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Productivity and nutrient uptake of summer groundnut (*Arachis hypogaea* L.) towards different levels of irrigation and sulphur

U. GIRI, MD. HEDAYETULLAH, A. SAHA, [2]M. K. NANDA AND [1]P. BANDYOPADHYAY

Dept. of Agronomy, College of Agriculture Tripura, Lembucherra-799210, West Tripura,
[1]Dept. of Agronomy, [2]Dept. of Agril. Meteorology and Physics, Faculty of Agriculture,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur - 741252, Nadia, West Bengal

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ABSTRACT

A field experiment was conducted to study the effect of levels of irrigation and sulphur on nutrient uptake (N, P, K and S) from sandy-loam soil, residual soil nutrient status, consumptive water use (CU), water use efficiency (WUE), yield attributes as well as yield of summer groundnut during two consecutive years of 2009 and 2010 at the University research farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal. The experiment composed of 24 treatment combinations (8 irrigation considered as main plot and 3 level of sulphur as sub-plot) in a split plot design replicated thrice. The study revealed that both irrigation and sulphur levels significantly influenced yield attributing characteristics, the pod yield (t ha^{-1}) and nutrient uptake from the soil. Highest values were exhibited when sulphur received the crop @ 15 kg ha^{-1} (S_2). The highest CU (639.04 mm), and WUE (6.16 kg ha^{-1} mm^{-1}) were recorded under three irrigations applied at flowering, pegging and pod filling stage (I_8) followed by two irrigations at pegging and pod filling stage (I_7), respectively. The residual soil fertility status (N, P, K and S) was not significantly influenced by irrigation as well as sulphur levels except the residual sulphur status of the soil. The maximum S status of the soil was recorded under no irrigation condition (I_1) combined with sulphur applied @ 30 kg ha^{-1} (S_3), three irrigations applied at flowering, pegging and pod filling stage (I_8) combined with sulphur applied @ 0 kg ha^{-1} (S_1) was recorded the minimum S fertility status of the soil.

***Keywords*:** Groundnut, irrigation, nutrient uptake, productivity and sulphur

Oilseeds and oils have assumed an importance of their own in the economy of the country. Oilseeds constitute the second major agricultural crop in the country next to food grains in terms of tonnage and value. Groundnut is the major oilseed crop in India which is the largest growing country accounting for 33% of the world's production and 40% of the world's groundnut area, mostly grown during winter as well as summer season under irrigated condition. The ever increasing demand for edible oil calls for enhancing production of oilseed under limited land and water resource following improvised agronomic management.

Economic use of water application at critical physiological growth stages towards moisture scarcity during summer season can save the water as well as nutrient without hampering the potential yield of groundnut (Patra *et al.*, 1998). The groundnut grown on light textured soils generally suffers from sulphur deficiency due to leaching of SO_4^{2-} . The crop responds significantly to the application of sulphur (Singh and Chaudhary, 1995) which is involved in the bio-synthesis of primary metabolites such as methionine, cysteine and cystine amino acid, for improving the yield and quality of oil seed crops that can able to obtain higher yield under balanced fertilization. Therefore, keeping with this view an attempt was undertaken to study the optimum scheduling of irrigation and sulphur for higher groundnut yield and the residual status of nutrients under new alluvial zone of West Bengal during summer seasons.

Email: utpalagro84@gmail.com

MATERIALS AND METHODS

The field experiment was conducted in sandy loam soil of the research farm under Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West (23^{0}N latitude and 89^{0}E longitude, at an elevation of 9.75 m above mean sea level). The experiment was done during pre-*kharif* season in consecutive two years (2009 and 2010) to study the effect of scheduling of irrigation at different physiological growth stages along with varying levels of sulphur on yield, nutrient uptake from soil, residual soil nutrient status, soil moisture depletion pattern, CU, and WUE, respectively. Crop received average rainfall of about 300 mm throughout the growing period. Maximum and minimum temperature during that period were 41^{o}C and 16^{o}C, respectively. The experiment was laid out in a split plot design, having 8 levels of irrigation considered in main plots (I_1 – no irrigation; I_2 – irrigation at flowering stage; I_3 – irrigation at pegging stage; I_4 –irrigation at pod filling stage; I_5 – irrigation at flowering and pegging stage; I_6 – irrigation at flowering and pod filling stage; I_7 – irrigation at pegging and pod filling stage; I_8 – irrigation at flowering, pegging and pod filling stage) and 3 levels of sulphur (S_1 –sulphur @ 0 kg ha^{-1}; S_2 – sulphur @ 15 kg ha^{-1}; S_3 – sulphur @ 30 kg ha^{-1}) in sub-plots, respectively. Source of sulphur fertilizer was elemental sulphur (85%) and cultivar was used 'GPPD-5'.

The recommended dose of fertilizer of N, P_2O_5 and K_2O was applied @ 20:40:40 kg ha^{-1}, respectively. Source of fertilizers were urea, DAP and MOP for N, P_2O_5 and K_2O, respectively. Available N, P and K contents of soil were determined according to modified Kjeldahl method as described by Jackson (1967), Olsen's method and flame photometer method, as described by Jackson (1973), respectively and available S was estimated by turbidimetrically barium chloride procedure as described by Chesnin and Yien, (1950). The statistical analysis was done using the method of Gomez and Gomez (1984).

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

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Yield (kg ha}^{-1})}{\text{ET or CU value (mm)}}$$

ET = Evapotranspiration

CU = Consumptive Use

The weather data was recorded from the laboratory of AICRP on Agro-Meteorology, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, W.B., India.

RESULTS AND DISCUSSION

Level of irrigation

It reveals from the data that all the yield attributing characters of groundnut were significantly influenced by the level of irrigation and the highest values (no. of plants m^{-2}, no. of pods plant^{-1}, no. of kernels pod^{-1}, 100 kernel weight (g) and shelling percentage) were recorded where the crop received irrigation at flowering, pegging and pod filling stage (I_8) followed by the treatment (I_7) where irrigation was applied at pegging and pod filling stage (Table-1). The lowest values of yield attributing characters were recorded where crop grown without irrigation (I_1). This is in conformity with the results of Patra *et al.* (1998) and Ali (2001).

The pod yield (t ha^{-1}) was significantly influenced by the level of irrigation. The highest pod yield (3.94 t ha^{-1}) was recorded under irrigation applied at flowering, pegging and pod filling stage (I_8) followed by irrigation at pegging and pod filling stage (I_7) and they were at per (Table - 1). The lowest pod yield (1.8 t ha^{-1}) was recorded under no irrigation treatment (I_1). This might be due to application of 3 irrigations at important physiologically critical growth stages helps to better utilization of moisture resulting in an increase of yield attributing characters and ultimately yield. Similar results were observed by Jana *et al*. (1989).

The uptake of nutrients (N, P, K and S) by kernel, shell and haulm of groundnut and also total uptake of nutrients (N, P, K and S) by groundnut were significantly influenced by level of irrigation (Table – 2). The maximum uptakes of nutrients were recorded in three irrigations applied at flowering, pegging and pod filling stages (I_8). The minimum uptake of nutrients was recorded in no irrigation (I_1) treatment. Hosamani and Janawade (2006) found similar type of result.

The residual soil fertility status of nutrients (N, P, K and S) was not significantly influenced by level of irrigation except sulphur (Table - 3). The maximum residual soil fertility status of nutrients (N, P, K and S) was recorded in no irrigation (I_1) treatment. However, irrigation applied at flowering, pegging and pod filling stages (I_8) treatment recorded the minimum residual soil fertility status of nutrients (N, P, K and S). These experimental results are conformity with the finding of Hosamani and Janawade (2006).

Levels of sulphur

Yield attributing characteristics were significantly influenced by the level of sulphur also and the highest values of the characters (no. of plants m^{-2}, no. of pods plant^{-1}, no. of kernels pod^{-1}, 100 kernel weight (g) and shelling percentage) were exhibited when sulphur applied @ 15 kg ha^{-1} (S_2) followed by sulphur applied @ 30 kg ha^{-1} (S_3) presented in table – 1. The lowest values of yield attributing characteristics were recorded when sulphur applied @ 0 kg ha^{-1} (S_1). Chaplot *et al.* (1991) also observed the same results.

Table 3: Effect of levels of irrigation and sulphur on residual soil fertility of summer groundnut (Pooled)

Treatment	Nutrient status			
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (ppm)
Level of Irrigation				
I_1	369.92	37.21	204.61	3.66
I_2	349.22	34.25	199.24	2.84
I_3	345.29	33.58	191.94	2.41
I_4	354.71	36.63	200.96	3.58
I_5	336.33	31.26	176.00	1.77
I_6	343.14	31.55	184.17	2.29
I_7	326.24	30.06	170.39	1.48
I_8	306.10	27.77	162.48	1.25
SEm (±)	**32.70**	**3.20**	**11.24**	**0.39**
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**1.28**
CV (%)	**40.64**	**41.41**	**25.61**	**68.88**
Level of sulphur				
S_1	362.38	33.64	192.72	1.48
S_2	312.72	32.03	182.18	2.68
S_3	349.00	32.70	183.77	3.07
SEm (±)	**15.91**	**2.20**	**5.27**	**0.18**
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**0.50**
CV (%)	**32.30**	**46.51**	**19.60**	**51.05**

Pod yield of groundnut (t ha^{-1}) was significantly influenced by the level of sulphur (Table - 1). The highest pod yield (3.21 t ha^{-1}) was recorded when sulphur applied @ 15 kg ha^{-1} (S_2) followed by sulphur applied @ 30 kg ha^{-1} (S_3). The lowest pod yield (1.95 t ha^{-1}) was recorded when sulphur applied @ 0 kg ha^{-1} (S_1). This might be due to increased photosynthate and their subsequent translocation to storage organ resulted in better fill up of production. This is in conformity with the results of Shamsuddin *et al.* (1991) and Suriyapan *et al.* (1985). Similar findings were also observed by Tandon (1984) and Saunda *et al.* (2006).

The uptake of nutrients (N, P, K and S) by kernel, shell and haulm of groundnut and also total uptake of nutrients (N, P, K and S) by groundnut were significantly influenced by level of sulphur (Table – 2). The maximum uptakes of nutrients were recorded in sulphur applied @ 15 kg ha^{-1} (S_2) treatment. The minimum uptake of nutrients was recorded in no sulphur (S_1) treatment. Mishra and Singh (1989) and Panda *et al.* (1997) found similar type of results.

The residual soil fertility status of nutrients (N, P, K and S) was not significantly influenced by level of sulphur except sulphur (Table - 3). The maximum residual soil fertility status of nutrients (N, P and K) was recorded in no sulphur (S_1) treatment. But the sulphur applied @ 30 kg ha^{-1} (S_3) recorded the maximum residual soil sulphur. However, no sulphur (S_1) treatment recorded the minimum residual soil fertility status of sulphur (S).

Table 4: Effect of level of irrigation on soil profile moisture depletion, CU and WUE of groundnut (Pooled)

Irrigation Treatment	Soil profile moisture depletion (%)				CU (mm)	WUE (kg ha^{-1} mm^{-1})
	Depth of soil (cm)					
	0-15	15-30	30-45	45-60		
I_1	54.73	50.41	50.54	45.60	387.00	4.64
I_2	62.11	53.73	60.47	47.04	428.98	4.72
I_3	66.15	58.95	62.00	51.84	458.95	4.85
I_4	64.77	50.97	60.56	47.36	428.70	4.65
I_5	79.19	70.41	75.32	64.08	555.48	5.00
I_6	77.78	67.09	73.18	53.74	521.08	4.96
I_7	82.62	77.79	80.64	72.65	604.23	5.94
I_8	87.99	82.51	87.17	74.24	639.04	6.16

The interaction effect between the levels of irrigation and sulphur was significant on uptake of nitrogen by kernel, shell and total uptake, uptake of phosphorous by kernel, haulm and total uptake, uptake of potash by haulm and total uptake, and uptake of sulphur by kernel and total uptake. Within the same level of sulphur treatment, three irrigations applied at flowering, pegging and pod filling stages (I_8) recorded the maximum values followed by two irrigations at pegging and pod filling stages (I_7). Furthermore, within an irrigation treatment, sulphur applied @ 15 kg ha^{-1} (S_2) recorded the maximum values followed by sulphur @ 30 kg ha^{-1} (S_3). Irrespective of levels of irrigation and sulphur, the maximum values were recorded under three irrigations applied at flowering, pegging and pod filling stages (I_8) in combination with sulphur applied @ 15 kg ha^{-1} (S_2) treatment.

Effect of levels of irrigation and sulphur on the soil moisture depletion pattern, CU and WUE

Moisture depletion pattern of groundnut crop was influenced by irrigation levels. The data presented in the (Table-4) show that an increase in depth of soil, gradually decreased the soil moisture depletion pattern from second layer at all the levels of irrigation till the last depth of observation recorded. More amount of soil moisture utilization by the crop from surface (0-15 cm) layer might be due to more root concentration in this layer. Soil moisture depletion was maximum under irrigation applied at flowering, pegging and pod filling stage (I_8). The lowest depletion of soil moisture at different depths was found in under no irrigation treatment (I_1).

The lowest CU (387.0 mm), and WUE (4.64 kg ha^{-1} mm^{-1}) (Table-4) were recorded under no irrigation treatment (I_1) and the highest CU (639.04 mm), and WUE (6.16 kg ha^{-1} mm^{-1}) were recorded under irrigation applied at flowering, pegging and pod filling stage (I_8) followed by irrigation at pegging and pod filling stage (I_7). Similar results were observed by Chavan *et al.* (1999) and Reddy and Reddy (1993). Raskar and Bhoi (2003) also followed the same results.

Thus, it could be concluded from the experimental results that irrigation applied at flowering, pegging and pod filling stage (I_8) along with the application of sulphur @ 15 kg ha^{-1} (S_2) gave the best result with maximum crop water-use efficiency, maximum nutrient uptake and minimum residual soil fertility status in the region.

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