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The flowering, pollination and hybridization of groundnuts *(Arachis hypogaea L.)*

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RINGKASAN

Ciri-ciri pembungaan, teknik-teknik mengembiri dan pendebungaan kacang tanah telah diuji. Pembungaan didapati berlaku antara 0645 hingga 0900 jam dengan kelewatan setengah jam pada hari-hari mendung. Cepudebunga didapati matang satu jam sebelum bunga mengembang.

Kadar tumbesaran tiub debunga didapati lebih kurang 1 sm sejam dan persenyawaan dianggarkan terjadi di antara 5 hingga 6 jam selepas pendebungaan. Hasil lengai kacang tanah tidak bertambah dengan teknik "tripping" walaupun didapati bahawa pendebungaan bantuan boleh menambah bilangan "tugal" berbanding dengan pendebungaan semulajadi.

Pengembirian boleh dilakukan dengan menggunakan pengepit atau sedutan pada waktu petang, sehari sebelum bunga-bunga berkembang dengan tidak menjejaskan kejayaan pengacukan. Didapati juga beberapa kombinasi pengacukan dan induk-induk boleh memberi kejayaan pengacukan yang lebih daripada yang lain.

SUMMARY

The flowering pattern, emasculation and pollination of locally grown groundnuts were studied. Flowering generally occurred between 0645 to 0900 h with a half hour delay on dull days. Anther dehiscence occurred in the bud about one hour prior to blooming.

Pollen tube growth was approximately 1 cm per hour and fertilization was estimated to take place 5 to 6 hours after pollination. There was no improvement in pod set following tripping of the flowers although it was found that assisted pollination improved peg formation over natural self-pollination.

Emasculations can be carried out either using forceps or suction on the afternoon prior to the day of anthesis without any detrimental effect on the success of cross-pollination. Some cross-combinations and parents were capable of higher success in cross-pollinations than others.

INTRODUCTION

In the improvement of groundnuts *(Arachis hypogaea* L.) information pertaining to the flowering, pollination, and seed set of the crop relevant to the local environment is necessary. For example, while it is generally known that groundnut flowers bloom early in the day, the time of flowering differ from place to place. Flowering has been reported to occur as early as 0300 h in the Philippines (Jose, *et al.*, 1951) and between 0600 to 0800 h in India (Dainiel, *et al.*,1976). Dehiscence of the anthers has been reported to occur early, prior to flower opening which enables self-pollination to take place within the closed petals (Culp *et al.*, 1968).

Groundnut, being a naturally self-pollinated crop would have little need for insect assistance. However, it has been reported that only less than 10 percent of the numerous flowers produced, develop into mature pods (Othman, 1979; Lim

et al., 1980). The low pod set may be due to inefficient self-pollination. In some legume crops (e.g. *Medicago sativa, Vicia faba*) the flowers need to be tripped to effect pollination (Armstrong, 1935; Lawes, 1972; Lim and Knight, 1980).

Pod set can also be influenced by the efficiency of fertilization. The distance between the stigma and the ovary ranges from 2.0 to 6.0 cm (Othman, 1979) and slow pollen tube growth particularly where the style is long can influence the success of fertilization.

In the hybridization of groundnuts, the technique and time of emasculation as well as the parental influence on the outcome of the cross-pollination are important considerations. Success from artificial cross-pollination has been reported to vary from 38 to 70 percent depending upon the technique used and the efficiency of the operator (Halim and Ahmad, 1980; Nigam *et al.*, 1981; Norden, 1980). As each successful cross-pollination only yields a few seeds, a high success rate is desirable.

The flowering behaviour, pollination and hybridization of groundnuts is investigated in this study.

MATERIALS AND METHODS

A locally grown Spanish variety of groundnuts, "Local", obtained from Telok Chengai in Kedah, was observed for the time of flower opening and anther dehiscent. The crop was grown in the Universiti Pertanian Research Area in 1982.

The pollen tube growth rate was determined through pistil decapitation of pollinated flowers at various time intervals after pollination and at different distances from the stigma. Decapitation was carried out hourly upto five hours after pollination and the style excised at distances varying from 1 to 4 cm. Each treatment combination consisted of 15 flowers replicated three times.

In comparing emasculation techniques, the anthers were removed using either (a) forceps or (b) suction. Selected flower buds were emasculated in the later afternoon and pollinated the following morning. In a separate study, emasculations were carried out at two different times, (a) between 1430 and 1530 h and (b) between 1730 and 1830 h, on the day prior to flowering. In these studies, the success of pollination, as indicated by the peg formation, was used to compare the relative merit of each treatment.

The tripping requirement and hybridization studies were carried out on four varieties of groundnuts. These were Alabama, Tainang No. 1, Indonesian and Local. In the tripping studies, there was five replications with five plants each. On each plant an equal number of flowers were tripped or left as the untreated control. In the hybridization study the four varieties were crossed in all combinations including reciprocal crosses. All percentage data were transformed into arcsine values prior to biometrical analyses.

RESULTS

Flowering and Anther Dehiscence

Flower buds were seen one day prior to anthesis. The buds developed rapidly and most buds reached maximum size by the early afternoon (1430 h Malaysian Standard Time). Flowering occurred on the morning of the following day. Flowering was observed to begin from 0645 h on a fine morning with maximum blooming around 0730 ha. On dull and wet mornings, the flowering was delayed by half an hour (Figure 1).

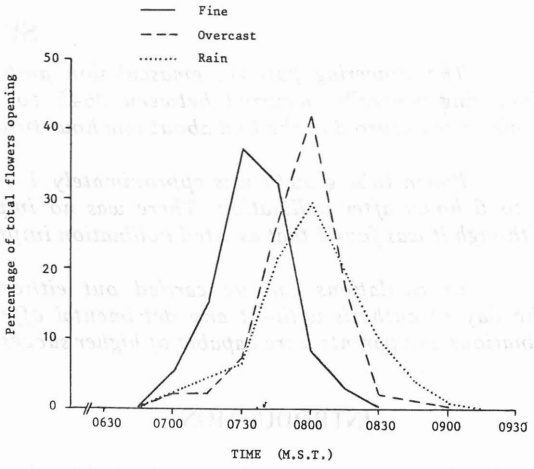

Fig. 1 – Time of opening of groundnut flowers

The dehiscence of the anthers were indicated by the presence of pollen within the keel petals. The anthers were found to dehisce beginning from 0545 h until 0715 h M.S.T. Most anthers dehisced at 0615 h. Flowering followed about one hour after pollen was released (Table 1).

TABLE 1
Time of anther dehiscent and anthesis in groundnuts

Time (M.S.T)	Number of flowers	
	With Anthers dehisced	Opened
0545	3	0
0600	23	0
0615	64	0
0630	87	0
0645	95	0
0700	98	5
0715	100	20
0730	100	57
0745	100	89
0800	100	97
0815	100	100

Growth Rate of Pollen Tubes

The formation of pegs after decapitation of the pistil indicated that the pollen tube had grown beyond the point of decapitation and fertilization had been achieved. The number of pegs formed decreased when the pistil was decapitated further away from the stigma and when the time between pollination and decapitation was reduced (Table 2). Flowers with pistils decapitated 5 hours after pollination at 1 cm from the stigma produced the largest number of pegs while few or no pegs were formed when the pistils were decapitated two hours after pollination at distances of more than 2 cm from the stigma.

TABLE 2
Mean Percentage of flowers with decapitated pistils forming pegs

Time after pollination (hours)	Distance of decapitation point from stigma (cm)			
	1	2	3	4
1	5.3^{bc}	0^{a}	0^{a}	0^{a}
2	16.6^{de}	0.8^{ab}	0^{a}	0^{a}
3	72.4^{gh}	35.2^{f}	27.7^{ef}	11.6^{cd}
4	91.2^{ij}	77.6^{gh}	70.6^{g}	25.5^{ef}
5	94.5^{j}	86.4^{hij}	79.5^{ghi}	78.8^{ghi}

Mean values having the same leter are not significantly different at P = 0.05 based on the New Duncan Multiple Range Test.

Methods and Time of Emasculation

In the two emasculation methods studied there was no significant difference between emasculation using forceps or by suction. The number of pegs formed from pollinations following the emasculations were similar with both methods. The proportion of pegs ɔrmed from the pollinated emasculated flowers was significantly more than the untreated control flowers suggesting that both the emasculation techniques used did not adversely affect the flower buds in their ability to form pegs (Table 3).

TABLE 3
Percentage of successful pollinations in two methods of emasculation

Emasculation method	Percent success	Angular values
Control (Not emasculated)	60.6	51.29
Forceps	78.6	64.14
Suction	80.6	66.79
LSD (P = 0.05)	–	9.49

In the comparison between flower buds emasculated in the early and in the late afternoon there was no significant difference in their ability to form pegs. The difference of 2 hours in the time of emasculation was not critical (Table 4).

TABLE 4
The effect of emasculation time on the percentage of successful pollinations in the afternoon.

Time of emasculation	Percent success	Angular value
Control (Undisturbed)	59.7	50.80
Early emasculation (1430 – 1530 h)	70.3	57.68
Late emasculation (1730 – 1830 h)	79.7	65.93
LSD (P – 0.05)	–	8.85

Tripping Requirement

The tripped and untripped flowers for all four varieties were not different in their ability to form pods (Table 5). There is no evidence,

therefore, to suggest the presence of a tripping requirement in groundnuts.

TABLE 5
Mean number of pegs and pods produced per plant plant from tripped and untreated flowers

Variety	Number of pegs		Number of pods	
	Untreated	Tripped	Untreated	Tripped
Alabama	48.6	51.2	29.0	32.6
Tainang	42.6	41.2	27.6	25.2
Indonesian	47.2	49.4	28.0	40.0
Local	41.2	44.0	35.6	38.2

Treatment means for untreated and tripped are not significantly different at P = 0.05 for all varieties.

Hybridization

All the four varieties studied were found to cross readily in all parental combinations with an average success of 31.6%. There was generally no significant difference among the cross-combinations for the proportion of successful cross-pollinations (Table 6). However, when each pair of crosses were compared, significant differences were found depending upon whether the variety was used as the pollen or seed parent (Table 7). The Tainang variety was found to be a better pollen parent than Alabama when crossed with the seed parent, Local. In crosses where Alabama was the seed parent, both the Tainang and Indonesian varieties were better pollen parents than variety, Local. Among better pollen parents than variety, Local. Among seed parents, the variety Alabama formed more pods than Tainang when cross-pollinated with a common pollen parent, Indonesian. The variety Alabama was also found to be a better seed parent than a pollen parent when crossed with Indonesian (Table 8).

DISCUSSION

Flowering and Emasculation

The flowering characteristics of the groundnut plants determine the time that is suitable for carrying out emasculations and cross-pollinations. Flowering commenced just after day-break with a delay of half an hour during dull or wet days. Peak flowering occured about 0730 h. M.S.T. and most flowers opened by 0900 h.

TABLE 6
Percentage successful cross-pollination from among four varieties

Cross combination	Mean Percent success (pod set)
Local and Alabama	24.4
Local and Indonesian red	25.1
Local and Tainang	42.7
Alabama and Indonesian	33.0
Alabama and Tainang	35.8
Indonesian and Tainang	28.8

All mean values were not significantly different at P = 0.05.

The anthers were found to dehisce before the flower opened. Emasculation must, therefore, be carried out in the bud stage. The groundnut flower buds only appeared one day before flowering and developed to its maximum size on the same day. In order to allow the buds to develop sufficiently for handling, emasculation was carried out in the later part of the day.

The results have shown that the emasculation of flower buds during the afternoon prior to the day of anthesis was not detrimental to the success rate following pollination and there were also no differences in the success of cross-pollination following emasculation either by using forceps or by suction. Thus bud emasculations may be carried out as early as 15 hours prior to anthesis using either method. The ability to carry out bud emasculation early also has significance in terms of labour costs reduction and the convenience of working hours.

Pollination and Fertilization

In groundnuts, self-pollination is the rule. The release of pollen from the anthers even before the flowers open excluded the entry of pollen from other plants. However the efficiency of self-pollination was questioned. The results in the emasculation and pollination study have shown that manually pollinated flowers are capable of producing more pegs than naturally self-pollinated flowers. This indicated that natural pollination by itself is not adequate for the optimum production of pegs.

The possibility of the presence of a tripping requirement to enhance pod set was also investigated. Although tripping of the staminal column

TABLE 7

Percentage of successful cross-pollinations among crosses with common male and female parents

Group	Parent A	Parent B	Mean % crosses producing pods (female x male)	
			A X B	B X A
1	Local	Alabama	26.5[b]	22.4[a]
		Indonesian	33.9 [ab]	27.9[a]
		Tainang	44.9[a]	40.6[a]
2	Alabama	Indonesian	42.2[a]	24.4[a]
		Tainang	42.1[a]	29.8[a]
		Local	22.4[b]	26.5[a]
3	Indonesian	Tainang	35.3[a]	22.7[b]
		Local	27.9[a]	33.9[ab]
		Alabama	24.4[a]	42.2[a]
4	Tainang	Local	40.6[a]	44.9[a]
		Alabama	29.8[a]	42.1[a]
		Indonesian	22.7[a]	35.3[ab]

Means values with the same letter are not significantly different at P - 0.05 based upon the New Duncan Multiple Range Test.

is necessary in *Medicago sativa* and *Vicia faba* to promote seed set (Armstrong, 1935; Lawes 1972); Lim and Knight, 1980), a similar requirement was not evident in this study. The four varieties used did not differ in pod yield whether flowers were tripped or untreated.

The growth rate of pollen tubes was based upon the formation of pegs following decapitation of the style. Fertilization, which is indicated by peg development, can only occur when the tip of the pollen tube bearing the generative nucleus has grown past the point of decapitation. The range of treatments applied allowed the hourly growth of the pollen tube to be monitored. Based on the formation of pegs, most of the pollen tubes had grown more than 1 cm in the first 3 hours after pollination, 2 to 3 cm after 4 hours and 4 cm after 5 hours. The results suggest that the average pollen tube growth is approximately 1 cm per hour. The inital 3 hours required for the pollen tube growth of 1 cm was due to the lag period for pollen germination, which took approximately 2 hours. Therefore, depending upon the length of the style, fertilization is estimated to occur 5 to 6 hours after pollination for styles 3 to 4 cm in length.

Hybridization

In the hybridization of groundnuts, a high success rate from the cross-pollinations is desirable. The male and female parents are often chosen based upon traits such as pod yield, seed quality and pest and disease resistance. However, it is also necessary that the parents be able to set seed well on cross-pollination. The number of seeds that can be recovered from each successful pollination may be only one or two. Therefore, when success from cross-pollination is low, a large number of crosses need to be made requiring much time and expenses.

The selection of parents and the crossing system, where possible, should consider the seed set ability of the cross-combination. The results

TABLE 8
Mean percent successful cross-pollination among reciprocal crosses

Reciprocal crosses	Percent pod set	
Local x Alabama	26.5	ns
Alabama x Local	22.4	
Local x Indonesian	33.9	ns
Indonesian x Local	27.9	
Local x Tainang	44.9	ns
Tainang x Local	40.6	
Alabama x Indonesian	42.2	ns
Iindonesian x Alabama	24.2	
Alabama x Tainang	42.1	ns
Tainang x Alabama	29.8	
Indonesian x Tainang	35.3	ns
Tainang x Indonesian	22.7	

n.s. $P \geq 0.05$
* $P < 0.05$

did not reveal any completely incompatible cross-combinations among the varieties used. However, some combinations of parents produced significantly fewer seeds from cross-pollinations than others. In a particular combination, some varieties were more successful than others when used as the seed parents than as the pollen parent. There was also an instance where one cross was better than its reciprocal cross for the percent pod set. The availability of pollen, the ease of emasculation and pollination are possible causes for the low pod set in specific combinations. The choice of parents in a particular cross-combination as well as the hybrid combination should be considered for this character.

CONCLUSION

Anthesis in groundnut plants occurs between 0730 and 0900 h M.S.T. and bud emasculation for hybridization can be carried out in the afternoon prior to the day of anthesis using either forceps or suction.

Natural pollination was found to be inadequate and there is a need for supplementary pollination. Tripping of the flowers does not assist the pollination process.

The duration from pollination to fertilization is estimated to be 5 to 6 hours depending upon the length of the style.

In general the varieties studied hybridized readily in all combinations. In a few cross-combinations, the choice of a variety for the seed or pollen parent influenced the success of the cross-pollinations.

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