Madras Agric. J. 78, (5-8): 178-181 (1991) https://doi.org/10.29321/MAJ.10.A01838

EFFECT OF WATER STRESS ON YIELD AND YIELD ATTRIBUTES OF GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

The effects of water stress imposed at different phenophases on growth, yield and its attributes of 'J 11' and 'GG 2' groundnut were studied during summer 1985 in lysimeters. Leaf-area index, days to 50% flowering, days to leaf opening were suppressed due to water stress imposed at all the phenophases, but more so when the crop was stressed during the flowering stage. Yield reduction due to water stress was maximum during the pod development stage. Reduction in flower fertility, number of effective to total pegs and increase in the percentage of pods due to water stress finally reduced the pod yield. The pod development stage was critical for groundnut yield under water stress. 'GG 2' was comparatively drought tolerant.

Key words: Water stress, yield attributes, groundnut

Though groundnut (*Arachis hypogaea* L.) is reputed as a drought tolerant crop (Pandey *et al.*, 1984), available information on phenophases most sensitive to moisture stress is controversial (Billas and Ochs, 1961; Martin *et al.*, 1978; Bhan, 1979; Nageswara Rao *et al.*, 1985). The purpose of this experiment was to study the effect of single-cycle water stress imposed at certain phenophases on the growth dynamics, yield attributes, yield and reproductive efficiency of 2 groundnut varieties grown in the drainage type field lysimeters.

MATERIALS AND METHODS

An experiment was conducted in lysimeters (0.77 m diameter with 1.20 m depth) during summer 1985, on a medium black calcareous clay soil having pH (1:2.5) 7.4, electrical conductivity (1:2.5) 0.18 mmhos/cm, $CaCO_3$ 3.5%, organic carbon 0.59%, Olsen's P 0.87 ppm, available K 160.7 ppm and moisture content 28 and 14% at field capacity and permanent wilting point. The experiment was conducted at Junagadh. Ten treatment combinations comprising 5 treatments of water stress; no water stress, i.e. normal irrigation and water stress imposed at 4 phenophases, *viz.*, seedling to flowering (28-48 days after germination), pegging to pod development (55-75 days after germination) and 2 bunch varieties ('J 11' and 'GG 2') were replicated thrice in a factorial randomized design. About 20 bold seeds were sown per lysimeter on 8th February, 1985. In each lysimeter, 11 groundnut plants were raised and the crop was fertilized with the recommended doses of 25 kg N and 21.8 kg P/ha. Water stress was imposed by withholding water for 20 days during the particular phenophases of the varieties. Water stresses were given at 0.8 IW: CPE (depth of irrigation water; cumulative pan evaporation) ratio. The depth of water was 50 mm and total number of irrigation was 12. The crop was harvested on 26th May, 1985.

Flowers were counted daily until cessation of flowering. Leaf-area was measured *in situ* using automatic portable leaf-area meter and was calculated as per the formula suggested by Hunt (1978). The indices concerned with the reproductive efficiency namely dry matter stress index, fertility index, fruiting coefficient and fruiting efficiency were calculated using the following formulae:

$$\text{Dry matter stress index} = \frac{\text{Dry matter of stressed seedling}}{\text{Dry matter of controlled seedling}} \times 100$$

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$$\text{Fertility Index} = \frac{\text{Number of pegs/plant}}{\text{Number of flowers/plant}}$$

$$\text{Fruiting coefficient} = \frac{\text{Nut yield/plant}}{\text{Total dry matter production}}$$

$$\text{Fruiting efficiency} = \frac{\text{Number of fruiting points}}{\text{Dry matter yield}}$$

RESULTS AND DISCUSSION

Though days to leaf opening increased under water stress in both the varieties, maximum number of days were required when the stress was imposed at flowering stage (Table 1). Leaf expansion of 'J 11' was more sensitive to drought conditions. Leaf-area index showed the same response. It was curtailed maximum under the stress during flowering in both the varieties, probably because of the reduced rate of cell-division and cell enlargement (Rameshbabu *et al.*, 1984). The lesser effect of the stress in the later stage may be attributed to development of extensive deep root-systems and hardiness of the crop as it advances towards reproductive phase. Initiation of flowering was delayed by 4-5 days and days to 50% flowering were increased owing to water stress. Dry matter stress index was the lowest at flowering stage and it increased with the aging of plants. These results corroborate the work reported elsewhere (Anon., 1985).

Yield and yield attributes:

The lowest pod, haulm and biological yields were recorded (Table 2) under stress during flowering period. The next lower yield resulted from water stress during pod development. This was probably the result of the combined effect of reduced plant size and severe moisture stress during late pod-filling.

Table 1. Dynamics of growth under water stress at different phenophases of two peanut varieties

Growth parameters	Water stress at different phenophases											
	J 11						GG 2					
	Control	Flowering	Pegging	Pod development	Pod maturation	CD (0.05)	Control	Flowering	Pegging	Pod development	Pod maturation	Cd (0.05)
Days to leaf opening	3.3	5.8	5.6	5.4	5.1	1.6	3.0	5.4	3.4	3.2	3.0	1.2
Leaf area index	1.77	0.88	1.72	1.68	1.10	0.4	2.28	2.15	1.78	1.60	1.87	0.4
Days to first flowering	43	48	45	44	44	NS	38	42	38	36	38	4.0
Days to 50% flowering	54	60	56	54	54	3.0	46	42	51	53	50	2.0
Dry matter stress index	-	0.69	0.88	0.87	0.97	0.22	-	0.66	0.76	0.75	0.78	0.17

Table : 2. Yield attributes and yield of groundnut under water stress at different phenophases

Variety	Stress treatment phenophase	Flower counts/ plant	Total pegs/ plant	Effective pegs/ plant	Pods/ plant	Undeveloped pods/ plant	Developed pods/ plant	Total pods/ plant	100-seed weight	Shelling (%)	Pod yield g/plant	Haulm yield g/plant	Biological yield (g/plant)
'J 11'	Control	74	62.3	50.7	2.4	4.3	19.8	24.2	12.8	75.8	19.9 (-)	39.1 (-)	59.0 (-)
	Flowering	62	50.6	43.6	5.0	4.3	15.0	19.2	12.2	76.4	14.6 (26.6)	25.1 (35.8)	39.7 (19.3)
	Pegging	61	46.3	37.0	4.6	2.0	14.2	16.2	11.0	3.7	11.0 (44.7)	33.5 (14.3)	44.7 (24.2)
	Pod development	71	48.6	38.7	7.2	4.2	11.0	14.2	9.0	73.0	8.7 (56.3)	35.3 (9.7)	44.0 (25.4)
	Pod maturation	72	61.0	47.0	6.2	2.2	18.7	20.9	10.2	76.0	18.7 (6.0)	39.0 (0.3)	57.7 (25.4)
	CD (0.05)	2.2	4.6	5.1	3.3	1.1	3.4	2.1	1.2	2.0	1.0	11.0	12.3

	Control	78	68.2	49.8	3.2	2.1	21.2	23.3	14.0	76.5	20.8 (-)	24.1 (-)	44.7 (-)
	Flowering	68	60.5	46.5	3.4	2.0	18.2	20.2	12.6	76.5	18.0 (12.6)	13.2 (45.2)	31.2 (30.2)
'GG 2'	Pegging	70	51.0	42.5	2.2	2.9	17.4	20.4	12.6	74.2	17.5 (15.0)	21.7 (10.0)	39.2 (12.3)
	Pod development	72	67.8	50.1	9.1	6.2	13.2	19.5	9.7	72.5	12.7 (38.3)	23.0 (4.6)	35.7 (20.1)
	Pod maturation	76	71.0	49.6	4.0	3.8	19.8	22.2	12.5	77.0	19.4 (5.8)	23.8 (1.2)	43.2 (3.4)
	CD (0.05)	3.0	4.0	5.2	3.0	1.1	2.6	2.3	1.4	2.3	4.2	12.1	10.5

Table 3. Reproductive efficiency of groundnut under water stress at different phenophases

Variety	Water stress phenophases	Fertility index	Effective pegs/ total peg	Aerial pegs/sub-terminal pegs	Pods/ pegs	Percentage of pops	Nodule count	Pod weight/ number of flower	Fruiting coefficient	Fruiting efficiency	Reproductive yield/vegetative yield
	Control	0.84	0.81	0.23	0.48	09.9	68	0.27	0.34	0.45	0.48
	Flowering	0.82	0.86	0.16	0.44	03.9	51	0.16	0.38	0.61	0.58
'J 11'	Pegging	0.72	0.80	0.25	0.44	28.4	50	0.18	0.25	0.46	0.33
	Pod development	0.68	0.76	0.32	0.37	51.4	54	0.12	0.20	0.46	0.25
	Pod maturation	0.84	0.77	0.30	0.44	29.7	54	0.28	0.48	0.46	0.47
	CD (0.05)	0.17	0.03	0.07	0.02	12.2	07	0.08	0.10	0.04	0.06
	Control	0.87	0.73	0.38	0.48	13.7	54	0.28	0.46	0.59	0.85
	Flowering	0.88	0.77	0.32	0.43	16.8	41	0.26	0.58	0.76	1.36
'GG 2'	Pegging	0.73	0.83	0.20	0.48	10.8	43	0.25	0.44	0.58	0.81
	pod development	0.94	0.74	0.35	0.39	46.6	46	0.18	0.35	0.80	0.53
	Pod maturation	0.93	0.70	0.43	0.45	18.0	55	0.28	0.46	0.56	0.82
	CD (0.05)	0.21	0.04	0.11	0.04	9.5	09	0.05	0.06	0.11	0.12

The flower counts, total pegs and effective pegs were curtailed maximum under stress at flowering stage. The total pods, developed pods, 100-seed weight and shelling were reduced greatly under the stress at pod development stage. Consequently, the number of pods and undeveloped pods, were reduced because of the stress during the pod development. This directly seems to have determined the maximum yield depression in both the varieties when stressed at the pod development stage. The bunch type groundnut thus is sensitive to moisture stress at pod development stage and the reduction under moisture stress are mediated through reduction in photosynthetic surface (Leaf area index). This could also be attributed to a decrease in seed size, whereas the reduction by stress during pod formation was primarily related to a reduction in either pod number or seed number per pod. Though the flowering and pegging stages were considered to be the most sensitive ones to moisture stress (Reddi, 1976; Doorenbos *et al.*, 1979; Pathak *et al.*, 1987), the present investigation revealed that pod development phase, during which demand of photosynthetic products for active sinks (pods) is higher, is sensitive to moisture stress causing yield losses. These results are in agreement with those of Gibbons (1980) and Patel and Padalia (1980). In this study temporarily adverse effect of stress during early growth stages was buffered by heavy flush of flowers and hence the pegs as the stress terminated.

Reproductive efficiency:

Fertility indices showed (Table 3) inconsistent results for 'J11'but were reduced by 16% under stress at pegging stage in 'GG2'. The ratio of effective to total pegs varied with stressed phenophase 'J 11' and to 44% under stress at pegging stage with 'GG 2'. Pod: peg ratio was reduced to 23 and 19% under stress at pod development stage in both the varieties. Stress during pod development had rendered the pods in pod stage as evidenced by the highest pod per cent of 51.4 and 46.6 recorded during stress during pod development stage for 'J 11' and 'GG 2', respectively. Nodulation suffered most during stress at flowering stage. Fruit weight to flower number ratio was too low under stress during pod development stage. Fruiting coefficient, reproductive efficiency and reproductive to vegetative dry matter partitioning are important yield determinants and all were reduced while stress was imposed during the pod development stage.

Varietal response:

Plant growth reduction was more in 'J 11' compared to 'GG 2'. Under stress during pod development stage pod yield was reduced to 8.7 g/plant in 'J 11' and to 12.7 g/plant in 'GG 2' (Table 2). This was attributed to more number of flowers, pegs and pods and higher shelling percentage and higher reproductive efficiency of 'GG 2' as measured by pod : peg ratio, pod percentage, fruiting coefficient, and fruiting efficiency which were almost double in 'GG 2'. This higher efficiency is a resultant of favourable partitioning of assimilates, into reproductive and vegetative organs. Reproductive to vegetative dry matter accumulation was almost twice in 'GG 2' under stress during pod development stage. Because 'GG 2' responded positively during the stress at the sensitive phenophase i.e. pod development, it could outyield 'J 11'.

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