International Journal of Plant & Soil Science

Volume 36, Issue 3, Page 35-44, 2024; Article no.IJPSS.112819
ISSN: 2320-7035

Impact Possibility of Organic, Inorganic and Integrated Production Systems for Crop Productivity and Soil Fertility

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2024/v36i34396

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/112819

Original Research Article

Received: 25/11/2023
Accepted: 01/02/2024
Published: 03/02/2024

ABSTRACT

A field experiment was conducted from 2015-16 to 2021-22 at the Centre for Research on IFS, S.D. Agricultural University, Sardarkrushinagar to study the Impact possibility of organic, inorganic and integrated production systems for crop productivity and soil fertility. Crop sequence Groundnut-wheat-greengram recorded significantly highest groundnut equivalent yield (4886 kg/ha) with application of RDF + 10 t/ha FYM once in year, The percent increase in average of three cropping sequences was about 39.1 % in soil organic carbon, 4.1 % in soil available nitrogen, 1.6 % in

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available phosphorus, 7.2 % in available soil potash, 26.1% in Fe, 22% in Mn, 15.1% in Zn and 64.7% in Cu, while 9.9 % increase in soil water holding capacity and 2.1 % decrease in bulk density, highest microbial counts (bacteria, Actinomycetes and Fungi) under 100 % organic treatment over treatment of State recommendations + 10 FYM/ha once in a year.

Keywords: Bjamrut; ghanjvamrut; jivamrut; microbial counts.

1. INTRODUCTION

Organic agriculture is a production system, which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent possible, organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests. Growing of high yielding varieties within discriminate use of fertilizers, poor water management practice sand in efficient plant-protection measures in modern chemical intensive agriculture has resulted into degradation of lands owing to low crop yields with poor quality of produce [1]. Conversion of modern chemically intensive agriculture to a more sustainable form of agriculture like organic farming appears obey an option for maintaining the desirable agricultural production in future [2]. Generally, it is common thinking that yields of several crops reduce during the initial years under organic farming, but high market value of organically grown produces may be able to compensate the losses in yields Mahapatra et al. [3]. Food crops grown using organic inputs having less or no chemicals are being preferred over conventionally produced food by the end users. Food materials produced organically has got it place in food market in developed and developing countries [4]. Crop based nutrient requirement studies are also going on. But so far no work has been carried out on Integrated Nutrient Management (INM) for crops and cropping systems to address various issues on soil, water and air pollution. Saving of chemicals, improvement in soil health and quality, is also alarming need of this region as well as nationwide. This, calls for an urgent need to study the performance of predominant cropping systems with various nutrient management options in order to increase the profitability and productivity of crops and cropping systems as well as to enhance farm input use efficiency. Keeping this in view a research problem on "study of effect of organic, inorganic and integrated production systems on crop productivity and soil fertility under North Gujarat condition" has been planned to conduct the experiment at Centre for Research on IFS, SDAU, Sardarkrushinagar.

2. MATERIALS AND METHODS

A field experiment was conducted during 2015-16 to 2021-22 at Centre for Research on IFS, S.D.A.U., Sardarkrushinagar to study the effect of organic, inorganic and integrated production systems on crop productivity and soil fertility with different crop sequences under north Gujarat condition. The soil was very low in organic carbon and available nitrogen (141 $kgha^{-1}$) and medium in available P (13.47 kg ha^{-1}) and available K (180 kg ha^{-1}). Total six treatments *viz;* T_1:100 % organic (50% N through FYM + 25% N through vermicompost + 25% N through castor cake), T_2: 75 % organic + Innovative organic practices (Panchgavya and Jivamrut spray @ 2 %), and from 2020-21 onward IOP was application of Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month), T_3:100 % inorganic package, T_4: State recommendations (10 t FYM once in a year + RDF), T_5: 50 % organic package + 50 % inorganic package, T_6: 75 % organic package + 25 % inorganic package with three cropping sequences *viz;*CS_1: Groundnut - wheat - green gram, CS_2:Green gram - coriander - vegetable cowpea, CS_3:Green gram - fennel - fennel continue were executed in strip plot design. The soil was very low in organic carbon and available nitrogen (141 $kgha^{-1}$) and medium in available P (13.47 kg ha^{-1}) and available K (180 kg ha^{-1}). The all crops were fertilized as per treatments details and sown as per recommended spacing for each crops by using recommended varieties and seed rate. The castor cake was applied 10 days before sowing of crops.

3. RESULTS AND DISCUSSION

3.1 Groundnut Equivalent Yield (kg/ha)

Data presented in Table 1 showed that crop sequence C_1(Groundnut- wheat-greengram)

recorded significantly highest groundnut equivalent yield (4886 kg/ha) with application of RDF + 10 t/ha FYM once in year (T_4), while crop sequence C_3(Greengram- fennel- continue) registered significantly lower GEY (1364 kg/ha) under T_2(75 % organic+ innovative organic practices (application of Beejamrit + Ghanjeevamrit @250 kg/ha + Jivamrut @500 lit/ha/ irrigation twice in month). Data revealed that year has significant effect on crop sequences and treatment. The significantly highest GEY (5011 kg/ha) has been recorded under C_1 during first year (after conversion period) of experiment. Crop sequences expressed its significantly lower response over years. In case of treatments, T_4 registered significantly higher GEY (4225 kg/ha) during second, which was at par with first year also (4103 kg/ha). The interaction among treatments and crop sequences over years had fails to exert its significant effect on ground nut equivalent yield, but crop sequences C_1 recorded numerically higher GEY with application RDF + 10 t/ha FYM once in year during all the years after conversion period with all different nutrient management. Nitrogen application through organic manures significantly augmented the onion equivalent yield. This is due to greater availability of nutrients in soil, improved soil physical condition and higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture [5].

3.2 System Gross Profit (₹/ha)

Data presented in Table 2 revealed that crop sequence C_1 registered significantly highest system gross profit of 2,90,945₹/ha under T_1 (100 % organic sources), while all the crop sequences registered at par system gross profit with application of 75 % organic+ innovative organic practices (application of Bijmrit + Ghanjivamrut @250 kg/ha + Jivmrit @500 lit/ha/ irrigation twice in month, T_2) and 50% organic package + 50 % inorganic package(T_5). The lowest system gross profit was recorded under crop sequence C_3 with T_3 treatment. The crop sequences interaction with years was found significant. The significantly highest system gross profit was recorded in C_1 (2,75,729₹/ha) during all the years after conversion period. The treatment interaction also was found significant. Application of 100 % organic sources (T_1) registered significantly highest system gross profit of 2,29,029₹/ha over rest of treatments during all four years. The treatment T_3(1,91,036 ₹/ha and T_5(2,01,168 ₹/ha) was at par in case of system gross profit during 2018-19. The interaction among treatments and crop sequences over years had fails to exert its significant effect on system gross profit, but crop sequences C_1 recorded numerically higher system gross profit/ha with application of 100 % organic source during all the years after conversion period with all different nutrient management.

3.3 System Net Profit (₹/ha)

Data presented in Table 3 indicated that significantly highest net profit was recorded under T_1 with C_1 crop sequence (153222 ₹/ha), while the system net profit of C_1 cropping sequence was at par under treatment T_4(144185). The lowest system net profit was recorded under crop sequence C_3 with T_3treatment (33023). The crop sequences interaction with years was found significant. The significantly highest system net profit was recorded in C_1 (124979 ₹/ha) in mean of all four years after conversion period. The treatment and years interaction was found non significant. Application of 100 % organic sources (T_1) registered numerically highest system net profit of 144165₹/ha over rest of treatments. The interaction among treatments and crop sequences over years had fails to exert its significant effect on system net profit, but crop sequences C_1 recorded numerically higher system net profit/ha with application of 100 % organic source during all the years after conversion period with all different nutrient management.

3.4 Effect of Cropping System and Different Nutrient Management on Soil Properties

The cropping sequences and the nutrient management treatments showed significant influence on soil properties. Soil quality indices for the various cropping sequences and various nutrient management treatments were computed using key indicators viz., pH, EC, OC, micronutrients, Water holding capacity and bulk density. The detail introspection of the soil residual status after completion of seven years sequence presented in Table 4 clearly revealed that, there was improvement in major and minor soil available nutrients (N, P, K, Fe, Mn, Zn and Cu) and physical properties of soil (soil water holding capacity and bulk density of soil at the end of seventh years cycle over its initial value

Table1. Effect of different treatments and cropping sequences on groundnut equivalent yield in pooled (2018-19 to 2021-22)

Crop sequences x Treatments							
Treatments x Crop sequence	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
C_1	4214	3650	4230	4886	4585	3629	4199
C_2	3485	2934	3348	4117	3735	2947	3427
C_3	1606	1364	1485	1882	1780	1463	1597
Mean	3105	2649	3021	3628	3366	2680	
S.Em.±	66.66						
CD at 5%	186						
CV%	9.03						

Year x Crop sequences				
Crop sequences/ Year	**C_1**	**C_2**	**C_3**	**Mean**
Y_1	5011	3456	2485	3651
Y_2	4807	3829	1500	3370
Y_3	3365	3256	1185	2602
Y_4	3615	3169	1217	2668
Mean	4199	3427	1597	
S.Em.±	54.43			
CD at 5%	152			
CV%	9.20			

Year x Treatments							
Year/Treatments	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
Y_1	3590	3242	3745	4103	3944	3280	3651
Y_2	3381	2805	3214	4225	3811	2835	3370
Y_3	2682	2256	2546	3043	2819	2267	2602
Y_4	2754	2295	2579	3142	2892	2338	2667
Mean	3105	2649	3021	3628	3366	2680	
S.Em.±	76.97						
CD at 5%	215						
CV%	9.03						

Year x Crop sequence x Treatments												
Year/	**2018-19**			**2019-20**			**2020-21**			**2021-22**		
Crop sequences/ Treatments	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**
T_1	4978	3358	2434	4793	3849	1501	3408	3377	1260	3677	3356	1229
T_2	4471	3074	2181	4083	3130	1202	2906	2852	1009	3142	2680	1065
T_3	5175	3507	2552	4757	3482	1404	3340	3219	1080	3648	3184	906

T_4	5544	3986	2781	5888	4903		1884	3943	3769	1416	4169	3809	1449
T_5	5388	3764	2679	5394	4379		1659	3669	3468	1321	3888	3329	1461
T_6	4507	3048	2286	3924	3231		1349	2923	2851	1026	3164	2658	1193
S.Em.±	133.32												
CD at 5%	NS												
CV%	8.38												

Table 2. Effect of different treatments and cropping sequences on gross profit in pooled (2018-19 to 2021-22)

Crop sequences x Treatments							
Treatments/Crop sequence	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
C_1	290945	251669	233877	274064	255895	197928	250736
C_2	222339	187191	170778	209993	190522	150301	188721
C_3	102448	87028	75771	96014	90791	74644	87782
Mean	205244	175296	160142	193357	179069	140157	
S.Em.±	3766						
CD at 5%	10501						
CV%	9.03						

Year x Crop sequences				
Crop sequences/ Year	**C_1**	**C_2**	**C_3**	**Mean**
Y_1	275729	190011	136618	200786
Y_2	264141	210192	82257	185530
Y_3	185083	179367	65295	169601
Y_4	198909	174514	66960	146794
Mean	230958	188521	87782	
S.Em.±	3075			
CD at 5%	8574			
CV%	9.13			

Year x Treatments							
Year/Treatments	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
Y_1	229029	206852	191036	209312	201168	167318	200785
Y_2	215701	178950	163983	215538	194406	144601	185530
Y_3	200548	168947	153982	188303	173165	132659	161601
Y_4	175698	146435	131567	160275	147537	119251	146794
Mean	205244	175246	160142	193357	179069	140957	
S.Em.±	4348						
CD at 5%	12125						
CV%	9.03						

Year x Crop sequence x Treatments												
Year/Crop sequences/ Treatments	**2018-19**			**2019-20**			**2020-21**			**2021-22**		
	C_1	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**
T_1	317567	214261	155259	305803	245568	95734	305803	215439	80403	234609	214090	78396

T_2	285260	196136	139161	260489	199712	76648	260489	181973	64380	200438	170945	67923
T_3	263998	178907	130203	242708	177618	71623	242708	164184	55055	186095	162403	46202
T_4	282790	203317	141830	300415	250106	96092	300415	192257	72237	212635	194294	73897
T_5	274846	191999	136660	275216	223372	84632	275216	176909	67370	198305	169806	74501
T_6	229915	155445	116595	200212	164774	68816	200212	145441	52326	161371	135544	60839
S.Em.±	7531											
CD at 5%	NS											
CV%	8.86											

Table 3. Effect of different treatments and cropping sequences on net profit inpooled (2018-19 to 2021-22)

Crop sequences x Treatments							
Treatments/Crop sequence	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
C_1	153222	122067	122549	144185	129365	78487	124979
C_2	138268	106051	92965	122182	109580	67794	106140
C_3	43269	33221	33023	46600	39827	19573	35918
Mean	111587	87113	82846	104322	92924	55285	
S.Em.±	3746						
CD at 5%	10446						
CV%	17.74						

Year x Crop sequences				
Crop sequences/ Year	**C_1**	**C_2**	**C_3**	**Mean**
Y_1	173257	107630	84754	121880
Y_2	96515	127811	30394	84907
Y_3	82612	96986	13431	64343
Y_4	147533	92133	15096	84921
Mean	124979	106140	35919	
S.Em.±	3058			
CD at 5%	8529			
CV%	17.54			

Year x Treatments							
Year/Treatments	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
Y_1	144165	126839	120842	129675	123640	86122	121880
Y_2	105042	76599	71346	109057	94143	53253	84907
Y_3	86216	63893	59670	75575	66282	34422	64343
Y_4	110923	81121	79525	102982	87630	47342	84921
Mean	111587	87113	82846	104322	92124	55285	
S.Em.±	4325						
CD at 5%	NS						
CV%	16.68						

Year x Crop sequence x Treatments												
Year/Crop sequences/	**2018-19**			**2019-20**			**2020-21**			**2021-22**		
Treatments	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**	**C_1**	**C_2**	**C_3**
T_1	206226	130190	96080	161497	117075	36555	131368	106054	21225	183533	130019	19218
T_2	180166	114995	85355	118572	88384	22841	100832	80275	10574	139444	89804	14116
T_3	173977	101094	87455	99805	85358	28875	86372	80331	12307	150531	84591	3454
T_4	181103	115505	92416	162294	118198	46678	104445	99458	22823	177981	106482	24483
T_5	174165	111058	85697	142430	106332	33669	95967	86474	16406	150488	88864	23538
T_6	123904	72939	61524	82267	63746	13746	62934	43078	-2746	83222	53038	5768
S.Em.±	7492											
CD at 5%	NS											
CV%	17.54											

Table 4. Effect of cropping sequences and different nutrient management treatments on soil properties after completion of crop sequence 2021-22 (Summer 2022)

Crop sequences	Soil parameters		SOC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	pH	EC (dSm-1)	Fe (mg/ kg)	Mn (mg/ kg)	Zn (mg/ kg)	Cu (mg/ kg)	MWHC (%)	BD (gm/cc)
		Treatments												
CS_1 (G.nut-wheat-g.gram)	Organic	100% Organic	0.40	163	18.48	187	7.95	0.203	5.90	12.06	0.62	0.76	32.9	1.440
		75% organic+ IP	0.37	160	17.64	178	8.03	0.185	6.88	12.36	0.54	0.84	31.8	1.437
	Inorganic	100% inorganic	0.26	151	17.08	164	7.95	0.178	4.76	9.90	0.70	0.58	30.0	1.481
		State reco.	0.28	154	16.80	181	7.93	0.178	4.28	10.36	0.54	0.50	29.7	1.471
	INM	50% organic+50% inorganic	0.32	160	19.32	184	7.96	0.199	4.76	10.90	0.42	0.80	31.6	1.443
		75% organic+25% inorganic	0.34	163	20.44	182	8.01	0.190	5.74	10.56	0.48	0.84	31.7	1.442
		Initial status	0.21	141	13.47	180	7.22	0.150	3.50	5.26	0.30	0.42	29.5	1.540
	% increase/decrease of T1 over T4		40.9	6.1	10.0	3.5	0.3	14.1	37.9	16.4	14.8	52.0	10.7	-2.1
CS_2 (G.gram-coriander-veg. cowpea)	Organic	100% Organic	0.37	151	16.52	184	8.03	0.204	5.42	12.32	0.52	1.04	31.6	1.441
		75% organic+ IP	0.35	169	16.24	179	7.98	0.186	3.62	9.82	0.30	0.80	31.0	1.445
	Inorganic	100% inorganic	0.25	154	15.96	172	8.04	0.184	3.96	9.38	0.52	0.58	29.6	1.477
		State reco.	0.27	151	17.64	163	8.02	0.175	3.96	8.64	0.38	0.54	29.2	1.476
	INM	50% organic+50% inorganic	0.32	154	19.60	187	7.89	0.184	5.26	10.00	0.16	0.88	32.0	1.434
		75% organic+25% inorganic	0.34	154	17.64	170	7.88	0.204	4.60	10.16	0.22	0.66	32.1	1.455
		Initial status	0.21	141	13.47	180	7.22	0.150	3.50	5.26	0.30	0.42	29.5	1.540
	% increase/decrease of T1 over T4		40.6	0.0	-6.3	12.7	0.1	16.4	36.9	42.6	36.8	92.6	8.2	-2.4

CS_3 (G.gram-funnel- fellow)	Organic	100% Organic	0.36	163	19.60	182	8.01	0.180	3.62	9.04	0.70	0.72	33.1	1.445
		75% organic+ IP	0.35	144	19.32	185	7.96	0.208	5.08	9.86	0.76	0.66	31.7	1.447
	Inorganic	100% inorganic	0.25	151	17.92	163	8.07	0.184	2.82	8.02	0.50	0.50	29.8	1.468
		State reco.	0.27	154	19.32	172	7.93	0.211	3.62	8.40	0.66	0.50	29.9	1.471
	INM	50% organic+50% inorganic	0.3	154	20.44	181	7.97	0.239	4.12	8.70	0.56	0.58	31.2	1.474
		75% organic+25% inorganic	0.33	157	19.60	173	7.78	0.199	6.56	10.20	0.70	0.62	31.6	1.463
	Initial status		0.21	141	13.47	180	7.22	0.150	3.50	5.26	0.30	0.42	29.5	1.540
	% increase/decrease of T1 over T4		35.3	6.1	1.4	5.8	1.0	-14.5	0.0	7.6	6.1	44.0	10.7	-1.8

Table 5. Effect of nutrient management and crop sequences on microbial counts at end of the cropping sequence (2018-19 to 2021-22)

Crop Seq.	Microbial count (per gram of soil)	Organic management		Inorganic management	Inorganic management		Towards organic management
		T_1	T_2	T_3	T_4	T_5	T_6
CS_1	Bacteria($\times10^6$)	146.7	66.78	15.0	48.48	35.5	56.80
	Actinomycete($\times10^5$)	184.7	142.2	27.6	46.47	95.2	65.30
	Fungi($\times10^4$)	117.8	132.5	50.1	83.63	46.8	99.88
CS_2	Bacteria($\times10^6$)	51.38	44.53	4.81	13.87	25.8	22.10
	Actinomycetes $\times10^5$)	167.6	137.0	17.4	40.51	81.8	64.66
	Fungi($\times10^4$)	60.72	48.48	11.39	12.76	35.5	32.14
CS_3	Bacteria($\times10^6$)	75.63	116.1	10.8	198.7	53.0	215.70
	Actinomycete ($\times10^5$)	190.8	190.1	27.4	43.06	119.4	94.63
	Fungi ($\times10^4$)	114.0	96.25	25.00	17.45	39.23	33.30

Table 6. Details of inputs used, purchase price and sale price

A	25% premium price			Normal price	
1.	Selling price of groundnut pod	₹ 63.8/kg	1.	Selling price of groundnut pod	₹ 51.01/kg
2.	Selling price of wheat	₹ 27.6/ kg	2.	Selling price of wheat	₹ 22.10/ kg
3.	Selling price of kharif green gram	₹ 45.1/kg	3.	Selling price of kharif green gram	₹ 36.05/kg
4	Selling price of coriander	₹105.10/kg	4.	Selling price of coriander	₹ 84.05/kg
5	Selling price of cowpea(veg)	₹18.80/kg	5.	Selling price of cowpea(veg)	₹15.00/kg
6	Selling price of fennel	₹68.80/kg	6.	Selling price of fennel	₹55.0/kg
7	Selling price of summer green gram	₹52.50/kg	7.	Selling price of summer green gram	₹ 42.0/kg
a	FYM	₹ 0.6/kg	c	Labour charge	₹ 340/day
b	Vermi compost	₹ 6/kg	d	Castor cake	₹ 7.8/kg

of 2014-15 due to different nutrient management and three cropping sequences. The percent increase in average of three cropping sequences was about 39.1 % in soil organic carbon, 4.1 % in soil available nitrogen, 1.6 % in available phosphorus, 7.2 % in available soil potash, 26.1% in Fe, 22% in Mn, 15.1% in Zn and 64.7% in Cu, while 9.9 % increase in soil water holding capacity and 2.1 % decrease in bulk density under 100 % organic treatment(T_1) over treatment of State recommendations + 10 FYM/ha once in a year(T_4). Application of organic manure along with significantly improved the physical properties of soil. Maximum decrease in bulk density an increase in porosity were recorded with application of organic manure over the initial value due to addition of large amount of bulky organic manure in the field. These results are in close conformity with the findings of Pradhan and Mondal [1]; Varalakshmi et al. [6]. Continuous application of organic manures in sufficient quantities to improve the soil organic carbon in soil thereby sustaining the soil health have been reported by Tiwari *et al.* [7]; L.J. Desai et al. [8].

3.5 Microbial Population

Data presented in Table 5 indicated that highest numbers of bacteria, Actinomycetes and Fungi were found under 100 % organic sources and also in integrated nutrient management in all three crop sequences, while the lowest bacteria, actinomycetes and fungi were found under 100 % inorganic in all three crop sequences. Similar improvement in microbial properties of soil with organic nutrition has been reported by Dubey and Agrawal [9]; Saini et al. [10]. Shanmei et al. [11] also reported favorable effect of organic manures on soil biological properties [12].

4. CONCLUSION

It is concluded that groundnut - wheat-greengram crop sequence with recommended dose of nitrogen to each crop in the ratio of 50:25:25 through FYM: vermicompost: castor cake (based on 0.5%, 1.5% and 3.9% nitrogen content in respective organic source), in groundnut-wheat-green gram for obtaining higher system equivalent yield and net return and also improves soil health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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