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EFFECT OF INTEGRATED USE OF ORGANIC AND INORGANIC SOURCES OF PHOSPHORUS ON SOIL PHYSICO-CHEMICAL AND CHEMICAL PROPERTIES OF CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was conducted during 2009-10 on sandy loam Alfisol at College Farm, College of Agriculture, Rajendranagar, Hyderabad, A.P, India to study the response of phosphorus levels in combination with FYM @ 10 t ha^{-1} and phosphate solubilising bacteria (PSB) @ 2 kg ha^{-1} on various phisico-chemical properties of soil at flowering and at harvest of chickpea. The FYM application or PSB application to soil slightly reduced the soil pH towards neutral range due to rhizosphere acidification. Organic carbon and available N contents of soil at flowering significantly increased at P_{75} level over P_0 level but such increase was not observed at harvest. FYM application either alone or with PSB showed a significant increase in organic carbon content of soil at flowering. With the increase in the inorganic P levels and FYM application there was appreciable buildup in available P status. The treatments receiving FYM and FYM + PSB were at a par in increasing available P. Application of either graded levels of phosphorus or any component of P did not show any significant influence on available K status of soil at flowering. Increase in the level of P application was also not significant in increasing available K status of the soil at harvest. The available K status was significantly superior with FYM, with PSB and their combination when compared to inorganic P.Interaction effect was not significant both at flowering and at harvest.Available sulphur status of soil at flowering was significantly increased only at 75 kg P_2O_5 ha^{-1} and at harvest significantly increased upto P_{50} level and was on par with P_{75} treatment. Supplementing the crop with inorganic P along with FYM, PSB or FYM + PSB did not show significant variation in available S both at flowering and at harvest.The mean seed yield increased significantly by 44.0 per cent due to application of FYM along with PSB with graded levels of P. PSB inoculation at graded levels of P increased the seed yield by 28.9 per cent.

(Key words: organic and inorganic P sources, soil pH, EC, organic carbon, available nutrients, chickpea)

INTRODUCTION

Phosphorus is an important nutrient especially for pulses as a high phosphorus supply is needed for nodulation. It also influences N availability through N fixation. Phosphorus plays a pivotal role for the structure and regulatory functions in photosynthesis, root development, energy conservation and transformation, carbon metabolism, redox reactions, enzyme activation and inactivation, signaling and nucleic acid synthesis (Vance *et al*., 2003). But it is one of the highly immobile, inaccessible and unavailable nutrients present in the soil. Native available P in soil and applied P through fertilizer source become unavailable within a short period due to fixation in the soil (Meena *et al*., 2003). The high phosphatic fertilizer prices demand the need for recycling, mobilization and exploitation of fixed P to improve crop production. It could be made possible by developing strategies like integration of PSB, organic acids, arbuscularmycorrhizal fungi and rhizosphere manipulation through efficient P mobilizing genotypes along with inorganic P.

Application of farmyard manure is known not only to meet the nutrient requirement of crop, but also to improve the physical properties of soil (Venkateshwarlu, 2000). Activity of microbes gets enhanced in the presence of organic matter since organic matter (FYM) is the food for microbes. Soil inoculation with efficient strains of biofertilizer in association with mineral and organic manures have been known to enhance the efficiency of both these sources resulting in improved productivity of crop coupled with maintenance of soil fertility. With this view in mind a study was undertaken to ascertain the effect of organic and inorganic sources of P on soil physico-chemical properties under chickpea cultivation.

MATERIALS AND METHODS

Field experiment was conducted during post rainyseason of 2009-10 on Alfisol at College Farm of College of Agriculture, Rajendranagar, Acharya N.G. Ranga Agricultural University, Hyderabad. The soil was sandy loam with slightly alkaline pH of 8.12 and

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normal in EC (0.12 dSm^{-1}), low in organic carbon content (0.35 %)and available nitrogen (188 kg ha^{-1}), medium in available phosphorus (17.2 kg ha^{-1}), high in available potassium (368 kg ha^{-1}) and sufficient in available sulphur (33.6 kg ha^{-1}). The experiment was laid out in Randomised Block Design in factorial concept with three replications. Four levels of inorganic P (0, 25, 50 and 75 kg P_2O_5 ha^{-1}*viz.,* P_0, P_{25}, P_{50} and P_{75}), two levels of organic manure (0 and 10 t ha^{-1} of FYM) and two levels of PSB (without inoculation and with inoculation @ 2 kg ha^{-1}) were adopted, thus a total of 16 treatment combinations were imposed. Chickpea cv KAK - 2 was used for the study. All the cultural practices were followed as per the standard recommended practices. Composite soil sample was collected at flowering and at harvest from each experimental plot from 0 to 15 cm depth. The soil was mixed thoroughly and samples of about 0.5 kg were obtained by quartering technique and stored in neatly labelled polythene bags for soil analysis.Collected soils were sieved in a 2 mm mesh removing root hair as much as possible and assayed for pH, EC (Jackson, 1973), Organic Carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), phosphorus (Olsen *et al.,* 1954), potassium (Jackson, 1973) and sulphur (Chesnin and Yien, 1963).The harvested crop from each net plot was bundled separately and sun dried for 4 days and threshed. The threshed grains were cleaned and sun dried to a constant weight before recording final grain yield (kg ha^{-1}).

RESULTS AND DISCUSSION

Soil pH :

Neither the levels of P application nor the components of phosphorus management had significant effect on pH of the soil.Their interaction was also not significant at flowering stage of the crop (Table 1). Though not significant, the organic manuring or inoculation of soil with biofertilizers slightly reduced the soil pH towards neutral range. The pH of the soil at harvest was also not influenced by either P levels or components or both. The pH showed a slight decrease at harvest than at flowering. This might be due to the rhizosphere acidification as a result of organic acids released by FYM and PSB.

Soil EC :

The electrical conductivity of the soil both at flowering and harvest was not significantly influenced by either inorganic P application or by the components of phosphorus management (Table 2).

Organic carbon :

Organic carbon content of the soil at flowering increased significantly to 0.54 per cent (medium) due to application of inorganic P at 75 kg P_2O_5 ha^{-1} as against the low organic carbon content of 0.45 per cent in P_0. The organic carbon content was also low when either inorganic P alone or in combination with PSB was applied. When along with inorganic P, FYM or FYM + PSB were applied the organic carbon content increased significantly to 0.53 per cent. Interaction was not significant.This could be due to the reason that the effect of FYM excelled that of inorganic P at later stage. The inorganic P levels were not significant in increasing the organic carbon content of the soil at harvest. Among the components of phosphorus, FYM alone or with PSB were found to increase organic carbon significantly from 0.43 per cent with inorganic P to 0.58 and 0.60 per cent respectively. Interaction effects between inorganic P and FYM, inorganic P, FYM and PSB were significant. However, the highest organic carbon content of 0.73 per cent was recorded in the treatment receiving FYM and PSB without inorganic P (Table 3). This could be due to the release of organic acids and compounds into the soil as a result of FYM application.

Available nitrogen :

Available nitrogen content of soil at flowering was not influenced significantly by the application of inorganic P (Table 4). Application of FYM @ 10 t ha^{-1} either alone or in combination with PSB also increased significantly, the available N content of the soil to 191.7 and 193.1 kg ha^{-1} respectively when compared to 168.5 kg ha^{-1} observed with inorganic P alone. Inoculation with PSB alone did not show any influence on available N content of the soil. Significantly higher available N content of 214.1 kg ha^{-1} was obtained with the integrated application of inorganic P at 50 kg P_2O_5 ha^{-1} along with FYM and PSB over 156.8 kg ha^{-1} in the control.This might be due to increased availability of phosphorus (upto the level P_{75}), which through its effect on root nodulation fixes the atmospheric N by symbiosis, and the fixed N might be added to the soil through root exudates. Application of graded levels of P from 0 to 75 kg P_2O_5 ha^{-1} increased the available N status of the soil from 148.6 to 183.8 kg ha^{-1}. However, significant increase was observed upto 25 kg P_2O_5 ha^{-1} which was at par with the other two higher levels of P. Among the components of phosphorus management, FYM was significantly superior with 182.8 kg ha^{-1} of available N which was at par with the treatment in where, FYM was conjunctively applied with PSB with an available N content of 176.1 kg ha^{-1}. The highest value was obtained when inorganic P at 75 kg P_2O_5 ha^{-1} was combinely applied with FYM at 10 t ha^{-1}; the lowest was with control. This might be due to the additional amount of nitrogen supplemented through FYM. Tolanur and Badanur (2003) reported that the application of FYM along with recommended dose of fertilizer (25 kg N and P ha^{-1}) resulted in significant increase in the available nitrogen, phosphorus and potassium compared to application of recommended dose of fertilizer without FYM.

Available phosphorus :

Available phosphorus in the soil at flowering was influenced significantly due to the graded levels of P application and also by combinations of the three components (Table 5). The mean value increased significantly from 23.95 kg P ha^{-1} at control to 33.50 kg P ha^{-1} with the application of 50 kg P_2O_5 ha^{-1}, while P_{50} and P_{75} were at a par with regard to available P status of soil at harvest.When compared to inorganic P alone, the combinations of components were significant. The mean available P with inorganic P was 22.55 kg ha^{-1} which showed significant increase to 34.12, 28.35 and 37.17 kg ha^{-1} respectively due to the combination with FYM, PSB and both. The highest value of 41.22 kg P ha^{-1} was recorded due to application of P at 75 kg P_2O_5 ha^{-1} along with FYM and PSB. With the increase in the inorganic P levels, there was an increase in the available P. Appreciable buildup in available P status could be because of addition of phosphorus directly to the soil solution pool in the soil. Akbari *et al*. (2002) reported that the application of phosphorus @ 20 kg P_2O_5 ha^{-1} significantly increased the available phosphorus over control.Abdulla and Sharma (2003), who found the highest available P_2O_5 (48.47 kg ha^{-1}) with 40 kg DAP ha^{-1} over 20 kg DAP ha^{-1} (37.7 kg P_2O_5 ha^{-1}) and control (26.93 kg P_2O_5ha^{-1}).

The lowest available P status of 15.23 kg ha^{-1} was recorded in control. The interaction between the level of P application and combination of components was not significant. Available soil phosphorus status at harvest of chickpea increased significantly from a mean value of 21.99 to 34.69 kg P ha^{-1} due to application at 75 kg P_2O_5 ha^{-1}. Phosphorus when supplied only through inorganic source resulted in an available P status of 20.85 kg ha^{-1}, which showed a significant increase to 26.41, 31.72 and 34.52 kg ha^{-1} when integrated with PSB, FYM and PSB+ FYM. The highest available P of 38.52 kg ha^{-1} in the soil was recorded at harvest when 75 kg P_2O_5 ha^{-1}of inorganic P was supplied along with FYM and PSB. The lowest value was observed in the control. Above this, the organic anions compete with phosphates for chelation of metals like iron, Al and also Ca which form insoluble P compounds with applied P, causing effective solubilization of phosphates. This findings is in corroboration with the findings of Tanwar and Shaktawat (2004) who reported that application of 90 kg P_2O_5ha^{-1} along with PSB and FYM @ 10 tonnes ha^{-1} resulted in a higher soil N and P after the harvest of soybean crop compared to application of 0, 30 and 60 kg P_2O_5 ha^{-1} along with PSB and FYM.

Available P content of the soil increased significantly due to PSB application over control, which might be due to production of organic and inorganic acids which convert the insoluble phosphates to available forms. The results obtained are in close agreement with those reported byAbdulla and Sharma (2003) who reported that available P increased significantly with PSB inoculation over no inoculation in chickpea. Gupta and Yadav (2009),reported that the soil available N and P with PSB inoculation (135.0 and 23.9 kg ha^{-1}) increased over control (132.7 and 19.0 kg ha^{-1}) in chickpea. However, the interaction effect was not significant.

Available potassium :

Application of either graded levels of phosphorus or any component of P did not show any significant influence on the available K status of soil at flowering stage of chickpea. The interaction of inorganic P and the components of phosphorus management were not significant.

Increase in the level of P application was not significant in increasing available K status of the soil. Among the four components of P, inorganic P was found inferior to other, available K status was significantly superior with FYM, PSB and their combination when compared to inorganic P (Table 6). Similar beneficial effects of integrated use of inorganic fertiliser and FYM on available K status of soil after harvest were earlier reported by Kumptawat, (2004).

Available sulphur :

Available sulphur status at flowering was significantly increased only due to the higher level of phosphorus application at 75 kg P_2O_5 ha^{-1} which resulted in increase of mean available sulphur status to 27.46 kg ha^{-1}as against 23.63 kg ha^{-1} in the treatment receiving 0 kg P_2O_5 ha^{-1}. Significant difference was not observed among the different components and their interaction with level of phosphorus application.Available sulphur at harvest significantly increased from 21.23 kg ha^{-1} at P_0 level to 23.58 kg ha^{-1} with the application of 50 kg P_2O_5 ha^{-1} which was at par with the treatment receiving 75 kg P_2O_5 ha^{-1}. Supplementing the crop with inorganic phosphorus alone resulted in available sulphur status of 20.64 kg ha^{-1} which increased significantly to 24.59 kg ha^{-1} and 25.15 kg ha^{-1} respectively when inorganic phosphorus was integrated with FYM or FYM+PSB. Interaction effect was not significant (Table 7).These results are in conformity with the findings of Akbari *et al*. (2002) who reported that application of FYM @ 10 t ha^{-1} significantly improved sulphur status of soil after harvesting of groundnut to the tune of 20.82 per cent as compared to the respective control.

Seed yield :

Application of inorganic P at 50 kg P_2O_5 ha^{-1} significantly increased the mean seed yield of chickpea to 10.57 q ha^{-1} over 8.20 q ha^{-1} in P_0 (Table. 8).The increased seed yield with P application might be due to increased availability of phosphorus through its effect on Rhizobium and proliferation of root system. The results corroborate the findings of Gupta *et al*.(2009) who reported that the grain yield of chickpea increased significantly over control and 20 kg P_2O_5 ha^{-1} with the application of 40 kg P_2O_5 ha^{-1} through DAP. Singh *et al.* (2008) reported that the seed yield of chickpea increased significantly due to the application of 40 kg P_2O_5 ha^{-1} over control and Chesti and Tahir (2008) also observed that application of 60 kg P_2O_5 ha^{-1} recorded maximum grain yield over 0 and 30 kg P_2O_5 ha^{-1} in chickpea.

Integrated application of inorganic P, FYM and PSB resulted in significantly higher yield of 11.18 q ha^{-1} which was at par with combined application of inorganic P and PSB (10.47 q ha^{-1}) against 8.61 q ha^{-1} when inorganic P alone was applied. The seed yield was the highest when FYM and PSB were combinedly applied with inorganic P at 75 kg P_2O_5 ha^{-1},the value being 14.45 q ha^{-1} which was significantly higher than the yield of 9.92 q ha^{-1} obtained at the same level of P application without FYM and PSB. The seed yield obtained with 25 kg P_2O_5 ha^{-1} in integration with FYM and PSB was slightly higher but at par with the yield obtained with 75 kg P_2O_5 ha^{-1} alone. At P_0 level, application of FYM along with PSB increased the seed yield significantly to 9.09 q ha^{-1} against the seed yield of 6.28 q.ha^{-1} in control (Table 8).This might be due to increased phosphorus availability by organic manure and PSB. These results are in conformity with Manjunath *et al.* (2006), who found that the green pod yield of frenchbean was significantly superior with the integrated application of rock phosphate, FYM and PSB producing a yield of 82.53 q ha^{-1} over the control yield of 68.16 q ha^{-1}. Tanwar *et al.* (2010) reported maximum seed yield with treatment of conjunctive use of 25.8 kg P ha^{-1}, FYM and PSB (2.96 t ha^{-1}) over the treatment of 12.9 kg P ha^{-1} + FYM + PSB (2.80 t ha^{-1}).

Table 1. Soil pH as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	8.13	8.14	8.12	8.07	8.11	6.47	7.90	7.86	6.44	7.16
FYM	8.12	8.09	7.95	8.07	8.05	6.58	6.52	6.43	7.77	6.83
PSB	7.61	8.07	8.08	8.14	7.97	7.88	6.57	7.78	6.51	7.18
FYM + PSB	8.04	8.10	8.02	8.01	8.03	6.50	7.87	6.52	6.47	6.83
Mean	8.00	8.10	8.04	8.06		6.86	7.21	7.15	6.80	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	0.02	0.07	P levels (F_1)	0.30	0.9
P components (F_2)	0.02	0.07	P components (F_2)	0.30	0.9
F_1x F_2	0.05	0.14	F_1x F_2	0.61	1.8

Table 2. Soil EC (d S m^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	0.16	0.12	0.17	0.14	0.15	0.27	0.20	0.21	0.25	0.23
FYM	0.09	0.15	0.18	0.15	0.14	0.16	0.21	0.16	0.25	0.19
PSB	0.13	0.10	0.14	0.11	0.12	0.21	0.19	0.21	0.30	0.23
FYM + PSB	0.14	0.12	0.09	0.15	0.12	0.31	0.18	0.14	0.24	0.22
Mean	0.13	0.12	0.14	0.14		0.24	0.19	0.18	0.26	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	0.01	NS	P levels (F_1)	0.01	NS
P components (F_2)	0.01	NS	P components (F_2)	0.01	NS
F_1x F_2	0.01	NS	F_1x F_2	0.02	NS

Table 3. Organic carbon (%) content of the soil as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	0.38	0.48	0.51	0.56	0.48	0.49	0.39	0.38	0.44	0.43
FYM	0.50	0.52	0.55	0.56	0.53	0.67	0.60	0.53	0.52	0.58
PSB	0.43	0.50	0.54	0.50	0.49	0.42	0.47	0.42	0.56	0.47
FYM + PSB	0.51	0.53	0.52	0.56	0.53	0.73	0.62	0.54	0.53	0.60
Mean	0.45	0.51	0.53	0.54		0.58	0.52	0.47	0.52	

	At flowering S Em	At flowering CD @ 5 %	At harvest S Em	At harvest CD @ 5 %
P levels (F_1)	0.02	0.05	0.02	0.07
P components (F_2)	0.02	0.05	0.02	0.07
F_1x F_2	0.03	0.10	0.05	0.15

Table 4.Available nitrogen (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	156.8	169.2	170.9	177.2	168.5	125.6	163.0	144.3	169.3	150.7
FYM	200.7	185.0	201.8	179.2	191.7	175.6	154.1	194.4	207.0	182.8
PSB	169.3	181.9	135.7	143.7	157.6	130.2	198.3	158.1	163.1	162.4
FYM + PSB	181.77	175.0	214.1	201.2	193.1	163.1	163.1	182.4	195.7	176.1
Mean	177.1	177.8	180.6	175.3		148.6	169.6	169.8	183.8	

	At flowering S Em	At flowering CD @ 5 %	At harvest S Em	At harvest CD @ 5 %
P levels (F_1)	7.52	22.6	5.96	18.1
P components (F_2)	7.52	22.6	5.96	18.1
F_1x F_2	15.04	45.2	12.05	36.2

Table 5. Available phosphorus (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	15.23	19.65	24.16	31.18	22.55	13.36	17.85	21.47	30.45	20.85
FYM	27.00	30.14	38.28	41.06	34.12	25.12	28.62	35.22	37.91	31.72
PSB	22.15	26.13	32.04	33.08	28.35	20.29	23.28	30.18	31.89	26.41
FYM + PSB	31.42	36.52	39.54	41.22	37.17	29.18	33.47	36.92	38.52	34.52
Mean	23.95	28.11	33.50	36.63		21.99	25.80	31.01	34.69	

	S [illegible]m	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	[illegible]05	3.17	P levels (F_1)	1.13	3.41
P components (F_2)	[illegible]05	3.17	P components (F_2)	1.13	3.41
F_1x F_2	[illegible]10	NS	F_1x F_2	2.27	NS

Table 6.Available potassium (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	342.4	345.0	342.9	347.5	344.4	382.4	354.5	334.7	386.2	364.5
FYM	337.6	338.6	357.0	366.1	349.8	373.4	383.2	428.6	433.3	404.6
PSB	344.8	334.2	342.6	344.6	341.6	391.6	405.6	413.9	357.1	392.0
FYM + PSB	362.6	355.8	352.2	365.4	359.0	436.3	370.3	419.2	393.4	404.8
Mean	346.9	343.4	348.1	355.9		395.9	378.4	399.2	392.5	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	6.38	19.3	P levels (F_1)	8.03	24.5
P components (F_2)	6.38	19.3	P components (F_2)	8.03	24.5
F_1x F_2	12.85	38.6	F_1x F_2	16.10	48.1

Table 7. Available sulphur (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering – Phosphorus levels					At harvest – Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	21.62	22.41	23.06	24.15	22.81	19.18	20.12	20.98	22.28	20.64
FYM	25.41	26.20	27.28	29.17	27.01	22.67	23.57	25.10	27.02	24.59
PSB	21.89	24.10	25.16	26.24	24.35	19.87	22.66	22.51	24.11	22.29
FYM + PSB	25.62	26.79	28.04	30.30	27.69	23.22	24.12	25.72	27.56	25.15
Mean	23.63	24.87	25.88	27.46		21.23	22.62	23.58	25.24	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	1.04	3.17	P levels (F_1)	0.73	2.21
P components (F_2)	1.04	NS	P components (F_2)	0.73	2.21
F_1x F_2	2.09	NS	F_1x F_2	0.89	2.68

Table 8: Seed yield (q ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	6.28	8.42	9.82	9.92	8.61
FYM	8.44	9.41	10.38	11.08	9.83
PSB	8.97	9.82	11.29	11.78	10.47
FYM + PSB	9.09	10.38	10.80	14.45	11.18
Mean	8.20	9.51	10.57	11.81	

	S Em	CD @ 5 %
P levels (F_1)	0.44	1.34
P components (F_2)	0.44	1.34
F_1x F_2	0.89	2.68

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