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THE EFFECT OF WATER DEFICIT AT DIFFERENT GROWTH PHASES ON THE PERFORMANCE OF GROUNDNUT

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RINGKASAN

Beberapa varieti kacang tanah ditanam di dalam rumah kaca, kotak kayu dan di ladang, dan dibiarkan tidak bersiram selama tiga minggu pada beberapa peringkat tumbesaran. Keputusan menunjukkan hasil berkurangan sekiranya sesak air berlaku pada peringkat awal pembentukan lenggai. Sesak air pada peringkat tumbesaran yang lain tidak menjejaskan hasil.

INTRODUCTION

The majority of Malaysian groundnut is grown under unirrigated conditions. Apart from other factors, yields are commonly limited by the occurrence of drought stress. Future yield increase depends partly on the improvement of cultural practices and genetic manipulation to enable the groundnut to withstand water shortage better. More detailed information on the relationship between crop growth and drought stress are required before this development can be fulfilled.

It is well-established that the effect of water deficit on growth and yield depends both on the degree of stress and the stage of growth at which stress occurs. Some ontogenic stages, like those corresponding to the early growth of the reproductive organs, are particularly sensitive to plant-water balance which, if unfavourable, may result in an important reduction in grain yield. Very little is known about the effect of drought on the groundnut crop. However, work on soybean indicated that insufficient water during flowering and pod-filling stages frequently limits yields (DOSS, PEARSON and ROGERS, 1974).

The purpose of this study is to identify the sensitivity stages in groundnut variety, Matjam, both under the field as well as greenhouse conditions, and to determine if the sensitivity stages are also common in other varieties.

MATERIALS AND METHODS

Three experiments were carried out under greenhouse (Experiment I), field (Experiment II) and box (Experiment III) conditions. Groundnut, Matjam variety, was used in Experiments I and II while Matjam and five other varieties in Experiment III.

Experiment I

Seeds were sown in 23 cm diameter pots filled with a mixture of sand, top soil and peat in the ratio of 3:2:1 respectively. Each pot was given a basal application of 3.0, 0.4, 0.6 and 0.5 g of lime, urea, triple superphosphate and muriate of potash respectively. Randomized complete block design was used with each treatment (consisting of one plant) replicated five times. Five days of water deficit was imposed at seven growth phases, beginning at 4, 5, 6, 7, 8, 9, and 10 weeks after sowing, designated as T1, T2, T3, T4, T5, T6 and T7 respectively. These treatments were compared with the control (T8). Plants were watered daily, except during the treatment periods. Sampling was done at three growth phases, *viz.*, 91, 98 and 105 days after sowing. During each sampling, each plant was separated into leaves, stems, roots, pods

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and pegs. These parts were separately oven-dried (at 80°C for two days) and weighed. Daily flower count was done on all plants.

Experiment II

This experiment was carried out at Serdang Research Station on Munchong soil series. Randomized complete block design was used with each treatment replicated three times. The plot size was 5.5 m x 6.0 m with a planting distance of 50 cm between rows and 10 cm between plants. Two seeds were sown at each point, and the plants thinned to one plant per point two weeks after planting. Fertilizer was applied at 34:56:56 kg/ha of N:P:K respectively at planting.

Three weeks of water deficit was imposed at seven growth phases, beginning at 4, 5, 6, 7, 8, 9 and 10 weeks, designated as T1, T2, T3, T4, T5, T6 and T7 respectively. Water deficit was induced by withholding water from the treatment plot during the entire three-week treatment period. This was achieved by covering the plots with movable polythene roofs (5.5 m x 6.0 m). For more efficient water control, furrows (30 cm deep) which led to a main drain, were dug around each plot. A control (no water deficit) was included as a treatment. The untreated plots were sprinkler-irrigated every five days when there was no rain.

Sampling was done at three growth phases, *viz.*, 91, 98 and 105 days after planting. During each sampling, plants within one square metre (two rows of one metre each) were taken from the centre of the plots. The plants were then separated into leaves, stems, roots, pods and pegs. The parts were oven-dried (at 80°C for two days) and weighed separately. Daily flower count was done on five randomly selected plants in each plot.

Experiment III

The seeds were sown in boxes (1 x 1 x 1 m) filled with a mixture of sand, top soil and peat (3:2:1:). Each box was sown with two rows of groundnut at a spacing of 50 cm between rows and 10 cm between plants. The boxes were placed 1 m apart. Five groundnut lines were tested together with Matjam as a standard variety. The five groundnut lines were 7923A−75−9 (maturity 120 days), 7921A−57−18 (maturity 120 days), 7921A−201 (maturity 100 days), 7920A−609−3 (maturity 100 days) and 7920B−158−5 (maturity 100 days). Split plot design was used with water deficit treatment as a main plot and variety as a subplot.

Three weeks of water deficit was imposed at two growth phases, beginning at five and six weeks after sowing (equivalent to T2 and T3 in Experiment II). Water deficit was induced by covering the boxes with movable polythene roofs (5.5 m x 6.0 m) during the entire three-week treatment period. The untreated boxes were watered daily when there was no rain.

Sampling was done at maturity. All plants were harvested and separated into leaves, stems, roots and pods (developed and undeveloped). Each part was then separately oven-dried and weighed.

RESULTS AND DISCUSSION

Flowers started to appear between 24 days and 30 days after sowing with new flowers blooming daily. Flowering was affected by water deficit. Observations under glasshouse conditions indicated that flower number dropped after one or two days without watering *(Figure 1)*. However, a flush of flowers appeared as soon as the plants were rewatered. In T1 for example *(Figure 1)*, watering was stopped on day 29 and rewatering was done on day 34. In response, flower number dropped to almost zero after day 30 and increased sharply on day 35. Similarly, watering in T2 was stopped on day 36 and rewatering was done on day 41. In response, there was a sharp drop in flower number on day 37 and a sharp increase by day 43. This was in

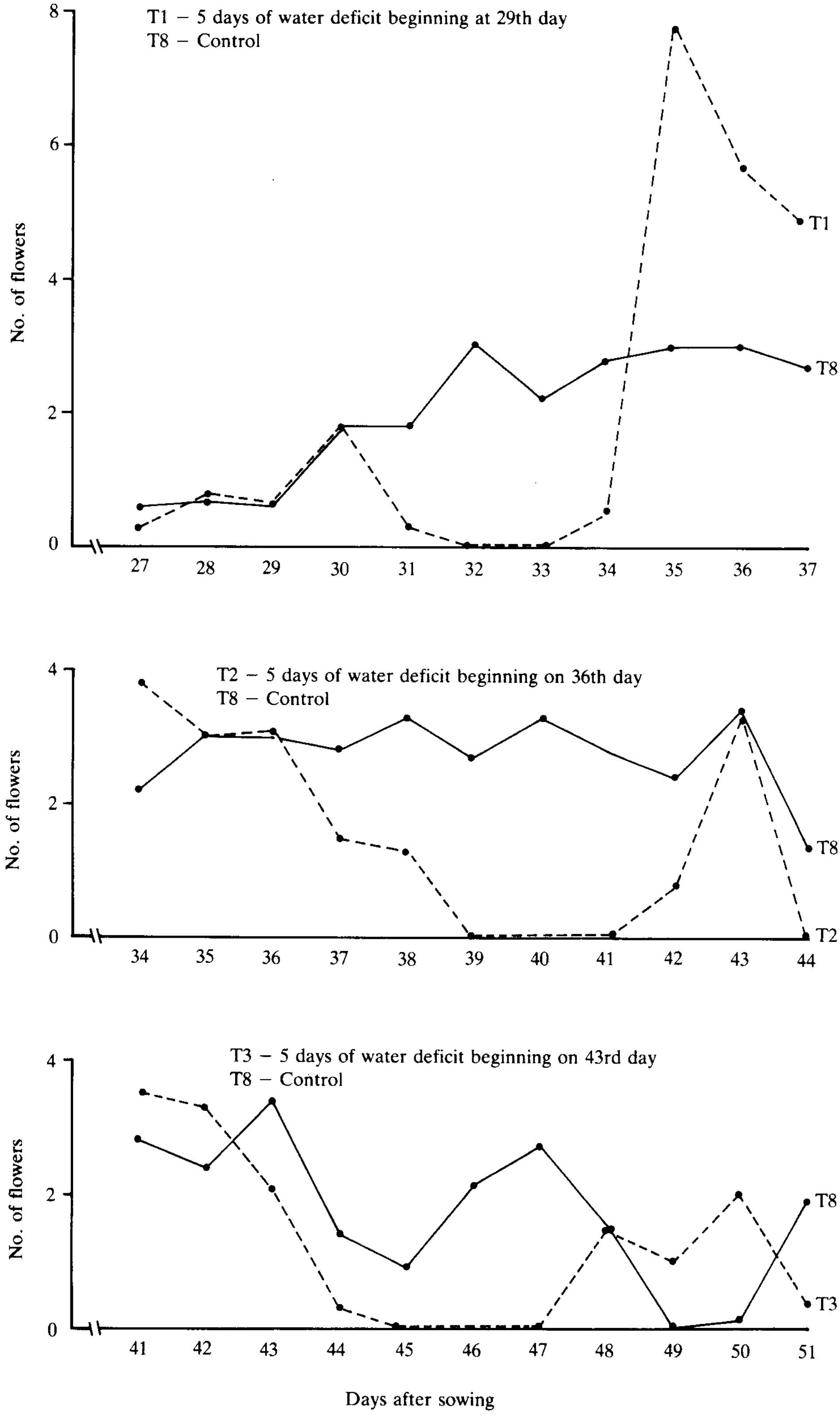

Figure 1. Effect of water deficit after sowing on flower production of groundnut (Experiment I).

contrast with that of T8 where the daily fluctuation in flower production during those periods was very small *(Figure 1)*.

The five-day stress under pot condition significantly affected the total number of flowers, especially if stress occurred during the fifth and sixth week *(Table 1)*. Under field condition where moisture reserve in the ground was greater, flowering was only slightly reduced in the first week of stress but was very much reduced during the second and third week. Total number of flowers per plant was, however, not significantly affected *(Table 2)*.

Under pot condition, plants began to wilt after five days without watering. As a result, the stress was terminated after five days in order not to lose the plants. The short period of water deficit did not significantly affect pod weights or numbers *(Table 1)*. However, plant weights were reduced with water deficit, especially in T2 *(Table 1)*.

Except for slight wilting at the end of the stress period, no visual treatment effect was noted in the field and box experiments (Experiments II and III). Results generally indicated no significant effect of water deficit on total plant weights in both experiments *(Tables 2* and *3)*. There was, however, a significant reduction in seed yield when stress occurred, especially during the rapid pod-filling stage, *i.e.*, fifth to seventh and sixth to eighth weeks (T2 and T3 in *Table* 2). It could not, however, be due to the temporary stop in flower production during the stress periods, as the number of pods was not significantly affected by the treatments in both Experiments I and II *(Tables 1* and *2)*. This was further supported by the larger number of flowers produced per plant. It had also been observed in a separate experiment that allowing only 30 flowers to develop on each plant did not significantly affect groundnut seed yield.

The lower seed yields in T2 and T3 appeared to be related more to the reduced 100-seed weight, as seed number was not much affected *(Table 2)*. This indicated that stress caused reduction in pod filling. This was further proven in Experiment III where the number of developed pods at maturity was reduced with water deficit (T2 and T3 in *Table 3*), indicating a delayed pod-filling. The effect of water deficit in reducing pod-filling has also been noted in soybean (Doss *et al.*, 1974; Sionit and Kramer, 1977) and field peas (Hiler, Van Bavel, Hossain and Jordan, 1972).

In Experiment II, water deficit beginning at week 5 (T2) was more critical than at week 6 (T3), but was *vice versa* in Experiment III. This might have been due to the different varieties used in Experiment III, where maturity period varied between 100 and 120 days. The longer maturity period of some varieties would mean a later pod-filling stage and thus a delayed sensitivity stage.

Seed yields were significantly lower in T2 and T3 compared with the control (T8) when harvested at 91 (reduced by 71% and 44% respectively) and 98 (reduced by 57%

Table 1. Effect of water deficit on mean plant weight, flower number, pod number and pod weight at different growth phases of groundnut under greenhouse condition (Experiment I)

Parameter	Treatment (Water deficit beginning at various weeks after sowing)							
	T1 (4th)	T2 (5th)	T3 (6th)	T4 (7th)	T5 (8th)	T6 (9th)	T7 (10th)	T8 (Control)
Mean plant wt. (g)	30.1a	17.5b	21.5ab	22.5ab	23.9ab	20.9ab	20.9ab	26.2a
Total no. of flowers	94a	57b	62b	75ab	90ab	92ab	65ab	88ab
Pod no.	25a	17a	23a	22a	21a	20a	23a	23a
Pod wt. (g)	10.8a	8.7a	10.0a	8.0a	7.9a	7.6a	8.7a	8.4a

Values with same subscripts within each row are not significantly different (5% level of probability).

Table 2. Effect of water deficit treatments on agronomic characters of groundnut under field condition

Parameter	Harvest (DAS)	Treatment (water deficit beginning at various weeks after sowing)							
		T1(4th)	T2(5th)	T3(6th)	T4(7th)	T5(8th)	T6(9th)	T7(10th)	T8(Control)
Total plant wt./m^2 (g)	91	474.7a	451.2a	496.7a	428.4a	460.6a	431.1a	537.6a	502.0a
	98	387.9a	366.5a	443.1a	390.6a	534.7a	419.4a	494.0a	391.1a
Mean no. of flowers/plant	–	88.0a	74.0a	86.0a	61.0a	62.0a	82.0a	84.0a	84.0a
Pod no./m^2	105	183.0a	176.0a	157.0a	182.0a	169.0a	141.0a	156.0a	157.0a
Seed no./m^2	105	300.7a	275.7a	252.3a	252.0a	226.3a	231.0a	288.0a	252.7a
100-seed wt. (g)	105	43.1b	34.1b	31.9b	58.6a	43.5b	45.9ab	39.7b	41.8b
Seed yield/m^2 (g)	91	101.6bc	43.4d	83.1c	105.9abc	121.5abc	122.6abc	143.9ab	148.7a
	98	107.7ab	45.9c	81.8bc	111.8ab	159.2a	133.3ab	141.4a	107.3ab
	105	126.6a	92.1a	83.2a	116.8a	98.9a	109.8a	118.7a	106.4a

DAS = Days after sowing.
Values with same subscripts within each row are not significantly different (5% level of probability).

and 24% respectively) days after sowing, but showed no significant difference from the other treatments at 105 days after sowing *(Table 2)*. Visual observations indicated large numbers of undeveloped pods in T2 and T3, especially when harvested at 91 and 98 days after sowing. Similarly, the number of developed pods was significantly smaller in the water deficit treatments in Experiment III *(Table 3)* while visual observation indicated a large number of undeveloped pods present at harvest. These indicated the possibility of the plants in T2 and T3 catching up with the control if harvesting was delayed.

Table 3. Effect of water deficit on developed pod number, plant, pod and seed dry weights of groundnut under box condition (Experiment III)

Parameter	T1	T2	T3
Plant dry wt./m^2 (g)	794.4a	734.8a	686.5a
Developed pod no./m^2	219.9a	191.5ab	124.3b
Pod dry wt./m^2 (g)	134.2a	112.9a	64.6b
Seed dry wt./m^2 (g)	81.9a	65.5a	34.1b

T1 – control
T2 – 3 weeks stress beginning at week 5
T3 – 3 weeks stress beginning at week 6
Values with same subscripts within each row are not significantly different (5% level of probability).

CONCLUSION

Water deficit at any time between the fifth and eighth week after planting can reduce seed yield. The greatest seed yield reduction was when stress began at weeks five and six where reduction could be as much as 24%–57% if harvested at maturity. This was found to be due to reduced pod-filling during stress. If, however, harvesting can be delayed, the plants may have been able to catch up in terms of seed yield. Unfortunately, delayed harvesting is not encouraged in the field, especially during the wet season when the plants will be susceptible to waterlogging and diseases. This can lead to further yield losses because of seed germinating in the pods as well as occurrence of rotten seeds. It was, therefore, advisable to schedule the planting season such that pod-filling stage does not fall within a dry period.

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ABSTRACT

A number of groundnut varieties were planted under glasshouse, box and field conditions, and were subjected to three weeks of water deficit at various growth phases. Results indicated reduced seed yield when water deficit occurred at the pod development stage. Water stress at other growth stages did not result in any significant yield reduction.

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