RESIDUAL EFFECT OF PHOSPHORUS MANAGEMENT ON ECONOMICS AND NUTRIENT BALANCE OF CHICKPEA-FODDER SORGHUM CROPPING SEQUENCE

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ABSTRACT

The Field experiments were conducted at the College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari during rabi and summer seasons of 2014-15 and 2015-16. The treatments comprised for chickpea were two levels and two sources of phosphorus (25 and 50 kg P_2O_5/ha from SSP and rock phosphate) along with and without VAM (Vesicular arbuscular mycorrhizae) @ 2.0 kg/ha as soil inoculants and one control (No phosphorus and VAM to chickpea). Total of 10 treatment combinations, laid out in a randomized block design, replicated three times. The succeeding fodder sorghum crop was superimposed on the same layout, keeping chickpea treatments as main plots and two fertility levels as sub-plots (75 % of the recommended dose (60 kg N + 30 kg P_2O_5/h) and 100% of the recommended dose (80 kg N + 40 kg P_2O_5/ha) with total twenty treatment combinations in a split plot design with three replications. The experiments were conducted on the same site during both the years without changing the randomization of treatments. The higher chickpea equivalent yield, net realization obtained from the treatment combination of 50 kg P_2O_5/ha from SSP + with VAM (T_8) to preceding chickpea and application of 100 per cent RDF to succeeding fodder sorghum under chickpea-fodder sorghum cropping system. The balance sheet of soil available N, P and S after two years of cropping cycles were positive with all treatments except N balance observed under chickpea [grown with no P and VAM and 25 kg P_2O_5/ha from RP alone]-fodder sorghum cropping system. The positive balance of these nutrients increased with increasing levels of phosphorus management to chickpea. The soil available K balance showed a negative balance in all treatments under chickpea-fodder sorghum cropping system.

KEY WORDS: Chickpea, Economics, Fodder Sorghum, Rock phosphate, SSP,VAM

INTRODUCTION

Pulses play an important role in agriculture because they occupy a unique position in every known system of farming as a main, catch, cover, green manure, intercrop and mixed crop. Its inclusion in rotation keeps the soil alive and productive. Pulse crop enriches the soil fertility by means of addition of organic matter and biological nitrogen. In recent past, most of

the research work has been confined mainly to the nutrients requirement of an individual crop and fertilizer recommendations made on the basis of fertilizer response of a single crop without considering the residual/cumulative effects of preceding crops, as a result rather high and sometimes uneconomic fertilizer recommendations are made. Hence, fertilization must be considered for cropping system and not for individual crop. Application of phosphatic fertilizers enriches the soil with non-labile pool phosphate which in turn, benefits the succeeding crops. Legumes respond well to phosphorus and the residual phosphate left in the soil can be an important source of P for the succeeding crop in legume based cropping system because phosphorus has a great residual potential. Moreover, the residual effect of P fertilization to *rabi* or summer crops on succeeding *kharif* crops has been found more profitable. Therefore, attempts are being made to recommend a dose of P fertilizer for a cropping system rather than individual crop. At present, studies on residual effect of phosphorus management on economics of cropping sequence and nutrient balance of chickpea-fodder sorghum cropping sequence after completion of two years of experiment was undertaken.

MATERIALS AND METHODS

Field experiments were conducted at the College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari during *rabi* and summer seasons of 2014-15 and 2015-16. The soil analysis indicated that the soil of the experimental plots was clay in texture (66.52 % and 65.27 %), low in organic carbon (0.47 % and 0.50 %), available nitrogen (211.00 and 219.00 kg/ha) and phosphorus (28.20 and 30.50 kg/ha), high in available potassium (335.80 and 347.50 kg/ha), medium in available sulphur (21.00 and 22.50 kg/ha) and slightly alkaline in reaction (pH 7.7 and 7.6.). The common dose of FYM (10 t/ha) was incorporated in soil before sowing of crop to a depth of 10-15 cm. Chemical fertilizers were applied in the experiment plots uniformly at the time of sowing as basal dose as per the treatments. The common dose of nitrogen was applied through urea and phosphorus was applied through single super phosphate (SSP) and rock phosphate (RP) as per the treatments. VAM (*Vesicular Arbuscular Mycorrhiza*) culture was treated as per the treatments. The treatment consisted of phosphorus management *viz.,* T_1 : Control (0 kg P_2O_5 /ha), T_2 : 25 kg P_2O_5/ha through SSP, T_3 : 25 kg P_2O_5/ha through RP, T_4 : 50 kg P_2O_5/ha through SSP, T_5 : 50 kg P_2O_5/ha through RP, T_6 : 25 kg P_2O_5/ha through SSP + VAM, T_7 : 25 kg P_2O_5/ha through RP + VAM, T_8 : 50 kg P_2O_5/ha through SSP + VAM, T_9 : 50 kg P_2O_5/ha through RP + VAM, T_{10} : Only VAM to chickpea in *rabi* season as main plot treatments replicated three times in randomized block design. During summer season each main plot treatment was split into two sub-plot treatments with two levels of recommended dose of fertilizer *viz.*,F_1 : 75 % RDF (60 kg N + 30 kg P_2O_5/ha) and F_2 : 100 % RDF (80 kg N + 40 kg P_2O_5/ha) to fodder sorghum resulting in twenty treatment combinations replicated three times in split plot design. SSP and RP were applied to chickpea crop as per treatments. VAM was mixed in that particular bed. Before application of RP, it was analysed for NPK content. The nitrogen was applied through urea, whereas phosphorus was applied through SSP. The 50% dose of nitrogen and full dose of SSP were applied at the time of sowing, remaining half dose of nitrogen was top dressed as urea as per treatment.

RESULTS AND DISCUSSION

Economics of chickpea-fodder sorghum cropping system

The adoption of any technology by the farmers depends upon its cost

effectiveness. The same principle is followed while deciding the levels of fertilizers. Therefore, while arriving at any conclusion or deriving any inference a detailed economic analysis is a must. Application of 50 kg P_2O_5/ha from SSP + VAM (T_8) to preceding chickpea and application of 100 per cent recommended level of fertilizers to fodder sorghum gave maximum net realization and benefit to cost ratio from the chickpea-fodder sorghum cropping system followed by the treatment with application of 50 kg P_2O_5/ha from SSP alone along with 75 per cent RDF. These findings are in accordance with those reported by Pankhaniya (2007), Gudadhe (2008) and Tandon (2009).

Balance sheet of soil available nutrients (N, P, K and S) in chickpea-fodder sorghum cropping system

The soil available nitrogen at initiation and after two years of experimentation indicated positive N balance in chickpea-fodder sorghum cropping system except T_1 (no P and VAM) and T_3 (25 kg P_2O_5/ha through RP). The net soil available N balance increased with increasing levels of P management applied to chickpea. Thus, the highest net balance of soil available N was under the treatments T_8 (9.91 kg/ha) followed by T_4 (8.68 kg/ha), T_9 (7.80 kg/ha) and T_5 (7.62 kg/ha). The positive N balance under chickpea- fodder sorghum sequence could be attributed to the addition of large quantity of organic matter such as roots, stubbles, leaves, nodules and bodies of microbes by chickpea and addition of N through symbiotic fixation. The higher available N content in soil applied to preceding chickpea may be ascribed to comparatively increased growth of chickpea due to combine application of P from SSP and RP with VAM, thereby, higher addition of nitrogen. Singh and Singh (1986) reported higher N balance under legumes (Chickpea, Pea, Lentil) - fodder sorghum cropping system. Also net soil available N balance after two years of chickpea-fodder sorghum cropping system was positive and it increased with increasing levels of fertilizers to fodder sorghum form 1.03 kg/ha (F_1 i.e., 75 % RDF) to 6.00 kg/ha (F_2 i.e., 100 % RDF).

The balance of net soil available P after two years of chickpea-fodder sorghum cropping system was positive under all residual treatments. The available phosphorus balance increased with increasing levels of P to chickpea and it was further increased with VAM soil inoculation over the same level of P in both SSP and RP sources of P. Thus, the highest P balance was observed under treatments T_9 (11.42 kg/ha) followed by T_7 (10.47 kg/ha), T_3 (9.71 kg/ha) and T_5 (9.43 kg/ha). The available P_2O_5 might have increased partly by the humic substances excreted by roots, mineralization and solubilizing effects of VAM and soil microflora as well as the CO_2 produced by roots and associated microorganisms, which might have promoted the solubilization of native and applied P_2O_5 and partly by the left over residual P_2O_5 applied to the fodder sorghum. Similar results have also been reported by Singh and Singh (1986), Kausale (2004), Pankhaniya (2007) and Tandon (2009). While, net soil available P_2O_5 balance after two years was positive under both the fertilizers levels applied to fodder sorghum and it increased with successive increase in fertilizers level F_1 (5.54 kg/ha) to F_2 (8.69 kg/ha).

The net soil available K balance showed a prominent negative balance under chickpea-fodder sorghum cropping system after two years (Table 47). The highest K depletion was observed under treatments T_1 (-48.77 kg/ha) followed by T_{10} (-48.10 kg/ha) and T_7 (-44.30 kg/ha). This could be attributed to the higher removal of K by crops as against no addition. Similar results have also been reported by Singh and Singh

(1986), Pankhaniya (2007) and Tandon (2009).

The balance of net soil available S after two years was positive under all residual treatments. The available sulphur balance in general increased with increasing levels of P to chickpea and it was further increased with VAM soil inoculation over the same levels of P without inoculation. Thus, the highest S balance was observed under treatments T_8 (7.86 kg/ha) followed by T_4 (7.32 kg/ha) and T_9 (7.14 kg/ha). This could be attributed to addition of sulphur through phosphatic fertilizers as it contains sulphur. Also net soil available S balance after two years was positive under both the fertilizer levels applied to fodder sorghum and it increased with successive increase in fertilizer levels F_1 (4.32 kg/ha) to F_2 (6.30 kg/ha).

CONCLUSION

The application of 50 kg P_2O_5/ha from SSP + VAM to preceding chickpea and 100 per cent RDF (80 kg N + 40 kg P_2O_5/ha) to succeeding fodder sorghum is most suitable for getting higher net realization and benefit to cost ratio from chickpea-fodder sorghum cropping system. The balance of soil available nitrogen, phosphorus and sulphur in chickpea-fodder sorghum cropping system can be increased with increasing level of phosphorus management to the preceding chickpea.

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Table 1: Residual effect of P management on economics of chickpea-fodder sorghum cropping system as influenced by different treatments

Treatments	Gross Realization (₹/ha)	Total Cost of Cultivation (₹/ha)	Net Realization (₹/ha)	Benefit to Cost Ratio
Residual effect of P managements in chickpea crop				
T_1	86374	29508	56887	2.93
T_2	101753	30763	70989	3.31
T_3	98550	30373	68177	3.24
T_4	129230	31779	97431	4.06
T_5	120970	30998	89970	3.90
T_6	104559	30893	73688	3.39
T_7	100466	30503	69963	3.29
T_8	134362	31909	102452	4.21
T_9	125409	31128	94301	4.03
T_{10}	88303	29878	58427	2.96
Fertilizer levels applied to succeeding fodder sorghum crop				
F_1	143893	43650	92269	2.79
F_2	145507	44372	93161	2.78

Table 2: Balance sheet of soil available nitrogen (kg/ha) after two years of chickpea-fodder sorghum cropping system as influenced by different treatments

Treatments	Initial Available Soil N	Addition of N Through Fertilizers in 2 Years	Total Available N (2 + 3)	Removal of N by Crops in 2 Years	Expected Balance of Available N (4 - 5)	Actual Balance of Available Soil N After 2 Years	Calculated Gain of Available N (7 - 6)	Net Available Soil N Balance After 2 Years (7 - 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Residual effect of P management in chickpea crop								
T_1	211.00	210	421.00	231.59	189.41	206.45	17.04	-4.55
T_2	211.00	210	421.00	313.92	107.08	213.78	106.70	2.78
T_3	211.00	210	421.00	281.24	139.76	210.49	70.73	-0.51
T_4	211.00	210	421.00	417.80	3.20	219.68	216.48	8.68
T_5	211.00	210	421.00	382.45	38.55	218.62	180.07	7.62
T_6	211.00	210	421.00	339.74	81.26	214.88	133.62	3.88
T_7	211.00	210	421.00	300.49	120.51	212.81	92.30	1.81
T_8	211.00	210	421.00	449.78	-28.78	220.91	249.69	9.91
T_9	211.00	210	421.00	399.76	21.24	218.80	197.56	7.80
T_{10}	211.00	210	421.00	249.88	171.12	208.70	37.58	-2.30
Fertilizer levels applied to succeeding fodder sorghum crop								
F_1	211.00	170	381.00	174.54	206.46	212.03	5.57	1.03
F_2	211.00	210	421.00	203.76	217.24	217.00	-0.24	6.00
G.M.	**211.00**	**190**	**401.00**	**189.15**	**211.85**	**214.51**	**2.90**	**3.51**

Table 3: Balance sheet of soil available phosphorus (kg/ha) after two years of chickpea-fodder sorghum cropping system as influenced by different treatments

Treatments	Initial Available Soil P	Addition of P Through Fertilizers in 2 Years	Total Available P (2 + 3)	Removal of P by Crops in 2 Years	Expected Balance of Available P (4 - 5)	Actual Balance of Available Soil P After 2 Years	Calculated Gain of Available P (7 - 6)	Net available Soil P Balance After 2 Years (7 - 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Residual effect of P management in chickpea crop								
T_1	28.20	80	108.20	30.13	78.07	30.58	-47.49	2.38
T_2	28.20	130	158.20	43.90	114.30	32.87	-81.43	4.67
T_3	28.20	130	158.20	37.07	121.13	37.91	-83.22	9.71
T_4	28.20	180	208.20	74.08	134.12	35.72	-98.40	7.52
T_5	28.20	180	208.20	63.69	144.51	37.63	-106.88	9.43
T_6	28.20	130	158.20	48.81	109.39	33.70	-75.70	5.50
T_7	28.20	130	158.20	40.64	117.56	38.67	-78.89	10.47
T_8	28.20	180	208.20	82.11	126.09	34.90	-91.18	6.70
T_9	28.20	180	208.20	68.12	140.08	39.62	-100.45	11.42
T_{10}	28.20	80	108.20	33.09	75.11	31.61	-43.50	3.41
Fertilizer levels applied to succeeding fodder sorghum crop								
F_1	28.20	110	138.20	20.78	117.42	33.74	-83.68	5.54
F_2	28.20	180	208.20	26.88	181.32	36.89	-144.43	8.69
G.M.	**28.20**	**145**	**173.20**	**23.83**	**149.37**	**35.31**	**-113.71**	**7.11**

Table 4: Balance sheet of soil available potassium (kg/ha) after two years of chickpea-fodder sorghum cropping system as influenced by different treatments

Treatments	Initial Available Soil K	Addition of K Through Fertilizers in 2 Years	Total Available K (2 + 3)	Removal of K by Crops in 2 Years	Expected Balance of Available K (4 - 5)	Actual Balance of Available Soil K After 2 Years	Calculated Gain of Available K (7 - 6)	Net Available Soil K Balance After 2 Years (7 - 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Residual effect of P management in chickpea crop								
T_1	335.80	0	335.80	134.31	201.49	287.03	85.55	-48.77
T_2	335.80	0	335.80	161.19	174.61	298.00	123.39	-37.80
T_3	335.80	0	335.80	147.72	188.08	289.52	101.45	-46.28
T_4	335.80	0	335.80	212.75	123.05	299.96	176.91	-35.84
T_5	335.80	0	335.80	194.45	141.35	297.61	156.26	-38.19
T_6	335.80	0	335.80	173.48	162.32	295.00	132.68	-40.80
T_7	335.80	0	335.80	155.81	179.99	291.50	111.51	-44.30
T_8	335.80	0	335.80	226.71	109.09	299.93	190.84	-35.87
T_9	335.80	0	335.80	204.23	131.57	298.95	167.39	-36.85
T_{10}	335.80	0	335.80	140.58	195.22	287.70	92.48	-48.10
Fertilizer levels applied to succeeding fodder sorghum crop								
F_1	335.80	0	335.80	87.47	248.33	292.42	44.09	-43.38
F_2	335.80	0	335.80	98.01	237.79	296.62	58.83	-39.18
G.M.	**335.80**	**0**	**335.80**	**92.74**	**243.06**	**294.52**	**51.46**	**-41.28**

Table 5: Balance sheet of soil available sulphur (kg/ha) after two years of chickpea-fodder sorghum cropping system as influenced by different treatments

Treatments	Initial Available Soil S	Addition of S Through Fertilizers in 2 Years	Total Available S (2 + 3)	Removal of S by Crops in 2 Years	Expected Balance of Available S (4 - 5)	Actual Balance of Available Soil S After 2 Years	Calculated Gain of Available S (7 - 6)	Net Available soil S Balance After 2 Years (7 - 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Residual effect of P management in chickpea crop								
T_1	21.00	0	21.00	58.89	-37.89	21.36	59.24	0.36
T_2	21.00	0	21.00	70.87	-49.87	26.65	76.52	5.65
T_3	21.00	0	21.00	67.16	-46.16	25.89	72.05	4.89
T_4	21.00	0	21.00	93.03	-72.03	28.32	100.34	7.32
T_5	21.00	0	21.00	86.95	-65.95	27.75	93.70	6.75
T_6	21.00	0	21.00	73.22	-52.22	27.35	79.56	6.35
T_7	21.00	0	21.00	68.64	-47.64	26.40	74.05	5.40
T_8	21.00	0	21.00	99.32	-78.32	28.86	107.18	7.86
T_9	21.00	0	21.00	90.07	-69.07	28.14	97.21	7.14
T_{10}	21.00	0	21.00	62.71	-41.71	22.43	64.14	1.43
Fertilizer levels applied to succeeding fodder sorghum crop								
F_1	21.00	0	21.00	14.01	6.99	25.32	18.33	4.32
F_2	21.00	0	21.00	16.36	4.64	27.30	22.66	6.30
G.M.	**21.00**	**0**	**21.00**	**15.18**	**5.81**	**26.31**	**20.49**	**5.31**

[MS received : December 22, 2018] *[MS accepted : December 27, 2018]*