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Productivity and soil fertility as effected by organic manures and inorganic fertilizers in greengram (*Vigna radiata*) - wheat (*Triticum aestivum*) system

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ABSTRACT

Field experiments were conducted during *kharif* and *rabi* for 2 consecutive years (2002-03 and 2003-04) at Hisar to evaluate the direct and residual effect of organic manures and phosphorus on productivity, nutrient uptake, soil fertility and economics of greengram-wheat cropping system. Three levels of organic manures (no organic manure, FYM 5 tonne/ha and vermicompost 5 tonne/ha) and 3 phosphorus levels (control, 9 and 18 kg P/ha) applied to only greengram and 3 recommended dose of fertilizers *viz.,* 50%, 75% and 100% applied to only wheat. Application of FYM and vermicompost to greengram increased grain yield and net returns of greengram on an average by 30.5% and 3,653 Rs/ha, respectively, over no manures. Application of 18 kg P/ha to greengram significantly increased grain yield of 264 and 98 kg/ha over control and 9 kg P/ha, respectively. Residual effect of both FYM and vermicompost on yield attributes and yield of wheat was significant over no organic manure, which produced grain yield of 4.13 and 4.15 tonne/ha and gave net return of 20,716 and 20,982 Rs/ha, respectively. The residual effect of 18 kg P/ha applied to greengram was significant on grain yield (4.17 tonne/ha) of wheat over control (3.82 tonne/ha) and 9 kg P/ha (4.02 tonne/ha). The available N and P in soil after greengram harvest, increased significantly over no organic manure application of FYM and vermicompost in greengram. NP uptake by greengram as well as succeeding wheat crop increased significantly with 9 kg P/ha over control. Application of 75% RDF (113, 20 and 40 kg/ha N, P and K) to wheat grown on residual fertility of manures and P applied to greengram, gave significantly higher productivity and net return of wheat as well as in greengram-wheat cropping system.

Key words: Farmyard manure, Mungbean, Nutrient uptake, Phosphorus, Residual effect, Wheat

The responses in component crop of the cropping system are influenced by the preceding crops and the input applied to them. Greengram (*Vigna radiata* L. Wilczek) is an important pulse crop popularly grown in rotation with wheat (*Triticum aestivum* L. emend. Fiori & Paol.) especially in semi-arid region of India under irrigated as well as rainfed conditions. The existing system of fertilizer application is based on the nutrient requirement of individual crops ignoring the carry over effect of the organic manures or inorganic fertilizers applied to the preceding crop. The management of organic manures and phosphorus is considered for cropping system as a whole rather than individual crop because they can not be fully utilized by the crop to which these are added and a substantial amount is left in the soil for subsequent crop and their residual effect thus become an important dimension for their management (Hegde, 1998). Organic manures although, not useful as sole sources of nutrients, are however, good complementary sources with inorganic fertilizers (Chaudhary *et al.,* 2004). Organic manures and phosphatic fertilizers have been carry-over effect on succeeding crops. About less than 30% of N and small fraction of P and K in organic manures may become available to immediate crop and rest to subsequent crops (Sharma and Vyas, 2001). Only half of the nitrogen and one-fifth of phosphorus may be recovered from organic manures in first season of application (Brady, 1996). Therefore, the rest nutrients will be available at slower rate to subsequent crops. As information on these aspects is lacking in greengram - wheat cropping system, present investigation was carried out.

MATERIALS AND METHODS

The field experiments were conducted during *kharif* and *rabi* for 2 consecutive years (2002-03 and 2003-04) at the Agronomy Research Farm of CCS Haryana Agricultural University, Hisar. The soil of the experimental field was sandy loam in texture, low in organic C (0.30%) and

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available N (146 kg/ha), medium in available P (15 kg/ha), high in available K (379 kg/ha) and slightly alkaline in reaction (7.9). The annual rainfall was 129.8 and 457.4 mm with maximum temperature 33.0 to 40.2 ºC and 30.0 and 38.8 ºC minimum 1.0 to 29.1 ºC and 3.9 to 27.9 ºC during 2002-03 and 2003-04, respectively. The experiment was laid out in randomized block design during *kharif* and in split plot design during *rabi* with 3 replications at same site during both the years. Main plot treatments applied to greengram in *kharif* consisted of 3 organic manure, viz. control, FYM and vermicompost @ 5 tonnes/ha, and 3 levels of phosphorus, *viz.,* 0, 9 and 18 kg P/ha. Sub-plot treatments applied to wheat in *rabi* were 50, 75 and 100% (150, 26 and 50 kg N, P and K/ha) recommended dose of fertilizer (RDF). As per treatments, FYM containing 0.58, 0.33 and 0.60% in 2002; 0.61, 0.32 and 0.45% in 2003 and, vermicompost (VC) containing 1.14, 0.54 and 0.39% in 2002; 1.10, 0.58 and 0.32% in 2003 of N, P and K, respectively, were applied 15 days before sowing and phosphorus applied at the sowing to greengram during both the years. Greengram 'Muskan' (MH 96-1) was sown in rows 30 cm apart using a seed rate of 20 kg/ha. After harvest of greengram, the plots were harrowed twice without disturbing the previous layout and each plot was divided into 3 sub-plots in which the aforesaid *rabi* treatments were applied. As per treatment half N and full P and K were applied basal and remaining half N was applied after first irrigation (22 DAS). Wheat 'Raj 3765' was raised in rows 20 cm apart using a seed rate of 120 kg/ha. Available N, P and K content in soil at 0-30 cm depth from each plot after greengram and wheat harvest were estimated. The plant samples were collected at harvest and analysed for N, P and K content in grain and straw. The total nutrient uptake by crop was worked out by multiplying nutrient content in grain and straw with their respective biomass and summing uptake values of grain and straw. The cost of cultivation of individual crop was calculated. The cost of cultivation of greengram was higher during 2002 than 2003, as a result of extra charges of irrigation and insecticide (Endosulphan) spray due to low rainfall and incidence of sucking pests. The price (Rs/tonne) of greengram grain and stover were Rs 13,350 and Rs 1,200 during 2002 and Rs 13,700 and Rs 1,000 during 2003, and that of wheat grain and straw were Rs 6,200 and Rs1,000 during 2002-03 and Rs 6,300 and Rs 1,000 during 2003-04, The net return from individual crop calculated by deducting the cost of cultivation from gross return and expressed as Rs/ha on the basis of cost of inputs and prices of outputs in experimentation years.

RESULTS AND DISCUSSION

Productivity of greengram

Organic manures and phosphorus significantly influenced the growth, yield attributes and yield of greengram over their respective control (Tables 1 and 2). Application of vermicompost being at par wits FYM significantly improved the root nodules/plant at 40 DAS, plant height, pods /plant and 1,000-grain weight over no manure (Table 1). The favourable effect of manures on chemical, physical and biological properties of soil might have resulted in higher growth parameters.

Application of FYM and VC significantly increased the grain and stover yields of greengram over no organic manure (control). However, both the organic manures were statistically at par with each other. The increase in grain yield due to FYM and VC over control was 30.6 and 33.1% during 2002, and 27.1 and 31.3% during 2003, respectively. This might be due to the fact that organic manures supplied to balanced nutrition to the crop, improved soil condition and thereby resulting in better growth and development leading to higher yield attributes and yield. Corroborative findings on VC by Kumar *et al*. (2003) and on FYM by Singh *et al*. (2001). Highest net return (Rs 12,254) was fetched with FYM followed by VC (Rs 11,930) and lowest was recorded with no organic manure (Rs 8,440). This might be due to less cost incurred on FYM application when compared with VC and very little difference in grain yield of both treatments.

The plant height, nodules/plant, pods/plant and 1,000-grain weight showed increasing trend with application of increasing P levels (Table 1). Successive increase in P levels had significant effect on grain as well as stover yield over their preceding levels. Application of 18 and 9 kg P/ha on an average gave 264 and 166 kg/ha more grain yield of over control, respectively. Application of 18 kg P/ha increased the net return by 13,551 and 1,252 Rs/ha over control and 9 kg P/ha, respectively (Table 2). The application of P increased its availability in soil resulting in improved growth and subsequently yields. Similar findings were earlier reported by Chaudhary *et al.* (2004).

Nutrient uptake of greegram

The application of VC being at par with FYM significantly enhanced the total N, P and K uptake by greengram crop over no organic manure. The differences in N, P and K uptake by greengram at harvest might be attributed to significant variation in their concentration and respective yields brought about by the application of manures over no organic manures. Increased N and P uptake due to manuring has also been reported by Rajkhowa *et al*. (2003). Phosphorus application significantly influenced the nutrient uptake, on an average application of 9 kg P/ha increased the total N, P and K uptake by 25.6, 23.2 and 32.4% respectively over control (Table 2). Higher dose of P (18 kg P/ha) did not cause any significant effect on nutrient uptake. The nutrient accumulation is dependent on concentration at cellular level and dry matter accumulation. Hence, improvement in N and P content under P fer-

Table 1. Effect of organic manures and phosphorus on growth and yield attributes of greengram

Treatment	Plant height (cm)		Root nodules/ plant		Pods/plant		Grains/pod		1,000-grain weight (g)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Organic manure (tonne/ha)										
No organic manure	63.5	71.3	13.91	17.53	16.27	16.67	9.31	9.52	30.01	30.74
FYM (5)	77.8	84.5	16.83	20.97	22.12	24.25	9.72	9.86	31.89	32.82
Vermicompost (5)	78.4	85.7	17.57	21.90	23.23	24.98	9.75	10.02	32.96	33.89
SEm±	1.1	1.0	0.5	0.6	0.48	0.54	0.20	0.18	0.57	0.61
CD (P=0.05)	3.3	3.1	1.50	1.81	1.45	1.62	NS	NS	1.72	1.83
Phosphorus level (kg /ha)										
0	65.7	74.1	13.95	17.47	16.62	17.87	9.43	9.59	30.63	31.36
9	75.3	82.1	16.42	20.42	21.63	22.96	9.63	9.76	31.75	32.67
18	78.7	85.3	17.94	22.51	23.27	25.07	9.72	10.05	32.48	33.42
SEm±	1.1	1.0	0.5	0.6	0.48	0.54	0.20	0.18	0.57	0.61
CD (P=0.05)	3.3	3.1	1.50	1.81	1.45	1.62	NS	NS	1.72	1.83

Table 2. Effect of organic manures and phosphorus levels on greengram yield, nutrient uptake and economics

Treatment	Grain yield (tonne/ha)		Stover yield (tonne/ha)		Nutrient uptake (kg/ha)						Gross return (Rs/ha)		Net return (Rs/ha)	
					N		P		K					
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Organic manure (tonne/ha)														
No organic manure	0.88	1.02	1.65	2.08	62.8	75.5	10.83	13.17	39.9	48.3	13,742	16,002	6,823	10,057
FYM (5)	1.15	1.29	2.38	2.91	93.0	109.6	15.18	17.91	62.8	74.3	18,234	20,600	10,634	13,875
Vermicompost (5)	1.17	1.33	2.40	2.93	94.7	112.4	15.47	18.37	65.7	77.7	18,530	21,210	10,174	13,685
SEm±	0.03	0.03	0.07	0.08	3.4	4.2	0.44	0.46	2.0	2.4				
CD (P=0.05)	0.08	0.09	0.22	0.25	10.2	12.5	1.33	1.39	5.9	7.3				
Phosphorus level (kg/ha)														
0	0.93	1.07	1.77	2.23	67.8	82.6	11.36	13.85	43.5	53.3	14,473	16,911	7,248	10,602
9	1.10	1.23	2.22	2.71	86.8	102.0	14.27	16.80	59.1	69.1	17,296	19,572	9,638	12,810
18	1.18	1.34	2.44	2.98	95.9	113.0	15.85	18.79	65.8	77.8	18,737	21,329	10,747	14,205
SEm±	0.03	0.03	0.07	0.08	3.4	4.2	0.44	0.46	2.0	2.4				
CD (P=0.05)	0.08	0.09	0.22	0.25	10.2	12.5	1.33	1.39	5.9	7.3				

tilization reflected in higher crop uptake. The results are in close accordance with Tomar *et al*. (1994) in blackgram.

Productivity of wheat

The residual effect of FYM and VC has significantly increased growth and yield attributes *viz.,* plant height, effective tillers/ metre row length and number of grains/ spike, grain and straw yields of succeeding wheat during both the years over no organic manures (Table 3). The increase in grain yield due to FYM and VC over no organic manure was 10.6 and 11.1% during 2002-03, 10.9 and 11.4% during 2003-04, respectively and gave net return of Rs 20,056 and 20,293 during 2003-04, Rs 21,375 and Rs 21,671 during 2003-04, respectively. Brady (1996) reported that only half of the N and one-fifth of P may be recovered from organic manures in first season of application. Thus, available N and P status of soil improved (Table 6) after greengram harvest which caused better nutrient uptake and increased the yield level. The results are in close accordance with the findings of Sharma and Vyas (2001).

The residual effect of phosphorus increased plant height, effective tillers/metre and number of grains/spike of wheat in both the years. Phosphorus applied at 18 kg P/ ha to greengram significantly enhanced grain and straw yield of wheat to the extent of 9.4 and 10.8 %, respectively, over control. Increase in grain yield of wheat due to application of phosphorus to previous crop was also noticed by Shivakumar and Mishra (2001).The average net return of 18 kg P/ha residual treatment was 2,828 and 1,191 Rs/ha higher than control and 9 kg P/ha, respectively (Table 4).

Nutrient uptake of wheat

The uptake of N, P and K by wheat increased significantly due to residual effect of VC and FYM on an average by 15.5, 17.3 and 13.6% and 14.1, 15.5 and 11.1%

respectively, over no organic manure application (Table 4). This may be attributed to increase their availability in soil and increased biomass production as a result of residual effect of FYM and VC. Application of 9 kg P/ha to *kharif* crop significantly increased N and P uptake by wheat crop over control.

Direct effect of fertilizers on wheat

The application of fertilizers at 75% RDF being on par with RDF increased the grain and straw yield of wheat significantly over 50% RDF in both the seasons. Application of 75% RDF to wheat recorded 18.8 and 18.9% higher grain yield of wheat during 2002-2003 and 2003-04, respectively, over 50% RDF. The N and P uptake by wheat crop was markedly increased by direct application of fertilizers upto 75% RDF in both the seasons. Further application of RDF did not cause any significant differences. Application of 75% RDF to wheat crop grown on residual fertility of organic manures and P applied to greengram, gave higher net return of Rs 20,504 during 2002-03 and Rs 21,831 during 2003-04, which was almost similar to RDF. This might be possible due to continuous and balanced supply of nutrients enhancing their availability exhibited higher crop yield and consequently higher uptake of nutrients. The results are in line with those of Modak *et al.* (1994)

Interaction effect of residual P and RDF to wheat

The wheat responded favourably up to direct application of RDF, where the preceding greengram received no phosphorus. Further, application of RDF up to 75% significantly increased the grain yield of over 50% RDF, where preceding greengram received either 9 or 18 kg P/ha. It showed that later 2 doses were able to meet the requirement of P in wheat. The residual effect of P was significant upto 18 kg/ha where wheat directly received only 50% RDF. Wheat responded upto 9 kg P/ha only where it received 50% RDF and no response of wheat to residual P where it received RDF directly. The combination of 9 kg P/ha applied to greengram and direct application of 75% RDF to wheat gave yield of wheat on par with the combination 18 kg P x 75%, 9 kg P x RDF and 18 kg P x RDF (Table 5).

Residual soil fertility

Application of FYM and VC being at par with each other significantly improved the available N and P status of soil after harvesting of preceding greengram crop over no organic manure application. Vermicompost increased the available N and P status of soil by 16.2 and 18.3%, respectively, over no organic manure treatment (Table 6). The corresponding improvement due to FYM was 10.6 and 15.7%, whereas, available K did not differ significantly in this respect. The improved availability of N and P in soil due to application of organic manures might be due to addition of nutrients through organic manures in addition to native nutrients of soil. Similar results were also reported by Rajkhowa *et al*. (2003). Different phosphorus levels did not influence available N status in soil after greengram harvest during both the years. Whereas,

Table 3. Residual and direct effect of organic manures and inorganic fertilizers on growth and yield attributes of wheat

Treatment	Plant height (cm)		Effective tillers/m		Number of grains/spike		1,000-grain weight (g)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Residual (kharif) Organic manure (tonne/ha)								
No organic manure	84.7	85.9	66.0	66.7	39.8	40.5	39.6	40.1
FYM (5)	88.2	90.3	73.7	74.4	42.1	42.7	40.2	40.7
Vermicompost (5)	88.7	90.9	74.2	74.9	42.3	42.9	40.4	40.9
SEm±	0.9	1.1	1.2	1.3	0.4	0.4	0.3	0.3
CD (P=0.05)	2.8	3.3	3.8	4.0	1.1	1.0	NS	NS
Phosphorus level (kg/ha)								
0	85.2	86.6	68.3	69.0	39.9	40.3	39.7	40.2
9	87.8	89.7	72.4	73.0	41.6	42.4	40.1	40.6
18	88.5	90.8	73.2	73.9	42.7	43.5	40.5	41.0
SEm±	0.9	1.1	1.2	1.3	0.4	0.4	0.3	0.3
CD (P=0.05)	2.8	3.3	3.8	4.0	1.1	1.0	NS	NS
Direct (rabi) recommended dose of fertilizer (%)								
50	83.3	84.0	61.2	61.9	38.2	38.8	39.6	40.1
75	88.5	90.8	75.1	75.7	42.7	43.3	40.3	40.8
100	89.8	92.4	77.7	78.3	43.4	44.0	40.4	40.9
SEm±	1.1	1.2	1.6	1.7	0.5	0.5	0.5	0.4
CD (P=0.05)	3.2	3.5	4.4	4.7	1.4	1.4	NS	NS

Table 4. Residual and direct effect of organic manures and inorganic fertilizers on yield, nutrient uptake and economics of wheat.

Treatment	Grain yield (tonne/ha)		Straw yield (tonne/ha)		Nutrient uptake (kg/ha)						Gross return (Rs/ha)		Net return (Rs/ha)	
					N		P		K					
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Residual (kharif)organic manure														
No organic manure	3.65	3.81	5.29	5.37	88.0	91.4	23.8	24.8	90.8	92.6	27,938	29,357	17,175	18,336
FYM (5 tonne/ha)	4.04	4.22	5.78	5.81	100.3	104.4	27.5	28.7	101.2	102.6	30,819	32,407	20,056	21,375
Vermicompost (5 tonne/ha)	4.06	4.24	5.89	5.98	101.2	106.0	27.9	29.1	103.1	105.2	31,056	32,702	20,993	21,671
SEm±	0.04	0.05	0.06	0.07	1.8	2.1	0.5	0.5	1.8	1.8				
CD (P=0.05)	0.13	0.14	0.19	0.20	5.5	6.2	1.4	1.5	5.5	5.3				
Phosphorus level (kg/ha)														
0	3.74	3.89	5.36	5.40	90.9	93.6	24.0	25.0	93.1	94.4	28,537	29,914	17,774	18,885
9	3.93	4.11	5.69	5.76	97.0	101.5	26.8	28.0	98.9	100.5	30,051	31,672	19,288	20,641
18	4.08	4.27	5.91	6.00	101.6	106.7	28.4	29.5	103.1	105.4	31,225	32,881	20,462	21,849
SEm±	0.04	0.05	0.06	0.07	1.8	2.1	0.5	0.5	1.8	1.8				
CD (P=0.05)	0.13	0.14	0.19	0.20	5.5	6.2	1.4	1.5	5.5	5.3				
Direct (rabi)recommended dose of fertilizer (%)														
50	3.45	3.60	5.05	5.08	82.1	85.6	20.7	21.5	86.2	87.2	26,425	27,727	16,272	17,327
75	4.10	4.27	5.88	5.95	101.9	106.1	28.7	29.8	102.9	105.0	31,269	32,865	20,504	21,831
100	4.21	4.40	6.03	6.13	105.5	110.1	29.8	31.2	106.0	108.2	32,119	33,874	20,748	22,214
SEm±	0.05	0.06	0.08	0.08	2.3	2.5	0.6	0.6	2.3	2.2				
CD (P=0.05)	0.16	0.16	0.22	0.24	6.4	7.2	1.7	1.8	6.4	6.3				

application of 9 and 18 kg P/ha significantly enhanced the available P in soil after greengram harvest over control treatment.

Application of organic manures and phosphorus levels to *kharif* crop and direct applied RDF levels to *rabi* crop did not influence available N and K in soil during both the years. Whereas, the available P in soil after wheat harvest was significantly higher with organic manures applied to preceding greengram over no organic manure application. This might be due to increased availability of P following decomposition of organic manures in this treatment through release of organic acids. Phosphorus application had no significant effect on residual available P in soil after wheat harvest. This may be due to the fact that wheat crop might have utilized the higher nutrient content during its growth and neutralized the availability. Increasing levels of RDF to wheat also increased the available P status of soil. The increased values of available P are ascribed to the addition of P in wheat crop. Application of 75% RDF being ae par with RDF increased available N and P content in soil significantly over 50% RDF.

Consequently application of 75% RDF (113, 20 and 38 kg/ha N, P and K) to wheat superimposed after 5 tonne FYM/vermicompost and 9 kg P to greengram gave higher productivity and proved most remunerative for greengram-wheat cropping system.

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Table 5. Interaction between phosphorus levels and recommended dose of fertilizer (RDF) levels on grain yield (t/ha) of wheat

Phosphorus level (kg/ha)	*Recommended dose of fertilizer levels (%)*					
	2002-03			2003-04		
	50	75	100	50	75	100
0	3.11	3.92	4.19	3.23	4.07	4.38
9	3.45	4.15	4.20	3.60	4.33	4.41
18	3.79	4.23	4.23	3.96	4.42	4.43
SEm± for RDF level at same or different levels of P			0.10		0.10	
CD (P=0.05) for RDF level at same or different level of P			0.27		0.27	
SEm± for P level at same level of RDF			0.09		0.09	
CD (P=0.05) for P level at same level of RDF			0.26		0.26	

Table 6. Effect of organic manures and phosphorus on available nutrient status in soil after greengram and wheat harvest

Treatment	After greengram (kg/ha)						After wheat (kg/ ha)					
	N		P		K		N		P		K	
	2002	2003	2002	2003	2002	2003	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Residual (kharif) organic manure												
No organic manure	144.3	135.2	12.77	13.02	369	377	133.3	135.0	12.5	13.6	364	373
FYM (5 tonne/ha)	158.6	150.5	14.44	15.41	384	389	137.0	142.8	14.6	16.1	372	380
Vermicompost (5 tonne/ha)	165.8	159.1	14.65	15.87	390	396	139.5	143.7	15.3	16.8	372	377
SEm±	4.0	3.5	0.21	0.25	7.3	8.7	3.0	3.3	0.3	0.3	5	6
CD (P=0.05)	12.0	10.5	0.63	0.74	NS	NS	NS	NS	0.8	0.8	NS	NS
Phosphorus level (kg/ha)												
0	149.6	144.4	12.68	12.81	384	388	134.2	135.4	13.6	14.7	364	373
9	158.4	149.4	14.23	15.35	380	389	137.9	142.6	14.3	15.6	371	378
18	160.7	151.0	14.95	16.14	379	386	137.7	143.5	14.4	16.2	374	379
SEm±	4.0	3.5	0.21	0.25	7.3	8.7	3.0	3.3	0.25	0.3	5	6
CD (P=0.05)	NS	NS	0.63	0.74	NS	NS	NS	NS	NS	NS	NS	NS
Direct (rabi) recommended dose of fertilizer (%)												
50							130.6	135.2	12.5	13.0	363	370
75							138.1	142.7	14.6	16.6	372	378
100							140.1	143.6	15.3	16.9	374	383
SEm±							4.0	3.9	0.3	0.3	6	6
CD (P=0.05)							NS	NS	0.8	0.9	NS	NS

*Initial available N:146.3, P:14.6 and K: 379 kg/ha

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