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Response of Groundnut (*Arachis hypogaea*) under Different Phosphorus Management Options in Central Dry Zone of Karnataka

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ABSTRACT

Background: Phosphorus is considered as the second most important plant nutrient because of its significant role in various biochemical activities such as photosynthesis, respiration, root growth, energy storage, cell division *etc*. Phosphorus is required in greater amounts for pulse crops because of high demand in energy transfer molecules used in nitrogen fixation. Application of proper dose of phosphorus fertilizer is very crucial in deciding the productivity of the groundnut. The bioavailability of the phosphorus fertilizers mainly depends on the soil properties *viz*., pH, organic carbon, amount of Fe and Al oxides, $CaCO_3$ and microbial load in the soil. In this context, the present study was designed to know the growth and yield parameter of groundnut by using appropriate combination of microbial culture with different levels of phosphorus at central dry zone of Karnataka.

Methods: Field experiments were carried out for three consecutive years during 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, Karnataka, India to study and understand the efficiency of DGRC culture (microbial culture) with different levels of phosphorus on groundnut under *kharif* season. The experiment was laid out in randomized block design with three replication and ten treatments consisting of seed treatment with DGRC culture inoculants @ 20 g/kg groundnut seed (cv. TMV-2) with different doses of phosphorus (20 kg, 40 kg and 60 kg/ha).

Result: Three years pooled results indicated that there was a significant response of pod yield (2457 kg/ha) and higher economics like gross return (Rs. 1,15,138/ ha), net return (Rs. 73,115/ha) and B:C ratio (2.76) were also profitable with the application of 40 kg/ha of P + DGRC culture as compared to other treatments. Furthermore, higher nutrient uptake *viz*., N (99.60 kg/ha), P_2O_5 (16.68 kg/ha) and K_2O (58.86 kg/ha) were recorded in application of 40 kg/ha of P+DGRC culture.

Key words: DGRC culture, Farmyard manure, Groundnut, Nutrient management, Phosphorus.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the major legume growing in Karnataka. The crop is cultivated mainly for its seed and it comprises 40-50% oil, 20-30% protein and contains vitamin B as well. All other parts of the plant are used as animal feed (Ahmad *et al*., 2007). Poor soil fertility, lack of improved varieties, erratic rainfall and drought are some of the production constraints faced by farmers in Central Dry Zone of Karnataka. However, soils found in most groundnut growing areas are inherently poor with deficiencies in most of the essential plant nutrients especially nitrogen (N) and phosphorus (P) (Burri *et al*., 2010). Groundnut yields obtained by farmers in Central Dry Zone of Karnataka are generally low due to the poor soil fertility which has ensued as a result of continuous cropping coupled with low use of external inputs.

Proper doses of phosphorus fertilizer have vital effect on the yield of groundnut. The most obvious effect of P is on the plant root system (Kumar Naik *et al*., 2017). The adequate P levels encourage vigorous root and shoot growth promote early maturity, increase water use efficiency and economic yield (Brady and Well, 2002, Singh and Singh, 2000, Jain *et al*., 1990). Phosphorus is a key element involved in various functions in growth and metabolism of legumes (Ramesh *et al*., 1997) and it frequently a major limiting nutrient for plant growth in slightly alkaline soils of Central Dry Zone of Karnataka.

Plant growth promoting rhizobacteria (PGPRs) are environmental friendly, low cost and non-bulky agricultural inputs which play a significant role in plant nutrition as a supplementary and complementary factor to mineral nutrition

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(Peix *et al*., 2015). Balanced use of fertilizers organic manures along with bio-fertilizers for improving crop productivity and soil fertility status in cereals and cereal-based rotations is well documented (Garcia *et al*., 2012). Thus, substitution of some of the inorganic P requirement of groundnut through farm yard manure (FYM) and PGPRs is important to synthesize low cost nutrient management technology, besides addressing production vulnerabilities. In addition to proper dose of phosphorus, a suitable and efficient microbial culture should be used to increase its production.Based on these constraints at farmers level present study has been carried out to evaluate the appropriate combination of microbial culture and different levels of phosphorus on growth, yield and nutrient uptake of groundnut under Central Dry Zone of Karnataka.

MATERIALS AND METHODS

The field experiments were conducted during *Kharif* season of 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur of University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India (Table 1). The soil of the experimental plot was block in texture and slightly alkaline in reaction. The soil has low organic carbon content of 0.46 per cent and was low in available nitrogen 205 kg/ha, high in phosphorus 23.0 kg/ha and potash 321 kg/ha. The experiment was laid out in randomized block design with three replications. The experiment consisted of ten treatment combinations of seed treatment with DGRC culture inoculants @ 20 g/kg groundnut seed (cv. TMV-2) with different doses of phosphorus (20 kg, 40 kg and 60 kg/ha) the treatment details *viz.,* Control (no application of P), Application of 20 kg/ha of P, Application of 40 kg/ha of P, Application of 60 kg/ha of P, Application of 20 kg/ha of P+ DGRC culture, Application of 40 kg/ha of P+DGRC culture, Application of 60 kg/ha of P+DGRC culture, Application of FYM @ 2.5 t/ha, Application of FYM @ 2.5 t/ha+DGRC culture, Application of DGRC culture enriched FYM@100 kg/ha. A recommended dose of farmyard manure, nitrogen, potash and seed rate was applied. The cultural practices, irrigation and plant protection measures were taken as and when required.

RESULT AND DISCUSSION

Growth parameters and phosphorous fertilization

Three years pooled data presented in Table 2, 3 and 4 revealed that the growth and yield attributes significantly influenced by different treatments. Significantly higher plant height (40.67 cm) was observed in application of 60 kg/ha of P+DGRC culture and which is on par with the application of 40 kg/ha of P+DGRC culture, whereas, number of branches per plant (9.04), number of pods per plant (43.21) and 100 kernel weight (42.60 g) were significantly recorded by the application of 40 kg/ha of P+DGRC culture.The optimum availability of P to sustain crop growth. Further, P is a key component of molecules necessary for root growth and development, respiration, nucleic acid synthesis, N-fixation, plant maturity and seed production (Raychaudhury *et al*., 2003). Phosphorus is required in greater amounts for pulse crops than many other crops due to its high demand in energy transfer molecules used in nitrogen fixation. Moreover, integration of both organic and inorganic nutrient sources might improve fixation of nitrogen and to reduce the movement of P to non liable pools in the soil solution and also reduce the adsorption and immobilization of P (Ramana *et al*., 2002) which could be one of the reasons for higher dry matter production and growth of groundnut.

Effect of different P management options with DGRC cultures on groundnut productivity

Significantly higher seed yield (2614 kg/ha and 2652 kg/ha) were recorded when crop was fertilized with 40 kg P_2O_5/ha

Table 1: Physical and chemical properties of the soil of the experimental site at ZAHRS, Babbur farm, Hiriyur.

Particulars	Value	Method adopted
I Mechanical analysis		
Sand (%)	28.80	International pipette method (Piper, 1966)
Silt (%)	32.10	
Clay (%)	39.10	
Texture class	Clay loam soil	
II Chemical properties		
Soil pH (1:2.5)	8.10 (Moderately alkaline)	Potentiometry (Jackson, 1973)
Electrical conductivity (dSm^{-1} at 25°C)	0.86 (Normal)	Conductometry (Jackson, 1973)
Organic carbon(%)	0.46 (Low)	Wet oxidation method (Walkley and Black, 1934)
Available nitrogen(kg ha^{-1})	205 (Low)	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	23 (Medium)	Olsen's extractant method (Jackson,1973)
Available K_2O (kg ha^{-1})	321 (Medium)	Neutral normal ammonium acetate method (Jackson, 1973)
Available Zn (ppm)	0.31 (Low)	DTPA extractant by AAS method (Lindsay and Norwell, 1978)
Available Fe (ppm)	3.62 (Low)	

+ DGRC culture. But, it remained at par with 60 kg P_2O_5/ha (2607 kg/ha and 2638 kg/ha) during 2018 and 2019. While during 2020 the application of 40 kg P_2O_5/ha+DGRC culture recorded higher pod yield (2105 kg/ha). Three years pooled results indicated that there was a significant response of seed yield (2457 kg/ha) and haulm yield (3681 kg/ha) due to application of 40 kg P_2O_5/ha+DGRC culture followed by the application of 60 kg/ha of P+DGRC culture (2434 kg/ha and 3640 kg/ha) has compared to control (Table 4). A substantial quantity of applied P becomes unavailable to plants through complexation under calcareous and alkaline soil conditions with highly reactive Ca^{2+}. It has also been documented that P anions are very reactive, forming metal complexes with metal cations such as calcium in calcareous and alkaline soil. These reactions reduce the efficiency of applied P fertilizers by approximately 80% (Salvagiotti, 2017). Microorganisms such as phosphate solubilizing bacteria have been reported to modify phosphorus nutrition and increase its Solubilization in soil through many process such as, they may decrease the pH of the soil by the producing organic (gluconic acid) and mineral acids, alkaline phosphatases, phytohormones and H^+ protonation, anion exchange, chelation and siderophores production which promote P solubilisation in soil (Rodriguez and Fraga 1999). Moreover, the use of organics with inorganic fertilizers leads to better soil moisture utilization, nutrient uptake and less fluctuation in the soil temperature and improves soil organic matters which increase the soil water holding capacity, soil aggregation, microbial activity and soil porosity ultimately leading to higher crop productivity (Badole *et al*., 2003). Similar results were also reported by many other researchers which state that integration of chemical and organic sources led to higher crop productivity (Biswas *et al*., 2003; Soumare *et al*., 2003).

Effect of different P management options with DGRC culture on farm profitability and nutrient uptake

Economics of different treatments are presented in Table 5. Gross realization, cost of cultivation, net realization and B:C ratio of different treatments was worked out on the basis of current market prices of groundnut and inputs used. The results indicated that application of 40 kg P_2O_5/ha + DGRC culture was recorded higher gross return (Rs. 1,15,138/ha), net return (Rs. 73,115/ha) and B:C ratio (2.76) in pooled results.

Similarly, highest nutrient uptake of nitrogen (99.60 kg/ha), phosphorus (16.68 kg/ha) and potassium (58.86 kg/ha) in groundnut after harvest was noticed in the application of 40 kg P_2O_5/ha + DGRC culture (Table 6). Integrated application of P exits in the soil in several organic and inorganic forms in soil organic matter, minerals and in the soil solution. Plants taken up as orthophosphate ions from the soil solution. To maintain equilibrium, P moves from more available organic and inorganic pools to the soil solution. This more available or liable P includes mineralizable organic P, readily exchangeable adsorbed P moves from less

Table 2: Effect of microbial cultures on initial, final population and plant height of rainfed groundnut during *Kharif* 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Hiriyur, UAHS, Shivamogga.

Tr. no.	Treatments	Initial plant populations				Final plant populations				Plant height (cm)			
		2018	2019	2020	Mean	2018	2019	2020	Mean	2018	2019	2020	Mean
T_1	Control (no application of P)	375	531	559	488	281	507	432	406	34.0	35.59	36.93	35.51
T_2	Application of 20 kg/ha of P	376	451	501	442	288	424	400	370	32.9	33.47	34.62	33.66
T_3	Application of 40 kg/ha of P	377	482	538	465	294	450	418	387	34.3	35.40	36.63	35.44
T_4	Application of 60 kg/ha of P	380	513	539	477	301	447	421	389	34.8	36.87	38.09	36.59
T_5	Application of 20 kg/ha of P+DGRC culture	390	518	548	485	303	507	440	416	35.0	36.07	37.56	36.21
T_6	Application of 40 kg/ha of P+DGRC culture	392	527	555.	491	308	415	418	380	38.8	40.07	41.56	40.14
T_7	Application of 60 kg/ha of P+DGRC culture	388	527	546	487	303	532	452	429	38.5	41.10	42.40	40.67
T_8	Application of FYM @ 2.5 t/ha	372	419	479	423	292	391	380	354	32.9	33.03	34.98	33.64
T_9	Application of FYM @ 2.5 t/ha+DGRC culture	382	437	505	441	304	408	399	370	34.2	35.27	36.82	35.43
T_{10}	Application of DGRC culture enriched FYM@ 100 kg/ha.	377	609	520	502	305	592	453	450	33.7	35.60	36.93	35.41
	S.Em. ±	4.32	59.03	27.26	17.39	6.0	66.03	21.04	19.00	0.61	0.71	0.38	0.23
	C.D.(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1.80	2.29	1.14	0.69

Table 3: Effect of microbial cultures on shoot length (cm), number of branches per plant and number of pods per plant of rainfed groundnut during *Kharif* 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Hiriyur, UAHS, Shivamogga.

Tr. no.	Treatments	Shoot length (cm)				Number of branches/plant				Number of pods/plant			
		2018	2019	2020	Mean	2018	2019	2020	Mean	2018	2019	2020	Mean
T_1	Control (no application of P)	21.1	22.17	22.26	21.84	6.7	6.86	6.95	6.84	32.7	33.89	35.06	33.88
T_2	Application of 20 kg/ha of P	22.6	23.03	23.41	23.01	7.1	7.20	7.40	7.23	33.8	34.73	35.64	34.72
T_3	Application of 40 kg/ha of P	22.5	22.77	23.19	22.82	7.3	7.40	7.73	7.48	34.9	36.40	36.97	36.09
T_4	Application of 60 kg/ha of P	23.2	23.67	24.16	23.68	6.3	6.68	6.83	6.60	35.7	36.90	37.97	36.86
T_5	Application of 20 kg/ha of P+DGRC culture	23.6	24.40	24.80	24.27	6.8	7.02	7.41	7.08	35.2	36.07	38.26	36.51
T_6	Application of 40 kg/ha of P+DGRC culture	25.5	26.13	26.41	26.01	8.9	9.09	9.13	9.04	41.6	42.27	45.77	43.21
T_7	Application of 60 kg/ha of P+DGRC culture	24.7	25.40	25.50	25.20	8.0	8.07	8.56	8.21	40.3	41.60	43.00	41.63
T_8	Application of FYM @ 2.5 t/ha	22.7	23.87	22.99	23.19	7.9	8.00	8.17	8.02	34.9	35.50	36.83	35.74
T_9	Application of FYM @ 2.5 t/ha+DGRC culture	22.5	22.93	23.14	22.86	6.6	6.80	6.97	6.79	37.0	38.07	40.19	38.42
T_{10}	Application of DGRC culture enriched FYM@ 100 kg/ha.	22.2	22.80	23.33	22.78	7.2	7.41	7.67	7.43	37.6	38.27	40.76	38.88
	S.Em. ±	0.8	0.48	0.32	0.13	0.7	0.61	0.36	0.05	0.6	1.09	1.67	0.27
	C.D.(P=0.05)	NS	1.54	0.97	0.40	NS	NS	1.07	0.15	2.1	3.47	4.98	0.83

Table 4: Effect of microbial cultures on kernel weight, pod and haulm yield (Kg/ha) of rainfed groundnut during *Kharif* 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Hiriyur, UAHS, Shivamogga.

Tr. no.	Treatments	100 Kernel weight (g)				Pod yield (Kg/ha)				Haulm yield (kg/ha)			
		2018	2019	2020	Mean	2018	2019	2020	Mean	2018	2019	2020	Mean
T_1	Control (no application of P)	35.2	35.69	37.30	36.06	1897	1928	1523	1783	2609	2772	2799	2726
T_2	Application of 20 kg/ha of P	36.6	37.10	38.73	37.48	2050	2076	1531	1886	2804	2952	2977	2911
T_3	Application of 40 kg/ha of P	37.4	38.43	40.14	38.66	2119	2249	1686	2018	2906	3085	3097	3029
T_4	Application of 60 kg/ha of P	37.8	38.13	39.98	38.64	2356	2389	1796	2180	3225	3359	3384	3322
T_5	Application of 20 kg/ha of P+DGRC culture	37.6	38.17	39.86	38.54	2379	2418	1852	2216	3256	3442	3490	3396
T_6	Application of 40 kg/ha of P+DGRC culture	40.8	42.10	44.90	42.60	2614	2652	2105	2457	3582	3710	3751	3681
T_7	Application of 60 kg/ha of P+DGRC culture	39.6	41.20	42.40	41.07	2607	2638	2058	2434	3571	3661	3688	3640
T_8	Application of FYM @ 2.5 t/ha	36.4	37.37	39.87	37.88	2120	2162	1636	1973	2908	3094	3142	3048
T_9	Application of FYM @ 2.5 t/ha+DGRC culture	38.4	39.40	41.53	39.78	2440	2485	1256	2060	3349	3448	3470	3422
T_{10}	Application of DGRC culture enriched FYM@ 100 kg/ha.	38.5	39.27	41.59	39.79	2444	2493	1358	2098	3297	3409	3490	3398
	S.Em. ±	0.4	1.17	2.29	0.21	2.82	7.71	10.50	92.42	5.0	28.38	47.34	13.42
	C.D.(P=0.05)	1.3	3.75	6.80	0.63	9.01	24.66	31.20	274.61	16.0	90.79	140.65	39.88

Table 5: Effect of microbial cultures on Economics of rainfed groundnut under rainfed conditions during *Kharif* 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Hiriyur, UAHS, Shivamogga.

Tr. no.	Treatments	Gross returns (Rs./ha)				Net returns (Rs./ha)				B: C ratio			
		2018	2019	2020	Mean	2018	2019	2020	Mean	2018	2019	2020	Mean
T_1	Control (no application of P)	80411	87724	80338	82824	41411	46224	34588	40741	2.06	2.11	1.76	1.98
T_2	Application of 20 kg/ha of P	89204	94458	80760	88141	51504	54258	36310	47357	2.37	2.35	1.82	2.18
T_3	Application of 40 kg/ha of P	92191	102330	88937	94486	54291	61930	44287	53503	2.43	2.53	1.99	2.32
T_4	Application of 60 kg/ha of P	102500	108700	94739	101980	64200	67900	48689	60263	2.68	2.66	2.06	2.47
T_5	Application of 20 kg/ha of P + DGRC culture	103348	110019	97693	103687	65287	69319	51263	61956	2.71	2.70	2.10	2.50
T_6	Application of 40 kg/ha of P + DGRC culture	113709	120666	111039	115138	75309	79766	64269	73115	2.96	2.95	2.37	2.76
T_7	Application of 60 kg/ha of P + DGRC culture	113434	120029	108560	114008	74634	78729	61660	71674	2.92	2.91	2.31	2.71
T_8	Application of FYM @ 2.5 t/ha	92234	98371	86299	92301	49734	53371	38199	47101	2.17	2.19	1.79	2.05
T_9	Application of FYM @ 2.5 t/ha+ DGRC culture	106169	113068	66254	95164	63169	67568	17654	49464	2.47	2.49	1.36	2.11
T_{10}	Application of DGRC culture enriched FYM@ 100 kg/ha	106328	113432	71635	97132	63328	67932	23035	51432	2.47	2.49	1.47	2.14
	S.Em. ±	Data not subjected to ANOVA											
	C.D.(P=0.05)												

Table 6: Effect of microbial cultures on Nutrients uptake of rainfed groundnut during *Kharif* 2018, 2019 and 2020 at Zonal Agricultural and Horticultural Research Station, Hiriyur, UAHS, Shivamogga.

Tr. no.	Treatments	N Uptake (Kg/ha)				P Uptake (Kg/ha)				K Uptake (Kg/ha)			
		2018	2019	2020	Mean	2018	2019	2020	Mean	2018	2019	2020	Mean
T_1	Control (no application of P)	33.79	34.73	33.25	33.92	4.31	5.30	5.24	4.95	20.32	21.80	21.41	21.18
T_2	Application of 20 kg/ha of P	64.59	67.73	65.87	66.06	9.13	11.87	11.15	10.72	26.42	28.17	27.68	27.42
T_3	Application of 40 kg/ha of P	66.31	67.77	65.95	66.68	9.59	12.33	11.53	11.15	37.87	38.73	38.20	38.27
T_4	Application of 60 kg/ha of P	72.42	72.93	71.86	72.40	10.84	13.10	12.24	12.06	41.14	43.40	42.65	42.40
T_5	Application of 20 kg/ha of P+DGRC culture	77.26	78.40	77.25	77.64	11.64	13.47	12.85	12.65	42.30	45.60	44.63	44.18
T_6	Application of 40 kg/ha of P+DGRC culture	97.31	102.10	99.39	99.60	15.96	17.07	17.01	16.68	57.73	59.77	59.09	58.86
T_7	Application of 60 kg/ha of P+DGRC culture	91.29	95.10	94.13	93.51	15.32	16.03	16.08	15.81	48.67	49.00	49.22	48.96
T_8	Application of FYM @ 2.5 t/ha	66.31	68.40	67.90	67.54	9.59	10.27	10.62	10.16	37.87	39.20	39.36	38.81
T_9	Application of FYM @ 2.5 t/ha+ DGRC culture	83.27	86.53	84.41	84.74	13.18	14.27	13.82	13.76	46.62	47.10	47.24	46.99
T_{10}	Application of DGRC culture enriched FYM@1 100 kg/ha	80.25	82.43	82.70	81.79	12.50	13.03	13.03	12.85	45.09	46.00	46.40	45.83
	S.Em. ±	3.09	1.65	1.05	0.48	1.41	0.76	0.69	0.25	3.24	0.77	0.75	0.27
	C.D.(P=0.05)	7.50	5.28	3.11	1.45	1.18	2.44	2.07	0.75	9.57	2.46	2.24	0.82

available pools which include stable organic P and is strongly absorbed to soil minerals and compounds into liable pools to maintain P equilibrium status in the soils, thereby increases the nutrient uptake and biological yield of crops (Hao and Chang 2002). Moreover, integrated P management using chemical 40 kg/ha P fertilizer + DGRC culture led to reduction in plant requirements for inorganic P fertilizer which is likely to reduce cost of cultivation by reducing the dependent as on chemical P fertilizer. The results are in close agreement with the findings of many researchers (De Jager *et al*., 2001; Palm *et al*., 2001 and Ouedraogo *et al*., 2001). The present study revealed that application of 40 kg/ha P_2O_5/ha + DGRC culture effective in improving the growth, productivity and profitability and nutrient uptake of groundnut.

CONCLUSION

From the present study authors conclude that, application of 40 kg P_2O_5/ha + DGRC culture showed significant increase in the growth and yield parameters of groundnut *viz*., number of branches per plant (9.04), number of pods per plant (43.21), 100 kernel weight (42.60 g), seed yield (2457 kg/ha) and haulm yield (3681 kg/ha) and it is on par with the application of 60 kg P_2O_5/ha+DGRC culture (except plant height 40.67cm) as compare to other treatments and it has saved 20 kg P_2O_5/ha by increasing the higher gross return (Rs. 1,15,138/ ha), net return (Rs. 73,115/ha) and B:C ratio (2.76) and the highest nutrient uptake of nitrogen (99.60 kg/ha), phosphorus (16.68 kg/ha) and potassium (58.86 kg/ha) in pooled results.

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Conflict of interest

All authors declared that there is no conflict of interest.

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