

Impact possibility of organic, inorganic and integrated production systems for crop productivity and soil fertility

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 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.

Key words: Bjamrut, Ghanjvamrut, Jivamrut, microbial counts.

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 and 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 (Pradhan and Mondal, 1997). 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 (Modgal *et al.*, 1995). 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.* 2006. 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 its place in food market in developed and developing countries (Urkurkar *et al.* 2010). 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.

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 kg ha^{-1}) and medium in available P (13.47 kg ha^{-1}) and available K (180 kg ha^{-1}). Total six treatments viz; T₁:100 % organic (50% N through FYM + 25% N through vermicompost + 25% N through castor cake), T₂: 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), T₃:100 % inorganic package, T₄: State recommendations (10 t FYM once in a year + RDF), T₅: 50 % organic package + 50 % inorganic package, T₆: 75 % organic package + 25 % inorganic package with three cropping sequences viz;CS₁: Groundnut - wheat - green gram, CS₂:Green gram - coriander - vegetable cowpea, CS₃:Green gram - fennel - fennel continue were executed in strip plot design. The soil was very low in organic carbon and available nitrogen (141 kg ha^{-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.

Results and discussion

Groundnut equivalent yield (kg/ha):

Data presented in table 1 showed that crop sequence C₁(Groundnut- wheat-green gram) recorded significantly highest groundnut equivalent yield (4886 kg/ha) with application of RDF + 10 t/ha FYM once in year (T₄), while crop sequence C₃(Green gram-fennel- continue) registered significantly lower GEY(1364 kg/ha) under T₂(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 C₁ during first year (after conversion period) of experiment. Crop sequences expressed its significantly lower response over years. In case of treatments, T₄ 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 C₁ 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 (Meena *et al.* 2010).

System gross profit (₹ /ha)

Data presented in table 2 revealed that crop sequence C₁ registered significantly highest system gross profit of 2,90,945₹/ha under T₁ (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, T₂) and 50% organic package + 50 % inorganic package(T₅). The lowest system gross profit was recorded under crop sequence C₃ with T₃ treatment. The crop sequences interaction with years was found significant. The significantly highest system gross profit was recorded in C₁ (2,75,729₹/ha) during all the years after conversion period. The treatment interaction also was found significant. Application of 100 % organic sources (T₁) registered significantly highest system gross profit of 2,29,029₹/ha over rest of treatments during all four years. The treatment T₃(1,91,036 ₹/ha and T₅(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 C₁ 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.

System net profit (₹/ha):

Data presented in table 3 indicated that significantly highest net profit was recorded under T₁ with C₁ crop sequence (153222 ₹/ha), while the system net profit of C₁ cropping sequence was at par under treatment T₄(144185). The lowest system net profit was recorded under crop sequence C₃ with T₃treatment(33023). The crop sequences interaction with years was found significant. The significantly highest system net profit was recorded in C₁ (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 (T₁) 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 C₁ 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.

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 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(T₁) over treatment of State recommendations + 10 FYM/ha once in a year(T₄). Application of organic manure along with

significantly improved the physical properties of soil. Maximum decrease in bulk density and 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 (1997) and Varalakshmi *et al.*, (2005). 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.* (2002) and L.J. Desai *et al.* (2023).

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 (1999) and Saini *et al.*, (2005). Shanmei *et al.* (2002) also reported favorable effect of organic manures on soil biological properties.

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.

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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/ 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	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/ 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	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($\times 10^6$)	146.7	66.78	15.0	48.48	35.5	56.80
	Actinomycete($\times 10^5$)	184.7	142.2	27.6	46.47	95.2	65.30
	Fungi($\times 10^4$)	117.8	132.5	50.1	83.63	46.8	99.88
CS ₂	Bacteria($\times 10^6$)	51.38	44.53	4.81	13.87	25.8	22.10
	Actinomycetes $\times 10^5$)	167.6	137.0	17.4	40.51	81.8	64.66
	Fungi($\times 10^4$)	60.72	48.48	11.39	12.76	35.5	32.14
CS ₃	Bacteria($\times 10^6$)	75.63	116.1	10.8	198.7	53.0	215.70
	Actinomycete ($\times 10^5$)	190.8	190.1	27.4	43.06	119.4	94.63
	Fungi ($\times 10^4$)	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