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Effect Off Moisture Regimes and Phosphogypsum Levels on Yield, Nutrient Uptake and Soil Nutrient Balance of *Rabi* Groundnut

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ABSTRACT

The field experiment was conducted at College farm, Acharya N.G. Ranga Agricultural University (now Professor Jayashankar Telangana State Agricultural University), Rajendranagar, Hyderabad during *rabi* 2013-14 to study the influence of three moisture regimes *viz.*, 0.6, 0.8 and 1.0 IW/CPE ratios and five phosphogypsum levels *viz.*, Control (500 kg ha^{-1} gypsum at flower initiation), Phosphogypsum @ 250 kg ha^{-1} at flower initiation, Phosphogypsum @ 250 kg ha^{-1} (½ as basal and ½ at flower initiation), Phosphogypsum @ 500 kg ha^{-1} (½ as basal and ½ at flower initiation) and Phosphogypsum @ 500 kg ha^{-1} at flower initiation and was replicated thrice. Among moisture regimes highest yield, nutrient uptakes were obtained with $\mathbf{I_3}$ (1.0 IW/CPE) moisture regime but highest available nutrients in soil after harvest of groundnut were recorded with $\mathbf{I_1}$ (0.6 IW/CPE) moisture regime. Among phosphogypsum levels highest yield, nutrients uptake and available nutrients in soil after harvest of groundnut were obtained with Pg_5: Phosphogypsum @ 500 kg ha^{-1} at flower initiation.

Highlights

- Scheduling irrigation at $\mathbf{I_3}$ (1.0 IW/CPE) and phosphogypsum @ 500 kg ha^{-1} at flower initiation resulted in higher yield attributes, yields and uptake of nutrients in *rabi* groundnut under semi- arid climate of Hyderabad.
- After harvest of rabi groundnut the highest final soil nutrients (i.e., Nitrogen, Phosphorus, Potasium, Sulphur and Calcium) were recorded under scheduling irrigation $\mathbf{I_1}$ (0.6 IW/CPE) and among phosphogypsum levels the highest final soil nutrients were recorded under phosphogypsum @ 500 kg ha^{-1} at flower initiation.

Keywords: Phosphogypsum, moisture regimes, groundnut, nutrient uptake, IW/CPE, soil nutrient balance

Groundnut is an important oil and protein source to a large portion of the population in India. It is an annual, herbaceous legume and considered as king of vegetable oil seed crops in India and occupies a pre-eminent position in national edible oil economy. Groundnut seed contain 47-53 per cent oil, 26 per cent protein and 11.5 per cent starch. It is currently grown in an area of 42 Million hectares over the globe. Cultivation of groundnut under rainfed conditions and imbalanced nutrient management are the main reasons for low productivity of groundnut in Andhra Pradesh. Irrigation water, a crucial input in crop production is scarce and expensive. Efficient use of this input is essential which can be achieved through judicious water management practices. Adequate and timely supply of water is essential for higher yields. Keeping the total quantity of irrigation water constant, increasing the frequency of irrigation would maximize the yield in groundnut (Giri *et al*. 2017).

Groundnut is grown during rainy, winter and summer seasons in India. The average productivity is relatively low in rainy season. Groundnut has specific moisture needs due to its peculiar feature of producing pods underground. In groundnut early moisture stress restricts the vegetative growth which in turn reduces the yield and at the peak flowering and pegging period is most sensitive as the peg cannot penetrate through dry and hard surface. The *rabi* crop avails the residual moisture and the scanty rainfall during winter and produces substantial yield as compared to the *kharif* crop and few supplementary irrigations would improve the yield. Because of high productivity under assured irrigation, groundnut cultivation in *rabi* season is gaining popularity in irrigation scheduling, a climatologically approach based on IW/CPE ratio (IW- irrigation water, CPE- Cumulative pan evaporation) has been found most appropriate. This approach integrates all the weather parameters that determine water use by the crop and is likely to increase production at least 15-20%. Optimum scheduling of irrigation led to increase in pod yield and water use efficiency (WUE) (Taha and Gulati 2001).

To ensure increased yields of *rabi* groundnut in traditional areas of Andhra Pradesh and Telangana it is necessary to have a thorough understanding of the changes in the soil-plant-water relations and various morpho-physiological processes in relation to scheduling of irrigation water. Studies on various aspects of groundnut nutrition are limited particularly under varied soil moisture regimes, hence efforts are needed to quantify the crop response *vis-à-vis* at different nutrient levels.

Among the sources of sulphur, phosphogypsum is cheaper and potential sulphur source. It is a solid waste by-product of the wet phosphoric acid production from rock phosphate. Approximately 5.5 Million tonnes of phosphogypsum is discharged for every 1 Million tonnes of phosphoric acid production. In India, 6 to 8 Million tonnes of phosphogypsum is produced annually which supplies 1 to 1.5 Million tonnes of sulphur and 1.5 to 2 Million tonnes of calcium. Phosphogypsum contains 16 per cent sulphur and 21 per cent calcium along with some amount of phosphorus (0.2-1.2 % P_2O_5), trace amounts of silica (SiO_2), iron (Fe_2O_3), aluminium (Al_2O_3), sodium (Na_2O), potassium (K_2O) and some heavy metals.

The phosphogypsum, unlike other sulphur sources, offers all desirable agronomic features of an efficient sulphur fertilizer besides supplying calcium that is readily available to the growing plant, while elemental sulphur and organic sulphur must undergo microbial conversion before sulphur is made available to plants, but the sulphur in phosphogypsum becomes readily available in sulphate form. At the same time, sulphate form is kept available for a longer period due to its low solubility in water. Most of the other sulphate salts that are used for fertilizer are highly soluble and the sulphate may be leached from the soil before the plant removal (Biswas and Sharma 2008).

In spite of additional nutritional value, a high proportion is either dumped or staked for increasing concern to the risk of exposure to radiation. However, the relative radiation risk to people or the environment falls significantly below the level of radiation to which we are exposed through Naturally Occurring Radioactive Material (NORM). Hence, it may not be prudent, therefore, to allow such wastage of this large sulphur and calcium rich by-product (16% S and 21% Ca) in the back drop of wide spread sulphur and calcium deficiencies in Indian soils (Biswas and Sharma 2008). Keeping this in view, this study was taken.

MATERIALS AND METHODS

Field experiment was conducted at College farm, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad during *rabi* 2013-14 on sandy loam soil having low organic carbon (0.53 %) and available nitrogen (238.33 kg ha^{-1}), medium available phosphorous (29.33 kg ha^{-1}), sulphur and calcium (14.30 and 10.00 kg ha^{-1}), high potassium (423.36 kg ha^{-1}) and neutral in reaction.

The experiment was laid out in split plot design with combinations of three moisture regimes *viz*., 0.6, 0.8 and 1.0 IW/CPE ratios and five phosphogypsum fertilizer levels *viz*., Pg_1: Control (500 kg ha^{-1} gypsum at flower initiation), Pg_2: Phosphogypsum @ 250 kg ha^{-1} (at flower initiation), Pg_3: Phosphogypsum @ 250 kg ha^{-1} (½ as basal and ½ at flower initiation),

Pg_4: Phosphogypsum @ 500 kg ha^{-1} (½ as basal and ½ at flower initiation), Pg_5: Phosphogypsum @ 500 kg ha^{-1} (at flower initiation) and was replicated thrice. Groundnut variety K-6 (Kadiri-6) was sown on 10-10-2013 at a spacing of 22.5 cm × 10 cm with one seed $hill^{-1}$. Recommended N P K applied to all the treatments uniformly @ 30: 50: 50 kg ha^{-1}. Nitrogen and Phosphorus applied through urea and DAP, potassium through muriate of potash. Whole quantity of phosphorus and potassium and ½ nitrogen applied as basal and remaining ½ Nitrogen as top dressing at 25-30 DAS. Mean maximum and minimum temperatures were 32.8°C and 22.1°C respectively and 282.2 mm rainfall was received in 11 rainy days during the crop growing period. Mean bulk density and total available soil moisture in 60 cm depth of soil was 1.6 g cm^{-3} and 127.6 mm respectively. Mean moisture percentage at field capacity and permanent wilting point was 19.2 and 5.9. The total applied irrigation water was 267, 222 and 178 ha.mm for IW/CPE ratio of 1.0, 0.8 and 0.6 respectively. Five, four and three irrigations were given to IW/CPE ratio of 1.0, 0.8 and 0.6 respectively along with one irrigation to all treatments one day before harvesting. For every irrigation, 50 mm of water was applied using water meter in closed channels. Daily readings of evaporation were recorded from USWB class "A" open pan evaporimeter and irrigations were scheduled based on IW/CPE ratios.

RESULTS AND DISCUSSION

The data pertaining to yield attributes was presented in Table 1. Yield attributes *viz.,* number of pods $plant^{-1}$, 100 kernel weight (g), shelling percentage were significantly higher with moisture regime at I_3 (1.0 IW/CPE) and it was on par at I_2 (0.8 IW/CPE) only with number of pods $plant^{-1}$, 100 kernel weight (g), shelling percentage but superior over other treatments. Frequent irrigation under I_3 treatment might have created favorable moisture conditions for the crop growth consequently increased the values of the yield attributes than other treatments (I_1 and I_2). These results are in close conformity with the findings of Santosh Behera *et al*. (2015), Patel *et al*. (2009) and Dey *et al.* (2007).

Among the phosphogypsum levels, application of phosphogypsum @ 500 kg ha^{-1} at flower initiation recorded significantly maximum yield attributes and statistically on par with application of gypsum @ 500 kg ha^{-1} at flower initiation with all yield attributes except number of pods $plant^{-1}$. Among yield attributes interaction between moisture regimes and phosphogypsum levels was significant with number of pods $plant^{-1}$. Significantly highest number of pods $plant^{-1}$ (15.8) observed at interaction of I_3 (1.0 IW/CPE) and phosphogypsum @ 500 kg ha^{-1} at flower initiation (Pg5) fallowed by I_2Pg_5 and I_3Pg_2 respectively. Lowest number of pods $plant^{-1}$ (12.2) recorded at interaction of I_1Pg_3 (0.6 IW/CPE) (phosphogypsum @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation) (Table 1.a). The marked improvement in yield attributes might be due to balanced nutrition and efficient and greater partitioning of metabolites and adequate translocation of nutrients to the developing reproductive parts resulting in the production of greater pod number and shelling percentage These results are in close conformity with the findings of Surendra singh and Singh (2016), Somnath Chattopaddhyay and Goutam Kumar Ghosh (2012), Rout and Jena (2009) and Dey *et al.* (2007).

The data pertaining to groundnut pod and haulm yield were presented in Table 1. The highest pod and haulm yields (21.5 and 38.4 q ha^{-1}) were recorded when irrigation was scheduled at I_3 (1.0 IW/CPE), which was on par with I_2 (0.8 IW/CPE) treatment and both were significantly superior from remaining levels of irrigation. The lowest yields (17.4 and 32.3 q ha^{-1}) were regarded with I_1 (0.6 IW/CPE) treatment compared to other treatments. The higher pod and haulm yields with more frequent irrigation (I_3) might have accounted for their favorable influence on the growth (plant height, number of branches per plant, dry matter accumulation and leaf area index, respectively) and yield attributing characters (number of pods per plant, number of kernels pod^{-1}, 100 kernel weight, respectively). Pod and haulm yield of groundnut was significantly increased with increase in the frequency of irrigation which was ascribed to adequate moisture availability in turns have favored congenial conditions for the luxurious growth of crop and consequently increased the values of the yield attributes with I_3 compare to I_2 and I_1 treatments. These results are in close conformity with the findings of Santosh Behera *et al*. (2015) and Suresh *et al.* (2013).

Table 1: Yield and yield attributing characters of *rabi* groundnut as influenced by moisture regimes and phosphogypsum levels

Treatments	Yield Attributes			Yield (kg ha^{-1})	
	No. of Pods Plant^{-1}	100 Kernel Weight (g)	Shelling %	Pod yield	Haulm Yield
MOISTURE REGIMES (I)					
I_1-0.6 IW/CPE	13.0	40.1	64.7	1742	3234
I_2-0.8 IW/CPE	13.7	41.0	68.0	2081	3719
I_3-1.0 IW/CPE	14.1	41.4	69.8	2147	3799
SEm±	0.1	0.2	0.8	18	28
CD (P=0.05)	0.5	0.8	3.2	73	109
PHOSPHOGYPSUM LEVELS (Pg)					
Pg_1-Gypsum @ 500 kg ha^{-1} at flower initiation	13.7	41.3	68.2	2060	3665
Pg_2-PG @ 250 kg ha^{-1} at flower initiation	13.3	40.2	66.8	1958	3556
Pg_3- PG @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation	13.0	40.0	64.9	1795	3444
Pg_4- PG @ 500 kg ha^{-1} ½ as basal and ½ at flower initiation	13.4	40.7	67.1	2001	3555
Pg_5- PG @ 500 kg ha^{-1} at flower initiation	14.6	42.1	70.6	2136	3701
SEm±	0.1	0.4	0.8	20	55
CD (P=0.05)	0.4	1.0	2.4	59	161
INTERACTION (I × Pg)					
Sub treatments at same level of main treatments					
SEm±	0.3	0.5	1.9	41	62
CD (P=0.05)	0.8	NS	NS	36	287
Main treatments at same level of sub treatments					
SEm±	0.3	0.6	1.5	111	90
CD (P=0.05)	0.8	NS	NS	116	270

Among the phosphogypsum levels, application of phosphogypsum @ 500 kg ha^{-1} at flower initiation were recorded maximum pod and haulm yields (21.4 and 37.6 q ha^{-1}) but in which only haulm yield was on par with gypsum application @ 500 kg ha^{-1} at flower initiation. Lowest pod and haulm yields (17.9 and 34.4 q ha^{-1}) were recorded under Pg_3 (phosphogypsum @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation) treatment. Phosphogypsum application @ 500 kg ha^{-1} at flowering stage might have ensured adequate supply of calcium and sulphur, have favored in pod formation.

The results of the experiment clearly suggest that phosphogypsum is also efficient in increasing the pod and yield of groundnut similar to that of gypsum. The higher pod and haulm yield with application of phosphogypsum @ 500 kg ha^{-1} might attributed for their favorable influence on the yield. As phosphogypsum has relatively low solubility as compared to highly soluble S carriers, availability of S is made for a longer period. These results are in close conformity with the findings of Surendra Singh and Singh (2016), Somnath Chattopaddhyay and Goutam Kumar Ghosh (2012) and Rout and Jena (2009).

The interaction of moisture regimes and phosphogypsum levels on pod and haulm yields data presented in Table 1.b. The interaction effect between moisture regimes and phosphogypsum levels showed that significantly highest pod yield (23.03 q ha^{-1}) observed at interaction level I_3 (1.0 IW/CPE) and phosphogypsum @ 500 kg ha^{-1} at flower initiation (Pg_5), which was on par with I_3Pg_1, I_2Pg_5, I_3Pg_2, I_2Pg_4, I_2Pg_1, I_3Pg_4, I_2Pg_2 respectively. Lowest pod yield (15.6 q ha^{-1}) observed at interaction level I_1Pg_3 (0.6 IW/CPE and phosphogypsum @ 250 kg

Table 1.a: Number of pods plant-1 of *rabi* groundnut as influenced by interaction between moisture regimes and phosphogypsum levels

PHOSPHOGYPSUM LEVELS	MOISTURE REGIMES			MEAN
	I_1 (0.6 IW/CPE)	I_2 (0.8 IW/CPE)	I_3 (1.0 IW/CPE)	
Pg_1-Gypsum@ 500 kg ha^{-1} at flower initiation	14.5	13.8	12.6	13.7
Pg_2-PG @ 250 kg ha^{-1} at flower initiation	12.5	12.7	14.7	13.3
Pg_3- PG @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation	12.2	13.0	13.7	13.0
Pg_4- PG @ 500 kg ha^{-1} ½ as basal and ½ at flower initiation	12.6	14.1	13.5	13.4
Pg_5- PG @ 500 kg ha^{-1} at flower initiation	13.3	14.7	15.8	14.6
MEAN	13.0	13.7	14.1	13.6
Sub treatments at same level of main treatments				
SEm±				0.3
CD (P=0.05)				0.8
Main treatments at same or different level of sub treatments				
SEm±				0.3
CD (P=0.05)				0.8

Table 1.b: Pod Yield and haulm yield (kg ha-1) of *rabi* groundnut as influenced by interaction between moisture regimes and phosphogypsum levels

Phosphogypsum Levels	Pod yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
	Moisture Regimes			Mean	Moisture Regimes			MEAN
	I_1-0.6 IW/ CPE	I_2-0.8 IW/ CPE	I_3-1.0 IW/ CPE		I_1-0.6 IW/ CPE	I_2-0.8 IW/ CPE	I_3-1.0 IW/ CPE	
Pg_1-Gypsum @ 500 kg ha^{-1} at flower initiation	1820	2134	2224	2060	3351	3822	3821	3665
Pg_2-PG @ 250 kg ha^{-1} at flower initiation	1634	2064	2175	1958	3046	3641	3982	3556
Pg_3- PG @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation	1560	1848	1978	1795	3262	3371	3698	3444
Pg_4- PG @ 500 kg ha^{-1} ½ as basal and ½ at flower initiation	1788	2162	2054	2001	3100	3775	3789	3555
Pg_5- PG @ 500 kg ha^{-1} at flower initiation	1908	2197	2303	2136	3411	3985	3706	3701
MEAN	1742	2081	2147	1990	3234	3719	3799	3584
Sub treatments at same level of main treatments								
SEm±				41				62
CD (P=0.05)				111				287
Main treatments at same level of sub treatments								
SEm±				36				90
CD (P=0.05)				116				270

ha-1 ½ as basal and ½ at flower initiation). The interaction effect between moisture regimes and phosphogypsum levels showed that significantly highest haulm yield obtained at interaction I_2Pg_5 followed by I_3Pg_2, I_2Pg_1 and I_3Pg_1 interactions respectively. Lowest haulm yield observed at I_1Pg_2 interaction.

The data pertaining to nutrient uptake of groundnut was presented in Table 2. Maximum uptake of nutrients (N, P, K and S) at harvest (252.2, 24.4, 129.6 and 22.6 kg ha^{-1} respectively) were observed with I_3 (1.0 IW/CPE), which was significantly superior to other treatments. Lowest uptake (187.7, 17.4, 98.4 and 13.6 kg ha^{-1}) of nutrients were recorded with I_1 (0.6 IW/CPE) treatment. Maximum uptake of S (15.6 kg ha^{-1}) at 60 DAS was observed with I_3 (1.0 IW/CPE), which was on par with I_2 (0.8 IW/CPE) and both were significantly superior to other treatments. Lowest uptake (12.1 kg ha^{-1}) of nutrients was obtained with I_1 (0.6 IW/CPE) treatment. Among the phosphogypsum levels, application of phosphogypsum @ 500 kg ha^{-1} at flower initiation was recorded maximum uptake (259.6 N, 24.5 P, 138.3 K, 21.4 S at harvest and 16.6 kg ha^{-1} at 60 DAS) of nutrients but significantly superior than other treatments. Lowest uptake (178.5 N, 17.2 P, 87.1 K, 14.2 S at harvest and 12.0 kg ha^{-1} at 60 DAS) were obtained with Pg_3 (phosphogypsum 250 kg ha^{-1} ½ as basal and ½ at flower initiation). Interaction effect between both moisture regimes and phosphogypsum levels had significant effect observed in nutrient uptake sulphur at harvest only, Significantly superior sulphur uptake at harvest (28.1 kg ha^{-1}) observed with interaction level phosphogypsum @ 500 kg ha^{-1} at flower initiation (Pg_5) and at I_3 (1.0 IW/CPE) moisture regimes than other interactions. Lowest sulphur uptake at harvest (11.1 kg ha^{-1}) observed at interaction level I_1 (0.6 IW/CPE) and phosphogypsum @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation (Pg_3) (Table 3.a and Fig. 1&2). With increase in irrigation level from I_1 to I_3 N, P and K nutrient uptake also increased significantly which could be due to increase in supply of adequate soil moisture in soil

Table 2: Nutrient uptake of *rabi* groundnut as influenced by moisture regimes and phosphogypsum levels

TREATMENTS	NPK uptake at harvest (kg ha^{-1})			S uptake (kg ha^{-1})	
	N	P	K	60 DAS	at harvest
MOISTURE REGIMES (I)					
I_1-0.6 IW/CPE	187.7	17.4	98.4	12.1	13.6
I_2-0.8 IW/CPE	224.5	20.9	111.9	15.1	17.6
I_3-1.0 IW/CPE	252.2	24.4	129.6	15.6	22.6
SEm±	1.1	0.5	1.8	0.3	0.6
CD (P=0.05)	4.2	1.8	7.1	1.2	2.3
PHOSPHOGYPSUM LEVELS (Pg)					
Pg_1-Gypsum @ 500 kg ha^{-1} at flower initiation	236.7	22.2	121.0	15.1	19.7
Pg_2-PG @ 250 kg ha^{-1} at flower initiation	214.0	19.5	105.2	13.4	16.9
Pg_3- PG @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation	178.5	17.2	87.1	12.0	14.2
Pg_4- PG @ 500 kg ha^{-1} ½ as basal and ½ at flower initiation	218.4	21.3	114.8	14.3	17.5
Pg_5- PG @ 500kg ha^{-1} at flower initiation	259.6	24.5	138.3	16.6	21.4
SEm±	5.5	0.6	3.0	0.3	0.4
CD (P=0.05)	16.1	1.7	8.8	1.0	1.1
INTERACTION (I x Pg)					
Sub treatments at same level of main treatments					
SEm±	2.4	1.0	4.0	0.7	1.3
CD (P=0.05)	NS	NS	NS	NS	2.3
Main treatments at same or different level of sub treatments					
SEm±	8.6	1.0	5.0	0.6	0.8
CD (P=0.05)	NS	NS	NS	NS	2.9

Table 3: Physico- chemical and chemical properties of the soil after crop harvest as influenced by moisture regimes and phosphogypsum levels

TREATMENTS	EC (dSm^{-1})	pH	OC (%)	Nitrogen ($kg\ ha^{-1}$)	Phosphorus ($kg\ ha^{-1}$)	Potash ($kg\ ha^{-1}$)	Sulphur (ppm or ug)	Calcium (me 100 g^{-1} soil)
Initial values	0.140	7.52	0.535	238.3	29.3	423	14.3	10.0
MOISTURE REGIMES (I)								
I_1-0.6 IW/CPE	0.146	7.38	0.524	211.0	34.4	445	25.1	17.1
I_2-0.8 IW/CPE	0.153	7.31	0.523	200.0	33.1	439	23.1	16.0
I_3-1.0 IW/CPE	0.158	7.26	0.522	194.0	32.5	436	20.2	15.6
SEm±	0.006	0.05	0.0	2.1	0.2	1.4	0.6	0.1
CD (P=0.05)	NS	NS	NS	8.2	0.8	4.5	2.3	0.5
PHOSPHOGYPSUM LEVELS (Pg)								
Pg_1-Gypsum@ 500kg ha^{-1} at flower initiation	0.154	7.29	0.523	193.0	34.2	450	25.9	16.1
Pg_2-PG @ 250kg ha^{-1} at flower initiation	0.150	7.32	0.522	196.0	33.2	434	21.4	15.4
Pg_3- PG @ 250kg ha^{-1} ½ as basal and ½ at flower initiation	0.146	7.41	0.527	202.0	31.2	427	17.2	14.8
Pg_4- PG @ 500kg ha^{-1} ½ as basal and ½ at flower initiation	0.154	7.31	0.524	203.0	32.1	436	23.1	16.1
Pg_5- PG @ 500kg ha^{-1} at flower initiation	0.158	7.27	0.518	217.0	36.0	454	26.4	19
SEm±	0.014	0.04	0.003	2.2	0.3	2.8	0.7	0.1
CD (P=0.05)	NS	NS	NS	6.3	0.8	8.0	2.0	0.2
INTERACTION (I x Pg)								
Sub treatments at same level of main treatments								
SEm±	0.013	0.10	0.003	4.7	0.5	3.1	1.3	0.3
CD (P=0.05)	NS	NS	NS	3.9	NS	NS	NS	NS
Main treatments at same or different level of sub treatments								
SEm±	0.023	0.07	0.005	12.0	0.5	4.5	1.2	0.5
CD (P=0.05)	NS	NS	NS	12.6	NS	NS	NS	NS

which plays an important role in the mechanism of nutrient uptake involving diffusion, mass flow and interception. These results were in close conformity with the findings of Pawar *et al*. (2013), and Patel *et al*. (2009).

The data pertaining to pH, EC, organic carbon (OC) of groundnut was presented in Table 3. Soil pH, EC, organic carbon of groundnut in final soil was not significantly influenced by moisture regimes. The highest final soil N (211 kg ha^{-1}), P (34.4 kg ha^{-1}), K (445 kg ha^{-1}), S (25.1 ppm) and Ca (17.1 me 100 g^{-1} soil) nutrients were recorded under I_1 (0.6 IW/CPE) treatment. Lowest final soil N (194 kg ha^{-1}), P (32.5 kg ha^{-1}), K (436 kg ha^{-1}), S (20.2 ppm) and Ca (15.6 me 100 g^{-1} soil) nutrients were recorded under I_3 (1.0 IW/CPE) treatment.

Among the phosphogypsum levels, soil pH, EC, organic carbon of groundnut in final soil was not significantly influenced by phosphogypsum levels. The highest final soil N (216 kg ha^{-1}), P (36.0 kg ha^{-1}), K (454 kg ha^{-1}), S (26.4 ppm) and Ca (19.0 me 100 g^{-1} soil) nutrients values were recorded under phosphogypsum @ 500 kg ha^{-1} at flower initiation (Pg_5) when compared to all other treatments, in this only K and S both on par with Pg_1 (gypsum @ 500 kg ha^{-1} at flower initiation (Pg_1). Lowest final soil N (193 kg ha^{-1}) at Pg_1 (gypsum @ 500 kg ha^{-1} at flower initiation (Pg_1), P (31.2 kg ha^{-1}), K (427 kg ha^{-1}), S (17.2 ppm) and Ca (14.8 me 100 g^{-1} soil) nutrients were recorded under Pg_3 (phosphogypsum 250 kg ha^{-1} ½ as basal and ½ at flower initiation) treatment. The interaction effect between moisture

Table 3.a: Sulphur uptake (kg ha^{-1}) by *rabi* groundnut at harvest and Available nitrogen (kg ha^{-1}) in soil after harvest of *rabi* groundnut as influenced by interaction between moisture regimes and phosphogypsum levels

	Sulphur uptake (kg ha^{-1}) by *rabi* groundnut at harvest				**Available nitrogen (kg ha^{-1}) in soil after harvest**			
PHOSPHOGYPSUM LEVELS	**MOISTURE REGIMES**			**MEAN**	**MOISTURE REGIMES**			**MEAN**
	I_1 (0.6 IW/CPE)	**I_2 (0.8 IW/CPE)**	**I_3 (1.0 IW/CPE)**		**I_1 (0.6 IW/CPE)**	**I_2 (0.8 IW/CPE)**	**I_3 (1.0 IW/CPE)**	
Pg_1-Gypsum @ 500 kg ha^{-1} at flower initiation	15.6	18.5	24.9	19.7	191	204	184	193
Pg_2-PG @ 250 kg ha^{-1} at flower initiation	11.3	18.5	20.9	16.9	212	179	188	193
Pg_3- PG @ 250 kg ha^{-1} ½ as basal and ½ at flower initiation	11.1	14.7	16.7	14.2	218	197	190	202
Pg_4- PG @ 500 kg ha^{-1} ½ as basal and ½ at flower initiation	13.4	16.6	22.5	17.5	208	205	196	203
Pg_5- PG @ 500 kg ha^{-1} at flower initiation	16.6	19.5	28.1	21.4	220	219	211	217
MEAN	13.6	17.6	22.6	17.9	211	200	194	198
Sub treatments at same level of main treatments								
SEm±				1.3				4.7
CD (P=0.05)				2.3				11.0
Main treatments at same level of sub treatments								
SEm±				0.8				3.7
CD (P=0.05)				2.9				11.9

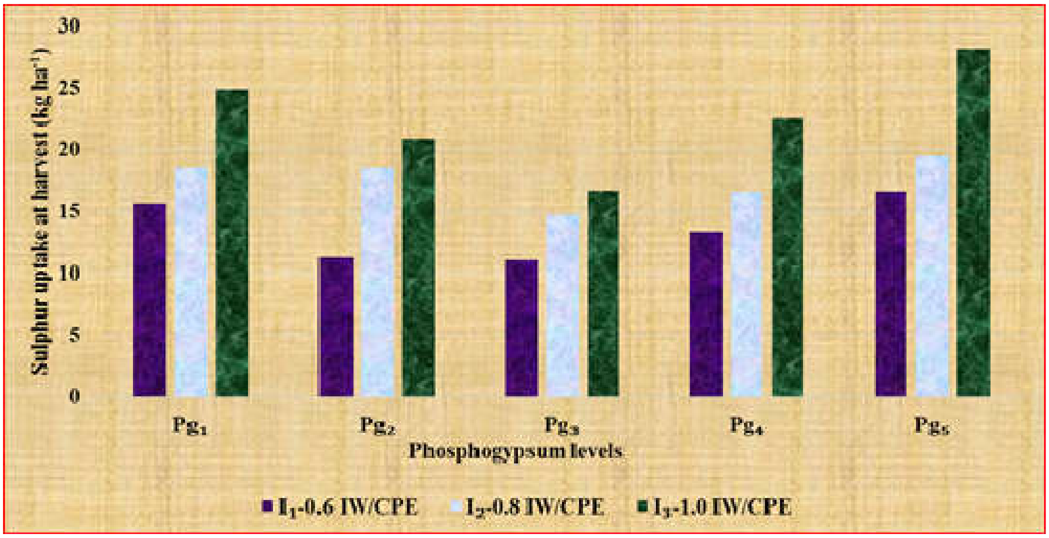

Fig. 1: Interaction effect of moisture regimes and phosphogypsum levels on sulphur uptake at harvest (kg ha^{-1})

regimes and phosphogypsum levels showed (Table 3.a and Fig. 1&2) that significantly superior final soil nitrogen (220 kg ha^{-1}) observed with interaction level phosphogypsum @ 500 kg ha^{-1} at flower initiation (Pg_5) and at I_1 (1.0 IW/CPE) moisture regimes which was on par with I_2Pg_5, I_1Pg_3, I_1Pg_2, I_3Pg_5. Lowest final soil nitrogen (184 kg ha^{-1}) observed at interaction level I_3 (1.0 IW/CPE) and @ 500 kg ha^{-1} at flower initiation (Pg_1). These results are in close conformity with the findings of Nayak *et al.* (2011) and Rout and Jena (2009).

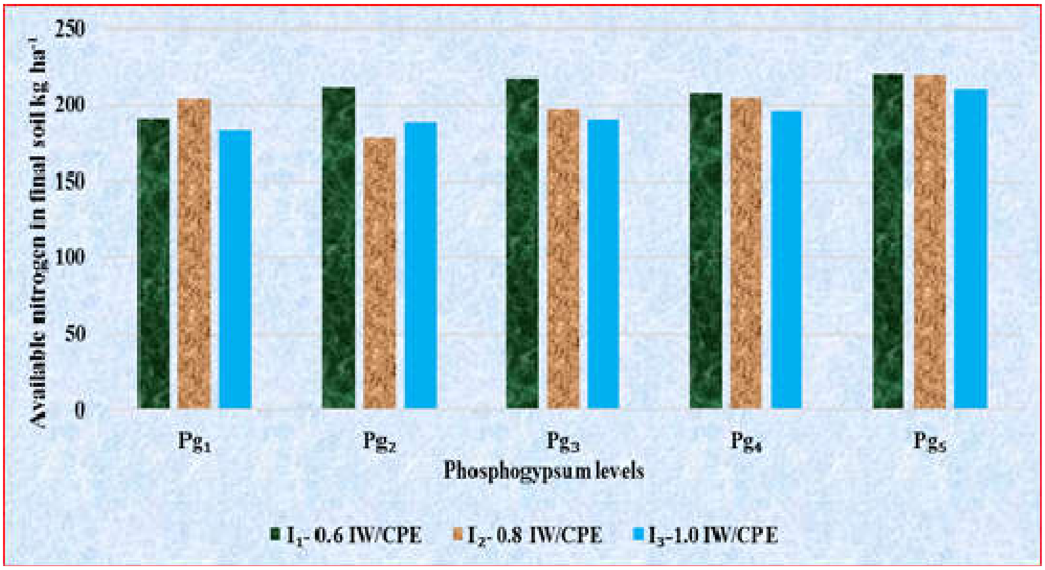

Fig. 2: Interaction effect of moisture regimes and phosphogypsum levels on available nitrogen at harvest (kg ha^{-1})

Fig. 3: Comparison between phosphogypsum levels

Fig. 4: Comparison between irrigation treatments I_1, I_2 and I_3

CONCLUSION

From the study it can be concluded that, scheduling irrigation at I_3 (1.0 IW/CPE) resulted in higher yield attributes, yields (pod & haulm) and uptake of nutrients. Among phosphogypsum levels application of phosphogypsum @ 500 kg ha^{-1} at flower initiation recorded higher yield attributes, yields and uptake of nutrients in *rabi* groundnut.

Soil pH, EC, organic carbon of groundnut in final soil was not significantly influenced by moisture regimes as well as phosphogypsum levels. After harvest of rabi groundnut the highest final soil nutrients were recorded under scheduling irrigation I_1 (0.6 IW/CPE) i.e: Nitrogen, Phosphorus, Potasium, Sulphur and Calcium and among phosphogypsum levels the highest final soil nutrients were recorded under phosphogypsum @ 500 kg ha^{-1} at flower initiation.

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