b	20.5ab
A. diogoi x NC 4	0.5a	10.5b	11.0b	0.0	0.0	0.0	0.0	0.0	0.0
NC 4 x A. duranensis	8.5a	29.0b	34.0c	8.5a	22.5b	9.5a	13.5	31.5	14.5
A. duranensis x NC 4	10.0a	35.0ab	54.5b	10.0	18.5	7.5	10.0	18.5	7.5
NC 4 x A. correntina	10.0a	25.5b	27.0b	10.0a	19.0b	16.5b	11.0a	27.5b	28.5b
A. correntina x NC 4	0.0a	27.5b	12.5ab	0.0	0.0	0.5	0.0	0.0	0.5

* Hybrid means followed by the same letter within each trait of pegs, pods, and seeds for GA_3 levels not significantly different at $p = 0.05$ as determined by Duncan's multiple range test.

Discussion

Seed production in peanuts not only requires fertilization and embryo growth, but also peg elongation and soil penetration plus pod development. GA_3 was useful for stimulating peg elongation for many of the species tested. This is a significant step toward seed production in species which must be maintained in a vegetative condition in the greenhouse. Not only were pegs observed on accessions which normally fail to produce these reproductive structures when self-pollinated, but significant increases were also observed in the numbers of pegs for several other species. However, addition of growth regulators to stimulate pegging is not the entire solution to increasing seed set. Unfortunately, seeds were not recovered for the species which do not produce pegs normally without GA_3. This could have resulted from embryo abortion, parthenocarpic development of pegs, or possibly both. Additional evidence of parthenocarpy was observed from *A. duranensis* x NC 4 crosses where each of the female plants in both replications of 176 ppm GA_3 spray treatments produced more pegs than the number of pollinations (Table 4). An analagous situation exists in *Pisum sativus* L. (4) and *Malus sylvestris* Mill. (3) where GA_3 will stimulate fruit development but seeds are not produced.

Treatments of self-pollinated *A. hypogaea* cultivars with GA_3 did not significantly affect pegging. However, when *A. hypogaea* was used as a female parent with accessions which normally produce a low percentage of successful crosses, significant increases in the numbers of pegs resulted from either cotton- or spray-applied GA_3. Corresponding increases in the numbers of pods and seeds were also observed. The percentage of pegs setting pods for *A. hypogaea* females with no GA_3 application was 78.3%, while an average of 64.9 and 50.5% was observed for 176 ppm GA_3 addition for cotton and spray, respectively. Even though a significant increase was observed in the total number of seeds recovered, peg (or embryo) abortion was higher in GA_3-treated plants than nontreated females. The seeds harvested from plants which had GA_3 applications were smaller and more shrivelled than those collected from non-GA_3-treated plants, but they were still viable. On the other hand, even though GA_3 significantly stimulated pegging on species for which hybrids had not been previously obtained when pollinated with NC 4, no increase in pods or seeds resulted from GA_3 additions. GA_3 thus

appears to have potential for increasing the numbers of seeds from species or hybrids which normally will produce seeds. However, applications will not result in seed increases for self- or cross-incompatible species. GA_3 appears to stimulate only part of the developmental sequence toward seed reproduction, and other stimuli for embryo development must be found.

Detrimental effects of GA_3 applications were observed as well as the desirable increase in pegging. For example, as the concentrations of GA_3 were increased, plants became chlorotic and sensitive to fertilizer burn. Plants with 176 or 352 ppm GA_3 had significantly longer main stems and lateral branches than nontreated plants. For plants with a runner habit, the effect could be considered neutral; but for upright species, the reproductive nodes--unless the branches were mechanically bent down--were often too high for pegs to reach the soil. In addition, flowering for most species was almost completely suppressed on GA_3-treated plants about 4 weeks after the experiment was concluded.

GA_3 apparently initiates activity of the peg meristem proximal to the basal ovule. Peg elongation without accompanying embryo development results in abortion, usually before soil penetration. Dosage effects may be important considerations for different species. Although 88 ppm GA_3 effectively stimulated peg development for many accessions tested, higher levels were needed for others such as *A. correntina, A. diogoi,* and *A. glabrata.* Linear, quadratic, and cubic responses in pegging to GA_3 concentrations were observed for different species. Because GA_3 may also have adverse effects on embryo development and other plant traits, such as stem length or leaf chlorophyll, the lowest level possible for inducing pegging should be used on peanut plants. Histological research will be needed at various treatment levels to define specific dosages for individual species of the genus. Although additional and more detailed histological work is necessary to accurately document embryo development in these and other species, the results indicate that embryo abortion occurs early in selfs of some species such as *A. chacoense,* thus limiting seed production. In other species such as *A. cardenasii,* failure of peg meristematic tissue to initiate elongation may be the primary cause of seed failure.

Literature Cited

1. Amir, J. 1969. A study on the reproductive stage of groundnut, *Arachis hypogaea* L. Induction of pod setting in the upper-nodal gynophores. Ann. Bot. 33:333-338.
2. Badami, V. K. 1935. Botany of groundnut. J. Mysore Agric. Expt. Un. 14:188-194, 15:58-70.
3. Bukovac, M. J., and S. Nakagawa. 1967. Comparative potency of gibberellins in including parthenocarpic fruit growth in *Malus sylvestris* Mill. Experiention (Basel) 23:865.
4. Garcia-Martinez, J. L., and J. Carbonell. 1980. Fruit-set of unpollinated ovaries of *Pisum sativum* L. Influence of plant growth regulators. Planta 147:451-456.
5. Halward, T. M. and H. T. Stalker. 1987. Cumpurison of embryo development in wild and cultivated *Arachis* Species. Ann. Bot. 59:9-14.
6. Mallikarjuna, N., and D. C. Sastri. 1985. Utilization of incompatible species of *Arachis:* Sequential hormone application. Proc. Internat. Workshop on Cytogenetics of *Arachis,* ICRISAT, Patancheru, A. P., India, pp. 147-151.
7. Peterson, C. M. 1974. The effects of gibberellic acid and a growth retardant on ovule formation and growth of excised pistils on *Nigella* Ranunculaceae. Am. J. Bot. 61:693-698.
8. Sastri, D. C. 1984. Incompatibility in Angiosperms: Significance in crop improvement. Adv. Appl. Biol. 10:71-111.
9. Sastri, D. C., and J. P. Moss. 1982. Effects of growth regulators on incompatible crosses in the genus *Arachis* L. J. Exp. Bot. 33:1293-1301.
10. Smith, B. W. 1954. *Arachis hypogaea.* Reproductive efficiency. Am. J. Bot. 41:607-616.
11. Smith, B. W. 1956. *Arachis hypogaea.* Embryogeny and the effect of peg elongation upon embryo and endosperm growth. Am. J. Bot. 43:233-240.
12. Stalker, H. T., and J. C. Wynne. 1983. Photoperiodic response of peanut species. Peanut Sci. 10:59-62.
13. Yasuda, S. 1943. Physiological analysis of the mechanism of fruit development in peanuts. I. General view. Jap. J. Bot. 13:243-253.
14. Ziv, M., and J. C. Sager. 1984. The influence of light quality on peanut (*Arachis hypogaea* L.) gynophore pod and embryo development *in vitro.* Plant Sci. Lett. 34:211-218.
15. Ziv, M., and E. Zamski. 1975. Geotropic responses and pod development in gynophore explants of peanut (*Arachis hypogaea* L.) cultivated *in vitro.* Ann. Bot. 39:579-583.

Accepted May 2, 1987