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# The Reproductive Characters of Four Varieties of Groundnuts (*Arachis hypogaea* L.)

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## RINGKASAN

*Ciri-ciri pembiakan bagi 4 jenis kacang tanah iaitu, Nudong, V-13, Matjam dan Alabama telah dikaji. Kesemua jenis menunjukkan corak yang sama bagi pembungaan, pembentukan tugal dan hasil lenggai. Hanya sebanyak 15 peratus bunga-bunga yang dikeluarkan menghasilkan lengai-lengai matang. Hasil yang rendah ini adalah disebabkan oleh pendebungaan yang kurang cekap dan pengguguran biji muda akibat pengaruh alam sekeliling yang kurang baik.*

## SUMMARY

*The reproductive characters of 4 groundnut varieties, Nudong V-13, Matjam and Alabama were studied. All varieties showed similar patterns of flowering, pegging and podding. Only 15 percent of the flowers produced developed mature pods. The low yield was attributed to inefficient pollination and abortion of developing kernels due to adverse environmental influences.*

## INTRODUCTION

Groundnuts is an important short term crop locally grown in rotation with rice and other crops. Yields of the crop vary from location to location and from season to season. There has been no significant improvement in yields despite many years of cultivation and the introduction of new varieties. Due to the inconsistent yields of the local and introduced varieties, it is difficult to identify superior material. The inconsistency in yields can be due to many factors, one of the most important being the basic fertility of the crop. Many yield studies on the groundnut crop were based upon the final yield and yield components. However, in order to understand more fully the reasons for the low yield, the reproductive characters of the crop at each stage of development from flowering up to pod maturity need to be studied. The various reproductive characters of two local and two introduced varieties were investigated in this study.

## MATERIALS AND METHODS

Four varieties of groundnuts were used in the study. They consisted of two locally adopted varieties (V-13 and Matjam) and two introduced varieties (Nudong and Alabama). The plants were grown in a randomised complete block design with four replications. Within each plot, 25 plants were labelled for the collection of flower, peg and pod production data. Another 5 plants within each plot were used for destructive studies such as the determination of hypanthium lengths, the number of ovules in the ovary and the number of developing kernels in the pegs. Pollen studies were also based upon these plants. Collection of the pollen samples were made during the second and third week of flowering with viability tests conducted on agar culture media using the perspex block technique (Lim, 1978). Pods were harvested 105 days after planting for the determination of pod and kernel number.

## RESULTS

### *Flowering*

In all varieties, flowering commenced 25 days after sowing. The daily flower production increased progressively with alternations of high and low production. The main flowering period spanned about 40 days after which sporadic

flowering was observed. The flowering pattern was similar for all the varieties studied and consisted of two peak flowering periods, one occurring during the first 3 weeks of flowering and the second in the later period of flowering. Rainfall appeared to stimulate flowering and generally preceded the period of high flower production (Figure 1).

The number of flowers produced during the first three weeks of flowering did not differ significantly from that produced in the later three weeks except in the variety, Matjam. This variety produced twice as many flowers in the first half of the flowering period than in the second half (Table 1).

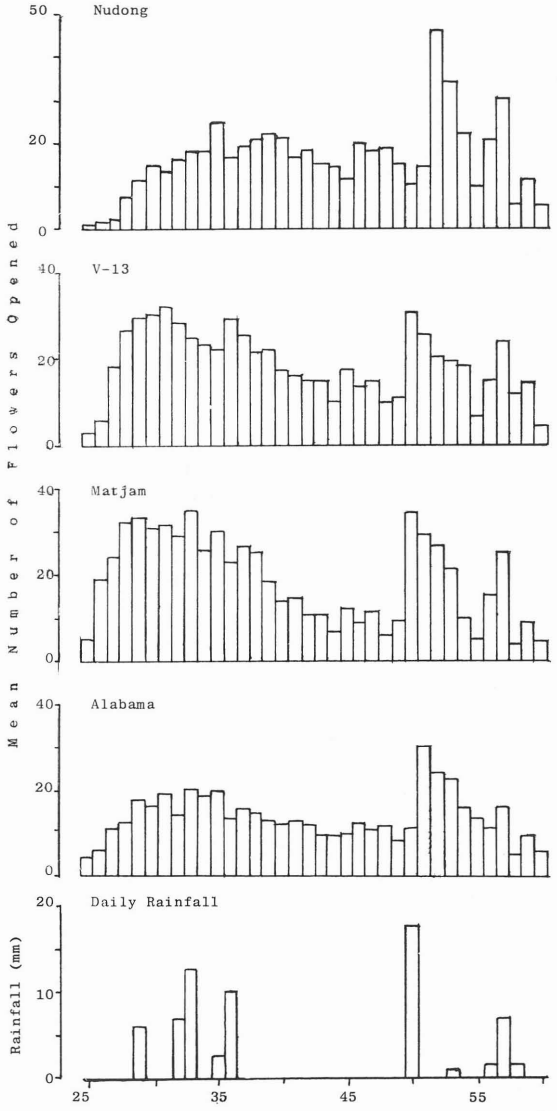


*Fig. 1. Mean daily flower production per plot (25 plants)*

The total number of flowers produced by the plants varied, ranging from a low of only 18 flowers to a maximum of 142 flowers. Due to the wide variation in flower numbers, the varieties were not significantly different for the number of flowers produced. An overall mean of 57 flowers per plant was obtained.

*Floral Morphology*

The groundnut flower consists of the usual standard, wing and fused keel petals of a legume flower. However, an unusual feature is the presence of an elongated calyx tube known as the hypanthium which resembles a flower stalk. The ovary is located at the base of the hypanthium and is attached to a filamentous style which is as long as the hypanthium. The length of the hypanthium ranged from 2 to 6 cm. No relationship was observed between the hypanthium lengths and the location of the flower. The average hypanthium length was 3.85 cm and not significantly different among the varieties studied (Table 2).

Within the petals, at anthesis the stigma was observed to be located slightly above the ring of anthers. The position of the stigma relative to the anthers may be disadvantageous to natural self-pollination.

*Pollen Production and Viability*

No differences were found among varieties for the mean number of pollen produced and the viability of the pollen grains. The average pollen production per plant was 8200 pollen grains. Viability was also high with an average of 89.8 percent germination (Table 3).

*Ovule Number*

The varieties V-13, Matjam and Alabama had a high frequency of ovaries containing 2 ovules. Very few ovaries had up to 3 ovules which was also the maximum number observed (Table 4). Variety Nudong, however, had a large number of ovaries with 3 and 4 ovules. No ovary was found with only one ovule; the minimum number observed was 2 ovules.

*Peg and Food Development*

Following syngamy, "pegs" were formed. The peg is a stalk-like structure (the gynophore) that develops from the base of the ovary and carries at its tip the fertilized ovules that eventually develop into kernels as the pod matures.

TABLE 1
Mean flower production per groundnut plant

| Flowers | Variety | | | |
|---|---|---|---|---|
| | Nudong | V–13 | Matjam | Alabama |
| Early | 26.5 ) | 37.8 ) | 40.7 ) | 26.9 ) |
| | ) ns | ) ns | ) * | ) ns |
| Late | 29.2 ) | 23.8 ) | 21.2 ) | 21.8 ) |
| Total | 55.7 | 61.6 | 61.9 | 48.7 |
| Range | 22–104 | 29–142 | 27–133 | 18–118 |
| S.E. | 2.14 | 2.28 | 1.92 | 2.19 |

ns = $P \geqslant 0.05$ * = $P < 0.05$

TABLE 2
The distribution of groundnut flowers for the length of hypanthium

| Hypanthium length (cm) | Frequency (% flowers studied) | | | |
|---|---|---|---|---|
| | Nudong | V–13 | Matjam | Alabama |
| 2.0 – 2.4 | 3 | 3 | 4 | 4 |
| 2.5 – 2.9 | 6 | 8 | 8 | 9 |
| 3.0 – 3.4 | 20 | 16 | 22 | 12 |
| 3.5 – 3.9 | 24 | 18 | 22 | 25 |
| 4.0 – 4.4 | 34 | 31 | 23 | 32 |
| 4.5 – 4.9 | 11 | 15 | 12 | 16 |
| 5.0 – 5.4 | 1 | 5 | 7 | 1 |
| 5.5 – 5.9 | 1 | 2 | 2 | 0 |
| 6.0 and above | 0 | 2 | 0 | 0 |
| Mean hypanthium length (cm) | 3.8 | 3.9 | 3.9 | 3.8 |

The number of pegs and pods produced were not significantly different among the varieties studied. An average of 50 percent of the flowers developed into pegs and out of these only 30 percent continued development into mature pods (Table 5). Based upon the number of flowers available, only 15 percent of the yield potential was realised.

Further loss of yield potential was evident from the limited development of the fertilized ovules (developing kernels) to maturity. The

TABLE 3
Pollen viability of groundnut flowers

| Variety | Pollen Production | | Pollen Viability | |
|---|---|---|---|---|
| | No. Per Flower | S.E. | % Germination | S.E. |
| Nudong | 7750 | 125 | 88.7 | 2.09 |
| V–13 | 8250 | 205 | 90.6 | 2.12 |
| Matjam | 8700 | 215 | 90.5 | 2.17 |
| Alabama | 8125 | 250 | 89.3 | 2.48 |

TABLE 4
Percentage of ovaries with 1, 2, 3 and 4 ovules

| Variety | Percentage of ovaries | | | | Mean no. of ovules per ovary |
|---|---|---|---|---|---|
| | 1 ovules | 2 ovule | 3 ovule | 4 ovule | |
| Nudong | 0 | 8 | 48 | 44 | 3.24 |
| V–13 | 0 | 95 | 5 | 0 | 2.08 |
| Matjam | 0 | 97 | 3 | 0 | 2.01 |
| Alabama | 0 | 97 | 3 | 0 | 2.13 |

TABLE 5
Peg and pod production of groundnuts

| Variety | Pegs | | Mature Pods | | |
|---|---|---|---|---|---|
| | Mean No./plant | Percent of flowers | Mean No./plant | Percent of Pegs | Percent of Flowers |
| Nudong | 27.4 | 49.2 | 6.0 | 22.2 | 11.0 |
| V–13 | 31.4 | 51.8 | 10.0 | 32.8 | 17.2 |
| Matjam | 29.2 | 47.2 | 10.3 | 35.0 | 16.9 |
| Alabama | 25.3 | 52.0 | 7.8 | 31.2 | 16.2 |
| Mean | 28.3 | 50.0 | 8.5 | 30.3 | 15.3 |

Differences between the varieties not significant at P = 0.05

number of developing kernels within the pegs varied. With the exception of the variety Nudong, the other varieties generally contained 2 developing kernels in the peg. The Nudong variety had many pegs with 3 and 4 developing kernels (Table 6).

During the development of the pegs into pods many of the developing kernels aborted. In all the varieties studied, most of the pods contained 2 kernels. The Nudong variety had, in addition, many 3-kerneled pods. Single-kerneled pods were also found (Table 7).

The distribution of pegs for the number of developing kernels was not significantly different from the distribution of ovaries for the number of ovules present. However, significant differences were obtained when the distribution of pegs was compared with that of pods for kernel numbers (Table 8). All varieties exhibited a similar pattern of an increase in the number of pods with 1 and 2 kernels. Thus, in addition to the low pod set, the low number of fertilized ovules that developed into mature kernels further reduced the yield.

## DISCUSSION

In all seed crops, yield is dependent to a large extent upon the basic reproductive units available. In groundnuts the basic reproductive units constitute the flowers. The production pattern of the groundnut flowers favour pod setting. The extended period of flowering is an advantage when conditions are less than favourable

TABLE 6
Percentage of pegs with 1, 2, 3 and 4 developing kernels (DK)

| Variety | Percentage of pegs | | | | Mean Number DK/peg |
|---|---|---|---|---|---|
| | 1 DK | 2 DK | 3 DK | 4 DK | |
| Nudong | 0 | 7 | 62 | 31 | 3.24 |
| V–13 | 0 | 92 | 8 | 0 | 2.08 |
| Matjam | 0 | 91 | 9 | 0 | 2.09 |
| Alabama | 0 | 87 | 13 | 0 | 2.13 |

TABLE 7
Percentage of pods with 1, 2, 3 and 4 kernels

| Variety | Percentage of pods | | | | Mean Number kernels/pod |
|---|---|---|---|---|---|
| | 1 kernel | 2 kernels | 3 kernels | 4 kernels | |
| Nudong | 11.2 | 50.6 | 35.8 | 2.4 | 2.29 |
| V–13 | 12.2 | 86.8 | 1.0 | 0 | 1.89 |
| Matjam | 13.1 | 85.7 | 1.2 | 0 | 1.91 |
| Alabama | 11.5 | 86.4 | 2.1 | 0 | 1.91 |

TABLE 8
Summary of Chi-square values for comparisons between distributions for the number of ovaries, pegs and pods according to the number of ovules, developing kerbels or seeds present

| Distributions compared | Variety | | | |
|---|---|---|---|---|
| | Nudong | V–13 | Matjam | Alabama |
| Ovaries vs. Pegs | 4.10 ns | 0.74 ns | 3.19 ns | 6.79 ns |
| Ovaries vs. Pods | 81.24 ** | 15.24 ** | 16.32 ** | 12.27 ** |
| Pegs vs. Pods | 75.71 ** | 17.80 ** | 21.70 ** | 19.37 ** |

ns = $P \geqslant 0.05$

** = $P < 0.01$

to pollination and fertilization. The flowering peaks observed in all varieties to follow rainfall are also plant responses to match favourable weather conditions with flower production. However, very late flowers would not have adequate time for pod development before the harvest. Pods take about 8 weeks to mature from the time of flowering and therefore, only the first 3 weeks of flowering may be considered to be useful. The number of flowers produced during the first 3 weeks varied among the varieties but were more than 3 times the number of pods produced.

Pollination and fertilization are necessary before further development can take place. The groundnut flower had no shortage of pollen in all the varieties studied. There were over 8000 pollen grains per plant of very high viability. The only problem that may arise is the pollination process. Only about 50 percent of the flowers develop pegs indicating that in half the flowers produced, pollination or fertilization was not achieved. The location of the stigma was observed to be slightly above the anthers. This can prevent natural self-pollination. The crop cannot rely on cross-pollination. A low level of natural cross-pollination of less than 2 percent has been reported (Culp *et al.*, 1968). It has also been found that manual pollinations resulted in more pegs being produced than when groundnut flowers were left undisturbed (Lim and Siegfred, 1984). Inadequate pollination may, therefore, cause the low peg formation.

Peg development follows fertilization (Smith 1956). However, pollination need not result in the fertilization of ovules. Many factors can delay the growth of pollen tubes and failure of fertilization. High temperatures and soil moisture stress have been cited (Ono and Ozaki, 1974). The length of the style as indicated by the hypanthium length can also influence the success of fertilization. The hypanthium length was found to range from 2 to 6 cm. The rate of pollen tube growth has been estimated at 1 cm per hour after an initial lag period of 2 hours for pollen germination (Lim and Siegfred, 1984). Thus, the flowers would require from 4 to 8 hours for fertilization to be affected. Although no study was made to relate the length of the hypanthium to peg formation, it is possible that fertilization of the ovules would be more likely to be achieved for flowers with short styles.

The development of pegs into pods did not always follow peg formation. Only one-third of the pegs reached maturity. The failure of pegs to develop into pods was largely due to the abortion of the developing kernels. Unfavourable temperature and moisture regimes following fertilization, nutritional deficiencies, especially calcium and the failure of double fertilization can result in the abortion of the young kernel (Ono and Ozaki, 1974; Shibuya and Suzuki, 1956; Singh *et al.*, 1980; Smith, 1954). For a peg to develop to maturity there must be at least one developing kernel within it.

Further losses in the yield potential was evident in the number of kernels within the pod. Abortion of the developing kernels resulted in fewer kernels being present in the pod than in the pegs. Comparisons between the distribution of the ovaries for ovule number, pegs for developing kernel number and pods for kernel number show no significant differences for the distribution of ovaries and pegs indicating that fertilization and kernel development at the early pegging stage were complete. However, differences were signi-

ficant on comparing the distribution of pegs and pods. Therefore further loss of the yield potential occurred after pegging. Due to the abortion of developing kernels, there were only a few pods with 3 or 4 kernels. Many pods were found with 2 kernels. Single-kerneled pods were also found when originally no ovary or peg contained only one ovule. The death of one or more fertilized ovule resulted in these pod categories. These losses in yield were found in all the varieties studied.

The varieties studied were similar in their flower production and reproductive characters up to pod maturation. In these varieties, inspite of many flowers being produced, only 15 percent of the flowers developed into mature pods. The number of ovules that developed into mature kernels were even fewer, representing only 12.7 percent of the ovules available. These losses in the reproductive potential of the crop was attributed to adverse environmental influences. Thus any improvement in environmental conditions can bring about yield improvement up to the limits of the basic fertility which is about 6 times the present yield obtained. The consistency in which all varieties suffer losses at each stage of reproduction suggest that the environmental factors greatly influence the outcome of the crop. Therefore, it is not surprising that inconsistent results have been obtained in field trials. From the results it is evident that conditions that can improve pollination and reduce abortion can result in large gains in yield improvement. The manipulation of planting dates to coincide with favourable conditions, supplementary irrigation and the supply of adequate nutrients are factors to consider.

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