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EFFECT OF MOISTURE REGIMES AND GYPSUM LEVELS ON GROWTH, SOIL MOISTURE, WATER USE EFFICIENCY AND ECONOMICS OF RABI GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

During Rabi 2021, a field study was carried out at Kishi Vignan Kendra, Palem, Nagarkurnool district, Telangana state, India to examine the effects of gypsum levels and moisture regimes on groundnut. Three moisture regimes (0.6, 0.8 and 1.0 IW/CPE ratios) and five gypsum fertilizer levels (G₀-control, G₁: Gypsum @ 300 kg ha⁻¹, G₂: Gypsum @ 400 kg ha⁻¹, G₃: Gypsum @ 500 kg ha⁻¹ and G₄: Gypsum @ 600 kg ha⁻¹) were combined in the split plot experiment, which was replicated three times. On December 24, 2021, the groundnut variety Kadiri Lepakshi 1812 one seed hill⁻¹ was planted at a spacing of 30 x 10 cm. All treatments received the recommended NPK at 30: 40: 50 kg ha⁻¹. N, P and K were applied through urea, DAP and muriate of potash respectively. I₃ (1.0 IW/CPE) had the highest plant height at 90DAS (26.30 cm) among the moisture regimes, while gypsum application at 600 kg ha⁻¹ had the highest plant height at harvest (27.4). I₃ (1.0 IW/CPE ratio) had the highest measured applied irrigation water of 500 ha.mm, followed by I₂ (0.8 IW/CPE ratio) (450 ha.mm) and I₁ (0.6 IW/CPE ratio) (400 ha.mm). Compared to other treatments, field (4.16 kg ha.mm⁻¹) and crop (4.10 kg ha.mm⁻¹) water use efficiencies were significantly greater with 1.0 IW/CPE. The water use efficiencies of the field (4.71 kg ha.mm⁻¹) and crop (4.42 kg ha.mm⁻¹) were significantly higher when 600 kg ha⁻¹ of gypsum was applied. The economics of groundnuts as they influence by gypsum levels and moisture regimes showed that at the I₃ (1.0 IW/CPE) irrigation level, higher gross returns (139521 Rs. ha⁻¹), net returns (87410 Rs. ha⁻¹) and benefit-cost ratios (2.65) were seen. Under I₁ (0.6 IW/CPE) the benefit-cost ratio (2.14), net returns (56714 Rs. ha⁻¹) and gross returns (107225 Rs. ha⁻¹) were all lower. Gypsum application at 600 kg ha⁻¹ was associated with higher benefit-cost ratio (2.53), net returns (80386 Rs. ha⁻¹) and gross returns (133309 Rs. ha⁻¹).

Keywords : Moisture Regimes, Gypsum Levels, Soil Moisture, Water Use Efficiency, Groundnut (*Arachis hypogaea* L.).

Introduction

In India, groundnut (*Arachis hypogaea* L.) is a major vegetable oilseed and protein crop that gives millions of people vital nourishment. It is grown on around 21.8 million hectares worldwide as of 2021, with more over 70% of the area being in China, India and the United States. Within India, during the 2019–2020 season, groundnut was cultivated on around 4.82 million ha, yielding nearly 9.95 million tonnes at an average productivity of 2.06 tonnes ha⁻¹. This

corresponds to 0.11 million hectares under cultivation in Telangana, yielding 0.26 million tons with a productivity of 2.39 tons per hectare ha⁻¹. Despite its significance, inefficient fertilizer management and primarily rainfed production continue to limit groundnut productivity. A strategic application of irrigation based on the irrigation-water to cumulative pan evaporation (IW/CPE) ratio has shown successful in lowering water use while increasing yield by 15–20% under *rabi* season circumstances compared to

kharif. In particular, insufficient irrigation lowers yields.

The yield potential of recently released high-yielding groundnut cultivars is also being increasingly limited by the depletion of soil minerals, particularly calcium and sulfur. With its ability to supply calcium (~23%) and sulfur (~18.7%) and its critical function in pod filling, seed quality, oil and protein synthesis, gypsum application is a cost-effective agronomic intervention. When applied promptly, it increases the quantities of sulfur-containing amino acids (methionine, cysteine) improves seedling vigor, pod development kernel quality and enhances the overall nutritional and commercial value. Increasing knowledge on soil-plant-water dynamics under various moisture regimes and measuring crop responses to various nutrient management strategies are important for maximizing groundnut yield in Telangana's traditional production zones.

A promising route to greatly increased yield and quality is provided, in particular, by fine-tuning mineral nutrition using gypsum and other inputs and optimizing irrigation scheduling with IW/CPE-based regimes. In order to maximize groundnut productivity under the current agroclimatic conditions, this study aims to combine different approaches and provide a robust package of practices.

Materials and Methods

The materials and procedures used during the current study are briefly described here. A field experiment was conducted in Krishi Vigyan Kendra in Palem, Nagarkurnool district, during *Rabi* 2021 (December 24 - April 23). The experimental site is 478 meters above mean sea level and is located at 16°31'07.4"N latitude and 78°15'04.6"E longitude. The goal of the current study is to examine how gypsum levels and moisture regimes affect the growth and yield of the *rabi* groundnut variety Kadirī Lepakshi-1812. The experiment was laid out in split plot design. The soil samples were taken from a depth of 0-30 cm and their physical and chemical characteristics were analyzed using standard procedures. The results showed that the soil had a pH of 7.1 and was medium in available nitrogen (260 kg ha⁻¹) by the alkaline permanganate method, phosphorus (25.3 kg ha⁻¹) by Olsen's method and potassium (201 kg ha⁻¹) by neutral ammonium acetate. Three moisture regimes (0.6 IW/CPE, 0.8 IW/CPE, and 1.0 IW/CPE) and five gypsum levels (G₀-control, G₁-300 kg ha⁻¹, G₂-400 kg ha⁻¹, G₃-500 kg ha⁻¹, and G₄-600 kg ha⁻¹) comprised the experiment into fifteen treatment combinations. To supply 30 kg N, 40 kg P₂O₅ and 50 kg K₂O ha⁻¹

fertilizers such as urea, DAP (for N and P) and MOP (for K₂O) were applied. Before planting, all of the phosphorus, potash, and half of the nitrogen (urea) were evenly distributed and mixed into the soil. Depending on the times of irrigation according to the treatment schedule, the remaining half dose of nitrogen was top dressed by band placement 25–30 days after sowing. Crops was sown at a row distance of 30 cm and 10 cm plant to plant. The crop was harvested in the fourth week of April after being sowed in the fourth week of December. Weekly mean minimum temperatures ranged from 15°C to 24.8°C with an average of 19.6°C during the crop-growing season, while weekly mean maximum temperatures ranged from 29°C to 38.9°C with an average of 34.2°C in 2021–2022. Rainfall averaged 0.6 mm and mean evaporation averaged 6.6 mm per day. In each net plot area, five plants were chosen at random to observe growth and yield-attributing characteristics. The plant samples were initially allowed to dry in the shade before being heated to 60°C in an electric oven until their weight remained constant. Based on this weight, the samples were then transformed into dry matter production (kg ha⁻¹). Total number of pods (filled and unfilled pods) from ten labelled plants in each treatment was counted, averaged and expressed as number of pods plant⁻¹. Three distinct random pod samples weighing 250 g each were selected, their kernels separated and their weights noted. To determine the shelling %, the kernel weight to pod weight ratio was calculated for each treatment. A sample of pods with an unknown weight was chosen from the net plot production in order to determine the test weight. The pods were shelled and the kernels were separated in order to estimate the weight of one hundred sound kernels. After being sun-dried from the produce in the net plot, the pods and haulm were weighed and quantified in kilograms per hectare in order to evaluate their yield. Data was recorded on the growth characteristic, which includes dry matter production (kg ha⁻¹), yield attributes and yield (kg ha⁻¹). As recommended by Panse and Sukhatme, statistical analysis was performed on the collected data.

Results and Discussions

Growth Parameters

Plant height (cm)

Before the gypsum was applied (30 DAS), the treatments had no effect on plant height. It did however, rise linearly from 60 DAS until harvest since plant height scaled up steadily but more slowly until maturity.

Effect of Moisture Regimes

The results regarding plant height at before gypsum application (30 DAS), 60, 90 DAS and at harvest. At every stage of growth, with the exception of the time prior to gypsum treatment, plant height was significantly impacted by moisture regimes. Plant height values were higher in the I₃ (1.0 IW/CPE) treatment than in the I₁ (0.6 IW/CPE) treatment. Plant height was shown to be non-significant across various moisture regimes at 60 DAS and harvest. At 90 DAS however, the I₃ (1.0 IW/CPE) treatment had a noticeably greater plant height value (26.30 cm) than the I₂ (0.8 IW/CPE) and I₁ (0.6 IW/CPE) treatments. Rather of timing irrigation through critical stages (I₁) alone, the increase in plant height may be due to optimal soil moisture availability encouraging nutrient uptake and resulting in higher growth. It was comparable to the results of Bhoi *et al.* (1993) and Pawar *et al.* (2013), who discovered that the tallest plants were seen when irrigation was scheduled at ratios of 75 mm CPE and 1.05 IW/CPE.

Effect of Gypsum

The data on plant height at before gypsum application (30 DAS), 60 and 90 DAS and at harvest reveals that gypsum application caused substantial changes in plant height at all phases of crop growth. Whereas at before gypsum application (30DAS), 60 DAS and at harvest it is found to be non-significant and at 90 DAS G₄ (Gypsum @ 600 kg ha⁻¹) showed significantly higher value (27.40 cm) of plant height over the other gypsum treatments. The plant height was highest (27.40 cm) with G₄ (gypsum 600 kg ha⁻¹) compared to other gypsum level treatments. This may be owing to the availability of sulphur and calcium through gypsum application which favoured the plant height. However shortest plant height (24.77 cm) was recorded with G₀-(control) at 90 DAS. The increase in plant height could be attributed to well-balanced nutrition in combination with adequate secondary nutrients such as calcium and sulphur supply viz., gypsum. Calcium may have aided in soil conditioning and as a result it boosted shoot growth. Gypsum includes sulphur (14%) and calcium (18%), which may favor the plant height. Similar views were held by Kannan *et al.* (2017) and Ramya and Singh (2022). Plant height was unaffected by the interaction between gypsum levels and moisture regimes.

Soil moisture studies

Total irrigation water applied

With ten (I₃), nine (I₂) and eight (I₁) irrigations, respectively and one irrigation to all treatments the day before harvesting, I₃ (1.0 IW/CPE) had the highest

applied irrigation water measured at 500 ha.mm, followed by I₂ (0.8 IW/CPE) (450 ha.mm) and I₁ (0.6 IW/CPE) (400 ha.mm). Groundnuts responded favorably to applied irrigation water at 1.0 IW/CPE ratio when the volume of irrigation water increased. These findings were found to be comparable to those of Kumar *et al.* (2000) and Sanjay *et al.* (2006). Before and after every irrigation, as well as right after incident of rainfall, a soil sample was taken to measure the moisture content of the soil. I₃ had the greatest soil moisture depletion, followed by I₂ and I₁.

Crop Evapotranspiration (Crop ETc)

Table 2 displayed the groundnut crop's evapotranspiration (ETc). In comparison to previous treatments, I₃ (1.0 IW/CPE) produced a greater value (525 mm) of crop ETc. There was a noticeable decrease in ETC when the amount of water utilized for irrigation was decreased. These findings closely matched those of Taha and Gulati (2001) and Hemalatha *et al.* (2004).

Reference evapotranspiration (Crop ETo)

The reference evapotranspiration values were displayed in Table 2. The crop's flowering-pegging and pod initiation stage (41-90 DAS) had the highest reference evapotranspiration (287.3 mm) when compared to other vegetative phases (0-40 DAS) and pod filling until maturity (91-120 DAS). According to Taha and Gulati (2001), the lowest reference evapotranspiration was reported at the vegetative stage (126.2 mm).

Crop coefficients (K_c)

The Table 2 provided information on crop coefficients for the vegetative stage (0–40 DAS), flowering–pegging and pod initiation (41–90 DAS) and pod filling to maturity stage (91–120 DAS). Crop coefficient K_c is the best-known approach for explaining yield as a function of ETc. In other words, it is the prediction of ETc requirement of the crop (ETc = K_c x ETo) not just as a simple value for the season, but as a cumulative value over time which shows the differential ETc needs in each individual crop growth sub phase (Mote *et al.*, 2018). Crop coefficients (K_c) were a function of water supply. The highest crop coefficient value recorded at flowering- pegging and pod initiation stage (41-90 DAS) of crop compared to other vegetative (0-40 DAS) and pod filling to maturity (91-120 DAS) stages. At 0-40 DAS, K_c values were low, due to incomplete canopy cover which might be accounted for the maximum water loss through evaporation from the bare soil. However, with the advancement of the crop age, the ratio increased accordingly up to 41- 90 DAS (flowering-pegging and

pod initiation stage) which represent the peak value of crop coefficient throughout the crop growth cycle. This reflects the increased water loss due to increased transpiring surface as a consequence of rapid leaf development and also indicates the maximum water need of the crop as a consequence of full canopy cover intercepting maximum incident photosynthetically active radiation (PAR). Later, the crop coefficient value decreased towards maturity stage, which reflects the senescence of the leaves and reduced root activity. These outcomes were similar to those that Hemalatha *et al.* (2004) reported.

Field water use efficiency (FWUE) and crop water use efficiency (CWUE)

Table 3 displays information on crop water use efficiency (CWUE) and field water use efficiency (FWUE) as impacted by various moisture regime treatments and gypsum levels. The results showed that both gypsum levels and moisture regimes had a considerable impact on FWUE and CWUE.

Effect of moisture regimes

The treatment I₃ (1.0 IW/CPE ratio) had field and crop water consumption efficiencies of 4.16 and 4.05 kg ha.mm⁻¹, which were considerably higher than I₂ (4.13 and 4.10 kg ha.mm⁻¹ respectively) across the moisture regimes. The irrigation I₁ (0.6 IW/CPE) ratio showed the lowest field and crop water consumption efficiency (3.98, 3.40 kg ha.mm⁻¹).

Effect of Gypsum levels

The efficiency of crop and field water consumption was strongly impacted by gypsum levels. When compared to other treatments, the field and crop water efficiencies for G₄ (Gypsum @ 600 kg ha⁻¹) were noticeably higher at 4.42 and 4.71 kg ha.mm⁻¹. Moisture regimes and gypsum levels were found to have a significant interaction effect on crop (4.73 kg ha.mm⁻¹) and field (4.80 kg ha.mm⁻¹) water use efficiencies with I₃ (1.0 IW/CPE) and G₄ (Gypsum @ 600 kg ha⁻¹) that was comparable to I₂ (0.8 IW/CPE) in terms of field water use efficiency (4.70 and 4.63 kg ha.mm⁻¹). These results were consistent with those of Naresha *et al.* (2018).

Table 1: Plant height (cm) of *rabi* groundnut as influenced by moisture regimes and gypsum levels

Treatments	Plant height (cm)			
	Before gypsum (30 DAS)	60 DAS	90 DAS	At harvest
Moisture Regimes (I)				
I1- 0.6 IW/CPE	12.26	19.74	25.74	26.38
I2- 0.8 IW/CPE	12.26	19.80	25.86	26.66
I3- 1.0 IW/CPE	12.32	19.90	26.30	26.79
SEm ±	0.10	0.13	0.10	0.16
CD (P=0.05)	NS	NS	0.42	NS
Gypsum levels (G)				
G0- Control	12.11	19.20	24.77	25.98
G1- Gypsum @ 300 kg ha ⁻¹	12.23	19.51	25.31	26.35
G2- Gypsum @ 400 kg ha ⁻¹	12.33	19.73	25.72	26.44
G3- Gypsum @ 500 kg ha ⁻¹	12.31	19.86	26.60	26.81
G4- Gypsum @ 600 kg ha ⁻¹	12.42	20.77	27.40	27.46
SEm±	0.12	0.16	0.15	0.16
CD (P=0.05)	NS	NS	0.46	NS
Interaction (I X G)				
Sub treatment at same level of main treatment				
SEm±	0.22	0.29	0.23	0.36
CD (P= 0.05)	NS	NS	NS	NS
Main treatment at same or different level of sub treatment				
SEm±	0.21	0.29	0.26	0.30
CD (P=0.05)	NS	NS	NS	NS

Table 2 : Crop evapotranspiration (Crop ETc), Reference evapotranspiration (Crop ET0) and Crop coefficients (Kc) of *rabi* groundnut as influenced by irrigation treatments

Growth stages	ETC (mm)			ET0 (mm)	KC		
	I1 (0.6 IW/CPE)	I2 (0.8 IW/CPE)	I3 (1.0 IW/CPE)		I1 (0.6 IW/CPE)	I2 (0.8 IW/CPE)	I3 (1.0 IW/CPE)
Vegetative (0- 40 DAS)	88.3	88.3	100.9	126.2	0.7	0.7	0.8
Flowering – pegging and pod initiation (41- 90 DAS)	258.5	258.5	287.3	287.3	0.9	0.9	1.0
Pod filling to maturity (91- 120 DAS)	119.7	119.7	136.8	171.0	0.7	0.7	0.8
Total	466.5	466.5	525.0	584.5	2.3	2.4	2.7

Table 3 : Crop and field water use efficiencies (kg ha.mm⁻¹) of *rabi* groundnut as influenced by moisture regimes and Gypsum levels

Treatments	CWUE (kg ha. mm ⁻¹)	FWUE (kg ha. mm ⁻¹)
Moisture Regimes (I)		
I1- 0.6 IW/CPE	3.40	3.98
I2- 0.8 IW/CPE	4.05	4.13
I3- 1.0 IW/CPE	4.10	4.16
SEm ±	0.03	0.03
CD (P=0.05)	0.13	0.12
Gypsum Levels (G)		
G0- Control	3.30	3.50
G1- Gypsum @ 300 kg ha ⁻¹	3.64	3.86
G2- Gypsum @ 400 kg ha ⁻¹	3.84	4.08
G3- Gypsum @ 500 kg ha ⁻¹	4.06	4.31
G4- Gypsum @ 600 kg ha ⁻¹	4.42	4.71
SEm±	0.03	0.03
CD (P=0.05)	0.09	0.10
Interaction (I X G)		
Sub treatment at same level of main treatment		
SEm±	0.07	0.06
CD (P= 0.05)	0.18	0.19
Main treatment at same or different level of sub treatment		
SEm±	0.06	0.06
CD (P=0.05)	0.19	0.19

Table 3(a) : Crop water use efficiency (Kg ha.mm⁻¹) of *rabi* groundnut as influenced by interaction between moisture regimes and gypsum levels

Gypsum Levels	Moisture Regimes			MEAN
	I1 (0.6 IW/CPE)	I2 (0.8 IW/CPE)	I3 (1.0 IW/CPE)	
G0- Control	2.80	3.50	3.60	3.30
G1- Gypsum @ 300 kg ha ⁻¹	3.16	3.90	3.86	3.64
G2- Gypsum @ 400 kg ha ⁻¹	3.40	4.13	4.00	3.84
G3- Gypsum @ 500 kg ha ⁻¹	3.60	4.26	4.33	4.06
G4- Gypsum @ 600 kg ha ⁻¹	4.06	4.46	4.73	4.42
MEAN	3.40	4.10	4.05	
Sub treatment at same level of main treatment				
SEm±				0.07
CD (P=0.05)				0.18
Main treatment at same or different level of sub treatment				
SEm±				0.06
CD (P=0.05)				0.19

Table 3 (b): Field water use efficiency (kg ha.mm⁻¹) of *rabi* groundnut as influenced by interaction between moisture regimes and gypsum levels

Gypsum Levels	Moisture Regimes			
	I1 (0.6 IW/CPE)	I2 (0.8 IW/CPE)	I3 (1.0 IW/CPE)	MEAN
G0- Control	3.30	3.50	3.70	3.50
G1- Gypsum 300 Kg ha ⁻¹	3.73	3.98	3.93	3.86
G2- Gypsum 400 Kg ha ⁻¹	4.00	4.16	4.10	4.08
G3- Gypsum 500 Kg ha ⁻¹	4.20	4.26	4.46	4.31
G4- Gypsum 600 kg ha ⁻¹	4.63	4.70	4.80	4.71
MEAN	3.98	4.13	4.16	
Sub treatment at same level of main treatment				
SEm±				0.06
CD (P=0.05)				0.19
Main treatment at same or different level of sub treatment				
SEm±				0.06
CD (P=0.05)				0.19

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