

Response of Summer Groundnut (*Arachis hypogaea*) to Levels of Irrigation and Sulfur

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Abstract A field experiment was conducted to study the effect of levels of irrigation and sulfur on growth parameters, yield attributes, yield consumptive use (CU) and water use efficiency (WUE) of summer groundnut (*Arachis hypogaea* L.) during two consecutive years (2009 and 2010) at Kalyani, Nadia, West Bengal during pre-*kharif* season in a sandy loam soil with 24 treatment combinations (eight irrigation level in main plot and three level of sulfur in sub-plot) in a split plot design replicated thrice. The maximum growth parameters, yield attributes and pod yield were recorded when three irrigations applied at the important physiological growth stages of flowering, pegging and pod filling stage in combination with sulfur

applied @ 15 kg/ha. The highest CU (639.0 mm) and WUE (6.2 kg/ha/mm) were recorded under three irrigations applied at flowering, pegging and pod filling stage followed by two irrigations at pegging and pod filling stage.

Keywords Consumptive use, Groundnut, Irrigation, Sulfur, Water use efficiency.

Introduction

Groundnut is a major oilseed crop in West Bengal after rapeseed - mustard, mostly grown during winter as well as summer seasons through irrigation water. The shortfall in per capita consumption of edible oil is gradually increasing and increase in production of oil by horizontal expansion has been ruled out. The only possible way of increasing productivity of groundnut through improved agronomic management. Economic use of water applied at important physiological growth stages during summer seasons save the natural resource without hampering the potential yield of groundnut [1]. Groundnut grown on light textured soils generally suffers from sulfur deficiency due to leaching of sulfate form of sulfur (SO_4^{2-}). Groundnut responds significantly to the application of sulfur [2] which is involved in the biosynthesis of primary metabolites for improving the yield and quality of oil seed crops and obtaining higher yield under balanced fertilization. Therefore,

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an attempt was made to study the optimum scheduling of irrigation and sulfur for higher groundnut yield under new alluvial zone of West Bengal during summer seasons.

Materials and Methods

A field investigation was carried out during two consecutive summer season (2009 and 2010) at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal which is situated at the 23°N latitude and 89°E longitude, at an elevation of 9.75 m above mean sea level. The soil of experimental field was sandy loam in texture and neutral in reaction (PH – 6.85) having low available nitrogen (240 kg/ha), medium available phosphorus (39 kg/ha) and medium available potassium (185 kg/ha). The experiment was laid out in three times replicated split plot design with 24 treatment combination having 8 schedules of irrigation (I₁ – no irrigation; I₂ – irrigation at flowering stage; I₃ – irrigation at pegging stage; I₄ – irrigation at pod filling stage; I₅ – irrigation at flowering and pegging stage; I₆ – irrigation at flowering and pod filling stage; I₇ – irrigation

at pegging and pod filling stage; I₈ – irrigation at flowering, pegging and pod filling stage) in main plots and 3 level of sulfur (S₁ – control; S₂ – 15 kg S/ha; S₃ – 30 kg S/ha) in sub-plots. Source of sulfur fertilizer was elemental sulfur (85%) and it was applied 15 days before sowing. Groundnut ‘GPBD-5’ was sown @ 100 kg/ha with the recommended fertilizer dose of 20:40:40 kg N-P-K/ha and the sources of fertilizers were urea, diammonium phosphate and muriate of potash, respectively and they were applied as basal dose. Two hand weeding were done at 15 – 20 DAS and at 30 – 35 DAS during both years of experimentation.

Water use efficiency (WUE) was computed using the following standard formula :

$$\text{WUE (kg/ha/mm)} = \frac{\text{Yield (kg/ha)}}{\text{ET or CU value (mm)}}$$

[ET = Evapotranspiration; CU = Consumptive Use]

The crop received total rainfall of 332.9 mm with 17 number of rainy days and 299.9 mm with 33 number

Table 1. Effect of levels of irrigation and sulfur on height of plant (cm), total dry matter accumulation (g/m²), yield attributing characters and pod yield (q/ha) of groundnut (pooled over two years).

Treatments	Plant ht at harvest (cm)	DM at harvest (g/m ²)	Plants /m ² (no.)	Pods/ plant (no.)	Kernels/ pod (no.)	100 kernels weight (g)	Shelling outturn	Pod yield (t/ha)	Oil %	Oil yield (t/ha)
I ₁	34.0	293.3	18.5	18.5	1.5	22.9	67.6	1.8	39.5	0.5
I ₂	43.3	463.7	18.6	20.3	1.6	24.4	72.2	2.0	42.3	0.6
I ₃	45.3	511.6	18.6	21.7	1.6	24.9	72.8	2.2	43.3	0.7
I ₄	39.2	387.6	18.6	19.9	1.6	24.3	71.6	2.0	41.2	0.6
I ₅	50.3	631.1	18.9	25.7	1.6	25.7	73.5	2.8	46.1	1.0
I ₆	47.6	570.7	18.7	24.7	1.6	25.3	73.4	2.6	45.5	0.9
I ₇	51.1	702.7	19.7	29.7	1.6	27.4	73.7	3.6	46.6	1.2
I ₈	53.3	839.3	20.8	29.9	1.7	27.6	75.9	3.9	47.9	1.4
SEm (±)	3.0	39.7	0.4	1.0	0.02	0.5	0.9	0.1	1.1	0.05
CD <i>p</i> = 0.05	9.8	129.6	1.2	3.1	0.1	1.6	2.9	0.4	3.7	0.2
CV (%)	28.0	30.7	8.0	17.2	6.2	8.3	5.2	20.5	10.9	23.0
Level of sulfur										
S ₁	43.1	465.3	18.8	20.7	1.5	22.9	71.6	2.0	40.7	0.6
S ₂	47.6	636.8	19.3	26.4	1.7	27.8	73.5	3.2	46.7	1.1
S ₃	45.8	547.9	19.1	24.3	1.6	25.3	72.7	2.7	44.7	0.9
SEm (±)	0.7	16.6	0.2	0.4	0.008	0.3	0.5	0.06	1.0	0.03
CD <i>p</i> = 0.05	2.0	47.0	NS	1.2	0.02	0.8	1.4	0.2	2.8	0.1
CV (%)	10.9	20.9	7.4	12.2	3.5	8.2	4.6	16.3	15.4	20.3

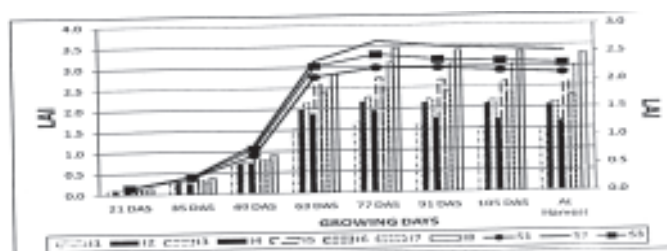


Fig. 1. Effect of levels of irrigation and sulfur on leaf area index of groundnut (pooled over two years).

of rainy days in the year of 2009 and 2010, respectively during the period of experimentation.

Results and Discussion

Growth parameters

The height of the plant and total dry matter accumulation were significantly influenced by levels of irrigation at harvest (Table 1). The tallest plants and the maximum total dry matter accumulation were produced where three irrigations were applied at flowering, pegging and pod filling stages (I_8) followed by two irrigations at pegging and pod filling stages (I_7) and they were statistically on a par in case of height of plants and shortest plants and minimum total dry matter accumulation were produced in no irrigation treated plants.

The height of the plant and total dry matter accumulation were significantly influenced by levels of

Table 2. Effect of level of irrigation on soil profile moisture depletion (%), CU (mm) and WUE (kg/ha/mm) of groundnut (mean of two years).

Irrigation Treatment	Soil profile moisture depletion (%)				CU (mm)	WUE (kg/ha/mm)
	0-15	15-30	30-45	45-60		
I_1	54.7	50.4	50.5	45.6	387.0	4.6
I_2	62.1	53.7	60.5	47.0	429.0	4.7
I_3	66.2	59.0	62.0	51.8	459.0	4.8
I_4	64.8	51.0	60.6	47.4	428.7	4.6
I_5	79.2	70.4	75.3	64.1	555.5	5.0
I_6	77.8	67.1	73.2	53.7	521.1	5.0
I_7	82.6	77.8	80.6	72.7	604.2	5.9
I_8	88.0	82.5	87.2	74.2	639.0	6.2

sulfur (Table 1) and the tallest plants and the maximum total dry matter accumulation were produced when sulfur applied @ 15 kg/ha.

The other growth parameters of groundnut [leaf area index, crop growth rate (CGR) and net assimilation rate (NAR)] were significantly influenced by level of irrigation irrespective of dates of recording observation (Figs 1, 2 and 3). The levels of irrigation increased all the growth parameters of groundnut up to 77 DAS and thereafter, gradually decreased upto harvest (120 DAS). The maximum values of growth parameters were produced where three irrigations were

Table 3. Effect of levels of irrigation and sulfur on net return (Rs) and benefit : cost ratio of groundnut (ha^{-1} basis) (pooled over ten years).

Treatment Level of Irrigation	Net return (Rs)	Benefit : cost ratio
I_1	24242.2	0.9:1
I_2	30164.9	1.1:1
I_3	35626.4	1.3:1
I_4	29318.3	1.1:1
I_5	50474.6	1.9:1
I_6	45115.7	1.7:1
I_7	73286.5	2.7:1
I_8	82766.9	3.0:1
SEm (\pm)	3430.5	0.1
CD $p = 0.05$	11187.6	0.4
Level of sulfur		
S_1	30888.6	1.3:1
S_2	62974.5	2.3:1
S_3	45260.2	1.5:1
SEm (\pm)	1691.7	0.1
CD $p = 0.05$	4785.6	0.2

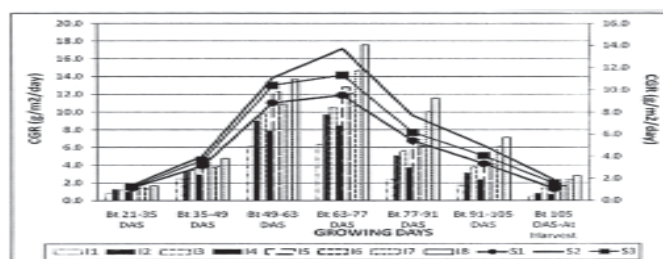


Fig. 2. Effect of levels of irrigation and sulfur on crop growth rate ($\text{g/m}^2/\text{day}$) of groundnut (pooled over two years).

applied at flowering, pegging and pod filling stages (I_8) followed by two irrigations at pegging and pod filling stages (I_7) and they were statistically at par in most of the dates of recording observation. Improvement in average soil moisture status in the root zone through frequent irrigation enhanced growth of the plants leading to more values of growth parameters of the plant by irrigation. This finding in close conformity with those of Mandal et al. [2]

The levels of sulfur significantly influenced LAI, CGR and NAR (Figs 1, 2 and 3) and were recorded maximum when sulfur applied @ 15 kg/ha. Further increase in the dose of sulfur @ 30 kg/ha did not affect its growth attributes. The beneficial effect of sulfur on the plant might be due to higher chlorophyll formation and synthesis of several enzyme systems that regulate higher growth in plants. These were conformity with the findings of Singh and Mann [3].

Yield attributes and yield

All the yield attributing characters and yield were significantly influenced by the schedules of irrigation (Table 1). The highest values of yield attributing characters [number of plant/ m^2 , number of pods/plant, number of kernels/pod, 100 kernel weight (g) and shelling out-turn] and yield (pod yield) were recorded under three irrigations applied at flowering, pegging and pod filling stages followed by two irrigations at pegging and pod filling stages and they were statistically at par except number of kernels plant⁻¹. Three irrigations applied at flowering, pegging and pod filling stages treatment and two irrigations at pegging and pod filling stages treatment recorded an increase in pod yield to the tune of 119.4% and 100.1% over control i.e., no irrigation treatment, respectively. This might be due to better utilization of moisture resulting in an increase of yield attributing characters and ultimately

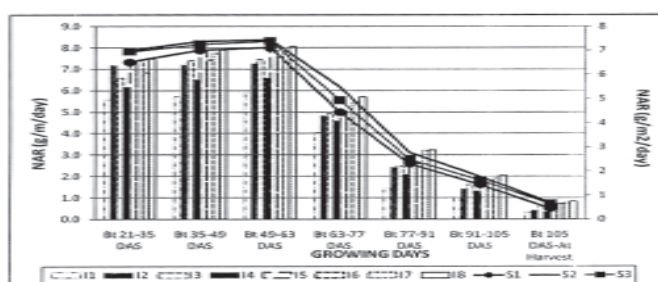


Fig. 3. Effect of levels of irrigation and sulfur on NAR ($\text{g/m}^2/\text{day}$) of plant of groundnut (pooled over two years).

reflected in yield. Similar results were observed by Dey et al. [4]. Similar trends were observed in case of oil yield also [5].

The level of sulfur significantly influenced all yield attributes and yield of groundnut (Table 1). The highest values of yield attributes and pod yield (3.2 t/ha) were recorded when sulfur applied @ 15 kg/ha followed by 30 kg/ha, but they were significantly differ from each other and they produced 64.8% and 37.6% increased pod yield over control, respectively. Increased photosynthesis and their subsequent translocation to storage organ resulted in better yield attributes of groundnut and subsequently, the yield. Similar trend also observed in respect of oil yield. This in conformity with the results of Vaghasia et al. [6].

Soil moisture depletion pattern, consumptive use and water-use efficiency

Soil moisture depletion was higher from first layer (0-15 cm) followed by third layer (30-45 cm) and second layer (15-30 cm), respectively, irrespective of level of irrigation (Table 2). It might be due to greater availability of soil moisture in this layer and the concentration of maximum roots in these layers. It is clearly shown in the Table 2 that the total amount of water was not depleted from the soil by the crop and the rest amount of water was retained in the soil at the time of harvest.

The higher CU and WUE were observed with maximum frequency of irrigation water i.e., three irrigation applied at flowering, pegging and pod filling stage than the lower frequencies (Table 2). It was also observed that CU was more than the amount of water applied through irrigation. This might be due to the fact that besides irrigation schedules, the crop received certain amount of rainfall during growth period. Similar results were observed by Sounda et al. [7].

Net return and benefit : cost ratio

Net return and benefit : Cost ratio were significantly

influenced by levels of irrigation (Table 3). The maximum net return and benefit : cost ratio were produced where three irrigations were applied at flowering, pegging and pod filling stages (I_3) followed by two irrigations at pegging and pod filling stages (I_2) and they were statistically on a par. The similar type of results was obtained by Hosamani and Janawade [8].

The level of sulfur significantly influenced net return and benefit : Cost (Table 3). The maximum net return and benefit : Cost ratio were recorded when sulfur applied @ 15 kg/ha followed by 30 kg/ha and they were significantly differ from each other. Similar type of findings was previously reported by Dutta and Mondal [9].

Thus, it could be concluded that irrigation applied at flowering, pegging and pod filling stage (I_3) along with sulfur applied @ 15 kg/ha gave the highest yield and economic benefit with maximum crop water-use efficiency.

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