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RESPONSE OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) TO IRRIGATION AND PHOSPHATIC FERTILIZERS IN A CALCAREOUS SOIL

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ABSTRACT

A pot experiment was conducted on calcareous soil to assess the effect of sources (MAP, DAP and APP), levels of phosphorus and moisture on availability, uptake of nutrients and yield of groundnut. The results indicated that the application of 60 kg P_2O_5 (27.26 mg kg^{-1} soil) through APP with 10 kg Fe (4.54 mg kg^{-1} soil) per hectare under the irrigation level of 17.5 per cent (M_0) has resulted in a significant increase in uptake of nutrients and yield of groundnut. The increase in pod and straw yield due to APP application were 7.25, 5.10 and 12.16, 9.48 pr cent, respectively higher as compared to MAP and DAP. P level (>27.26 mg kg^{-1}) had a negative effect on yield, but addition of Fe @ 4.54 mg kg^{-1} and P @ 27.26 mg kg^{-1} (P_3) further increased the pod and straw yield (19.98 and 15.59 per cent) over control. The treatment of irrigation at 25 per cent level (M_1) reduced the pod and straw yield to the extent of 13.75 and 5.53 per cent.

Key words : Phosphatic fertilizers, Irrigation, Groundnut.

INTRODUCTION

Groundnut is a number one soil crop because of its substantial contribution (about 50%) to the total oil seed production in the country. However, its yield remained stagnant at 800 kg ha^{-1} for a long time[1]. Rajasthan occupies sixth position in the country with respect to groundnut area 2.43 lakh ha and production of 2.70 lakh tonnes. It is mostly grown in southern Rajasthan in 67389 hectares and producing 75854 tonnes of seeds with an average yield of 11.26 q ha^{-1}.[2] Application of phosphatic fertilizers to groundnut resulted in increase in the formation of seeds and promoted pod and haulm yields[3]. Several workers have conducted comparative studies of various phosphatic fertilizers[4] in different parts of the country, but information available on the use of MAP, DAP and APP under different moisture regimes is still scanty. Hence, the present investigations was carried out to study the response of groundnut to sources of phosphatic fertilizers [mono ammonium phosphate (MAP), diammonium phosphate (DAP) and ammonium polyphosphate (APP)], with an objective to know their efficacy at different levels of

phosphorus and at two levels (17.5 and 25 per cent) of irrigation usually adopted in a calcareous soil of southern Rajasthan.

MATERIALS AND METHODS

A green house experiment was conducted during Summer season on a clay loam soil having sand content of 48.8 per cent, silt of 21.1 per cent, clay of 27.91 per cent, bulk density of 1.45 Mgm^{-3}, particle density of 2.46 Mgm^{-3}, water holding capacity of 29.8 per cent, EC of 0.58 dSm^{-1}, pH of 7.9, $CaCO_3$ content of 80 gm kg^{-1} and HCO_3^- of 4.0 mM. Available nitrogen, phosphorus, potassium, iron and zinc contents were 208.5, 12.0, 195.0, 6.2 and 1.0 mg kg^{-1}, respectively. The treatments comprised of three sources of phosphatic fertilizers (MAP, DAP and APP), applied at four levels of phosphorus [0 (P_0), 27.26 (P_1), 40.90 (P_2) mg P_2O_5 kg^{-1} soil and 27.26 mg P_2O_5 kg^{-1} + 4.54 mg Fe kg^{-1} (P_3) soil] and two levels of irrigation i.e. M_0 (soil water at 17.5 per cent) and M_1 (25.0 per cent level of soil water). Each treatment was replicated three times in a factorial completely randomized design (CRD). The addition of Fe with P in P_3 treatment was to nullify the latent chlorosis of ground in calcareous soils.

Earthen pots of 25 cm diameter lined with polythene, were filled with 5.0 kg air dry soil passed through 2 mm sieve. A basal dose of 30 kg N ha^{-1} (13.64 mg kg^{-1} soil) was applied after balancing the N contents of the phosphorus sources. Seven seeds of groundnut cultivar GG–2 (bunch type) were sown and later thinned to five plants in each pot. The crop was irrigated to 17.5 per cent of soil water content (M_0) and to 25.0 per cent soil water content (M_1). The soil water levels were maintained by depletion method. The pots were weighted before watering and the total weight of pot alongwith 5.0 kg soil + treatment + seed was recorded. The half pots (36 nos) were irrigated to 17.5 per cent soil water content (M_1). Daily evapo–transpirational losses were recorded by adopting direct weighment by means of a triple beam counter poise balance. Whenever there is a depletion of the soil water content from field capacity, enough water was added to bring back to field capacity[5].

The soil samples were taken at forty five days after emergence and at harvest of groundnut from individual pots to assess the avilable nutrients status of soil. Standard procedures were used from soil and plant analysis[6,7].

RESULTS AND DISCUSSION

Nutrients availability in soil : The availability of N, P, K, Fe and Zn were significantly influenced by phosphatic fertilizers (Table–1). The maximum availability of nutrients at 45 days after emergence and at harvest were recorded under APP application. Sources of phosphatic fertilizers revealed that APP improved the status of available nutrients (N, P, K, Fe and Zn) as compared to MAP and DAP due to its higher solubility and effectiveness in solubilization of organic matter, complexation of available Fe and Zn and stimulating the mineralization of N. APP maintains neutral pH (6.8) of media while MAP lowers (3.5) and DAP

raises (7.8) the pH values. These findings were in agreement with the findings of Giodana *et al.*[8]. Unique property of APP is the chelation or sequestering reaction with metal cations, which maintain higher concentration of micronutrients in addition to availability of phosphorus[9].

The availability of nutrients except potassium and nitrogen were significantly affected by the application of phosphorus levels. The maximum availability of phosphorus was recorded in the treatment of P applied at the rate of 40.9 mg P_2O_5 kg^{-1} soil (P_2). The availability of Fe and Zn were reduced and reached to a critical level (Fe below 5 mg kg^{-1} and Zn below 0.75 mg kg^{-1}) at 45 days after emergence and at harvest stage by increasing the level of phosphorus in P_1 and P_2 treatments. The reduction in available Fe and Zn is due to the antagonistic effect of P. The reduction in Fe and Zn availability ranged from 16.0 to 18.27 per cent and 15.05 to 18.77 per cent, respectively. The Fe deficiency in calcareous soils, was alleviated by the addition of Fe at the rate of 4.54 mg kg^{-1} along with P (P_3). Addition of Fe (P_3) increased its availability in soil at 45 days after emergence and at harvest. Similar, results were observed by Elgala *et al.*[10].

The results (Table 1) showed that soil water at 25 per cent level significantly reduced available N, P, K, DTPA extractable Fe and Zn contents in soils at 45 day after emergence and

Table 1. Effect of sources, levels of P and irrigation on fertility status of soil

Treatments	Available Nutrients									
	45 Days After Emergence					At Harvest				
	N	P	K	Fe	Zn	N	P	K	Fe	Zn
	(mg kg^{-1})			(µg g^{-1})		(mg kg^{-1})			(µg g^{-1})	
Sources of P										
MAP	129.83	17.85	172.92	5.71	0.84	127.43	15.85	169.82	5.03	0.73
DAP	128.96	16.52	172.92	5.32	0.77	126.56	14.51	169.66	4.63	0.67
APP	130.75	19.67	173.42	6.02	0.88	128.35	17.67	170.22	5.32	0.77
SEm±	0.223	0.231	0.266	0.085	0.023	0.222	0.231	0.536	0.086	0.021
C.D. at 5%	0.634	0.657	NS	0.242	0.065	0.632	0.657	NS	0.245	0.059
Levels of P										
P_0	129.82	13.42	173.02	6.00	0.93	126.42	11.42	170.62	5.31	0.83
P_1	129.85	18.33	173.28	5.45	0.90	127.95	16.33	170.14	4.77	0.79
P_2	129.91	22.31	173.02	5.04	0.79	127.01	20.30	169.82	4.34	0.68
P_3	129.81	17.98	173.02	6.22	0.71	128.41	15.98	169.03	5.54	0.60
SEm±	0.257	0.267	0.307	0.098	0.027	0.257	0.266	0.619	0.099	0.024
C.D. at 5%	NS	0.759	NS	0.279	0.077	0.731	0.757	NS	0.282	0.068
Irrigation										
M_0	130.22	19.74	173.83	5.80	0.87	127.82	17.74	170.66	5.11	0.76
M_1	129.47	16.28	172.33	5.56	0.80	127.07	14.28	169.14	4.87	0.69
SEm±	0.182	0.189	0.217	0.069	0.019	0.181	0.188	0.438	0.070	0.017
C.D. at 5%	0.518	0.538	0.617	0.196	0.054	0.517	0.535	1.246	0.199	0.048

NS = Non significant

at harvest. The maximum availability of N, P, K, Fe and Zn were 130.22, 19.74, 173.83 mg g^{-1}, 5.80 and 0.87 µg g^{-1} at 45 days after emergence and 127.82, 17.74, 170.666 mg g^{-1}, 5.11 and 0.75 µg g^{-1} at harvest under 17.5 per cent of soil water content. The higher water contents reduced the availablity of nutrients due to increased microbial respiration and decreased gas exchange resulting in the increased partial pressure of CO_2 and HCO_3^- concentration in soil[11].

Nutrient uptake : Sources of P (Table–2) had marked influence on uptake of N, P, K, Fe and Zn. The nutrient contents and uptake were high in APP as compared to MAP and DAP. Higher uptake of nutrients and chlorophyll contents under APP fertilization is due to more stimulation of root growth by APP, thereby increasing the ability of the plant to take up more nutrients[9]. The maximum uptake of N, P, K, Fe and Zn by pod (775.13, 171.83, 559.35, 15.56 and 0.749 mg g^{-1}) and straw (925.33, 248.92, 929.43, 22.72 and 1.202 mg g^{-1}) were recorded under APP treatment. The uptake of nutrients was high in straw because of high dry matter production as compared to pod.

Table 2. Effect of sources, levels of P and irrigation on uptake of macro (N, P and K) and micro (Fe and Zn) nutrients at harvest by groundnut

Treatments	Pod (mg g^{-1})					Straw (mg g^{-1})				
	N	P	K	Fe	Zn	N	P	K	Fe	Zn
Sources of P										
MAP	710.08	156.06	501.02	11.91	0.653	792.19	221.76	844.40	17.45	1.064
DAP	666.47	143.80	442.54	10.98	0.571	739.64	199.56	749.56	16.49	0.932
APP	775.13	171.83	559.35	15.56	0.749	925.33	248.92	929.43	22.72	1.202
SEm±	21.381	2.398	13.339	0.200	0.013	23.69	65.273	22.780	0.268	0.022
C.D. at 5%	60.865	6.827	37.972	0.570	0.037	67.455	15.009	64.848	0.762	0.063
Levels of P										
P_0	591.15	145.65	402.68	11.06	0.674	682.98	198.28	692.16	16.40	1.127
P_1	763.48	175.06	529.98	10.92	0.703	880.15	236.33	891.57	18.24	1.135
P_2	674.41	171.67	469.24	9.52	0.616	764.13	231.52	795.92	17.08	1.009
P_3	839.85	136.53	601.97	19.77	0.638	948.95	227.51	984.89	23.81	0.991
SEm±	24.689	2.769	15.403	0.231	0.015	27.362	6.088	26.305	0.309	0.025
C.D. at 5%	70.281	7.883	43.846	0.658	0.043	77.890	17.331	74.880	0.880	0.071
Irrigation										
M_0	770.16	169.09	550.58	13.90	0.727	872.19	241.97	895.98	19.56	1.142
M_1	664.28	146.36	451.35	11.73	0.588	765.92	204.85	786.28	18.21	0.989
SEm±	17.458	1.958	10.891	0.163	0.011	19.384	4.305	18.600	0.219	0.018
C.D. at 5%	49.696	5.574	31.004	0.465	0.031	55.077	12.255	52.948	0.622	0.051

The high levels of P (40.90 mg P_2O_5 kg^{-1} soil) reduced the uptake and contents of Fe and Zn content, but little influence was noticed on the uptake of N, P and K. Addition of Fe with P @ 27.26 mg kg^{-1} in soil showed increase in the uptake of N, K and Fe in both; the pod and straw. The increasing levels of P reduced the uptake of Fe and Zn; thereby reduce chlorophyll

content by additional supply of Fe alleviates its negative effect. These findings are in agreement with the findings of Lakhande *et al.*[4].

Concentration of nutrients and uptake was higher under 17.5 per cent of soil water (M_0) as compared to 25.0 per cent of soil water (M_1). The reduction in uptake of nutrients under excessive irrigation was due to low avilability of these nutrients as a result of reduced microbial and metabolic activities[11]. Soil water contents at 25.0 per cent reduces soil aeration and augments anaerobic condition temporarily causing negative effect on nutrients availability in the soil. The uptake of N, P, K, Fe and Zn were 770.16, 168.09, 550.58, 13.90 and 0.727 mg g^{-1} by pod and 872.19, 241.97, 895.98, 19.56 and 1.142 mg g^{-1} by straw under the treatment of 17.5 per cent soil water content.

Yield of groundnut : The pod and straw yield of groundnut was higher in APP as compared to MAP and DAP (Table–3). The response of groundnut to P sources was in the order of APP > MAP > DAP. The results are in agreement with the findings of Reddy *et al.*[12] who reported that pod yield was significantly increased with the application of APP as P sources. The high pod (24.26 g pot^{-1}) and straw (41.04 g pot^{-1}) yield with APP application was due to better soil environment in rhizosphere for P availability as compared to MAP and DAP.

Table 3. Effect of sources, levels of P and irrigation on groundnut yield

Treatments	Pod (g pot^{-1})	Straw (g pot^{-1})
Sources of P		
MAP	22.50	38.90
DAP	21.31	37.15
APP	24.26	41.04
SEm±	0.572	0.553
C.D. at 5%	1.628	1.574
Levels of p		
P_0	20.22	35.72
P_1	23.46	40.07
P_2	21.81	38.02
P_3	25.27	42.32
SEm±	0.662	0.638
C.D. at 5%	1.884	1.816
Irrigation		
M_0	24.15	40.08
M_1	21.23	37.98
SEm±	0.468	0.452
C.D. at 5%	1.332	1.287

The yield of groundnut was significantly influenced by phosphorus levels. The increase in P level beyond 27.26 mg kg^{-1} showed a negative effect on the yield. Addition of Fe @ 4.54 mg kg^{-1} and P @ 27.26 mg kg^{-1} (P_3) further increased the yield (highest pod 25.27 and straw 42.32 g pot^{-1} by P_3 treatment). The increase in yield of groundnut further confirms that Fe exerted a beneficial effect on chlorophyll content. The results are in agreement with the findings of Dhillon *et al.*[13].

The irrigation treatment to a level of 25 per cent of soil water showed significant reduction in the pod and straw yield to the extent of 13.75 (pod) and 5.53 per cent (straw) over control. The reduction in pod and straw yield could be due to low availaibility of macro and micronutrients in the soil, minimum uptake of nutrients and restrictive root respiration. Similar causes for reduction yield of groundnut under irrigation was reported by Chavan *et al.*[14].

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