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Effect of natural farming, organic farming and conventional farming on soil physical, chemical and biological properties

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Abstract
A field experiment has conducted at Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat in order to study the soil physical, chemical and biological properties under influence of low cost natural farming (LCNF), organic farming (OF) and conventional farming (CF) during *rabi* 2019-20 to *kharif* 2020. The results showed that significantly improve soil physical properties under organic and conventional farming during *Kharif*-2020. Among the different farming modules, organic and conventional farming module substantial improvement in total bacterial, fungal and actinomycetes count as well as soil organic carbon, sulphur and DTPA-extractable micronutrients (Fe, Zn, Cu and Mn) after harvest of crops as compare to natural farming. Soil available N, P and K markedly increased under conventional farming system that included RDF through fertilizers along with FYM.

Keywords: Natural farming, organic farming, conventional farming, RDF, FYM

1. Introduction
Farmers all across the world used to grow organic food before the 1940s, when the population was much lower than it is now, and yields were comparable to those of prehistoric times. As the world's population rose, growing organic food was no longer a viable option for feeding the world's population. To ensure food and nutritional security for the growing population and to increase income, there is an urgent need to enhance resource use efficiency, reduce input costs and improve crop yields. According to the International Food Policy Research Institute, the world needs to double food production per unit area/day. This calls for an urgent need to identify potential alternative farming strategies to achieve long term sustainable food production and food security.

To meet the demand of increasing population, farmers attract towards the use more and more chemicals in order to gain higher yield. Indian farmers increasingly find themselves in a vicious cycle of debt, because of the high production costs, high interest rates for credit, the volatile market prices of crops, the rising costs of fossil fuel based inputs, and private seeds. Indiscriminate use of chemical fertilizers and pesticides posed a threat to the soil and environment. Many investigations have shown their adverse effects of change in soil nature, soil contamination, ground water pollution, decrease in soil micro flora *etc*.

Natural farming mainly depends on the natural inputs which increase water holding capacity, aeration, organic carbon, enrich the soil with humus, and increase microbial activities. By adopting LCNF, over time shows improvements in yield, soil conservation, seed diversity, and quality of produce, household food autonomy, income, and health. Savings on the cost of seeds, fertilizers and plants protection chemicals has been substantial. Wide-scale adoption of LCNF would help to reduce the release of harmful chemicals to the air, water and soil. It will minimize the adverse impacts on farmer and consumer health and on biodiversity, reduce cost of cultivation, reduce risks, enhance soil fertility, and protect from uncertainties of climate change.

2. Materials and Methods
The investigation was conducted at Instructional Farm, Department of Agronomy, JAU, Junagadh, Gujarat during *rabi* 2019-20 to *kharif* 2020. The soil of experimental site was clayey in texture and slightly alkaline in reaction with pH 8.34, 7.97 and 7.74 and EC 0.54, 0.50 and 0.47 dS/m during *rabi* 2019-20, summer 2020 and *kharif* 2020, respectively.

The soil was low in available nitrogen (239.88 kg/ha, 236.39 kg/ha and 242.32 kg/ha), medium in available phosphorus (32.14 kg/ha, 32.48 kg /ha and 34.77 kg/ha) and medium in available potassium (254.06 kg/ha, 249.51 kg/ha and 254.11 kg/ha) during *rabi* 2019-20, summer 2020 and *kharif* 2020, respectively. The experiment was conducted on non-organic fixed plot with large plot technique and five samples collected from each of 2.7 m x 4.8 m plot. The details of the farming module are presented in Table 1. The present experiment included wheat and chickpea during *rabi* season; groundnut and sesame during summer season; groundnut and sweet corn during *kharif* season. Module-I included intercropping of wheat and chickpea (4:1 replacement series); groundnut and sesame (3:1 replacement series); groundnut and sweet corn (2:1 replacement series). The detail technical programme presented in Table 2.

Table 1: Package of various treatments of different farming systems

Treatments	Module details
Module-I	**Low cost natural farming(LCNF)** ▪ Intercropping of crops ▪ Seed treatment with *Beejamrut* by spraying on seed, mix well and dry before sowing ▪ Soil application of *Ghan Jeevamrut* @ 250 kg/ha along with FYM @ 250 kg/ha at sowing as well assoil application of *Jeevamrut* with irrigation at sowing, 30, 60 & 90 DAS ▪ *Achhadan*: Wheat straw mulch @ 5 t/ha ▪ Plant protection: *Agniastra*, *Brahmastra*, *Neemastra*, *etc.*, if required
Module-II	**Organic farming (OF)** ▪ Sole cropping of crops as per area covered in LCNF ▪ Seed treatment with biofertilizer by spraying on seed, respectively; mix well and dry before sowing ▪ Soil application of vermicompost @ 2 t/ha, FYM and foliar application of *Panchagavya* at 30, 45 and 60 DAS ▪ Plant protection: Pheromone trap, *Trichoderma*, *Beauveria*, *Metarhizium*, NPV, *etc*., if required
Module-III	**Conventional farming (CF)** ▪ Sole cropping of crops as per area covered in LCNF ▪ Seed treated with recommended fungicide before sowing of seed ▪ Soil application of recommended dose of chemical fertilizer and manures ▪ Plant protection: Recommended fungicides, insecticides and herbicides, if required

Table 2: Technical programme of present experimentation

Season-1	***Rabi***	
Crop and variety	Wheat, GJW 496	Chickpea, GG 5
Spacing	22.5 cm	45 cm × 10 cm
Seed rate	100 kg/ha	60 kg/ha
Manures and fertilizer	FYM 10 t/ha 120-60-60 kg N-P_2O_5-K_2O/ha	FYM 5 t/ha 20-40-0 kg N-P_2O_5-K_2O/ha
Season-2	**Summer**	
Crop and variety	Groundnut, GJG 31	Sesame, GJT 5
Spacing	30 cm × 10 cm	30 cm × 10 cm
Seed rate	100 kg/ha	3 kg/ha
Manures and fertilizer	FYM 10 t/ha 25-50-50 kg N-P_2O_5-K_2O/ha	FYM 5 t/ha 50-25-40 kg N-P_2O_5-K_2O/ha
Season-3	***Kharif***	
Crop and variety	Groundnut, GJG 22	Sweet corn, Sugar 75
Spacing	60 cm × 15 cm	60 cm × 20 cm
Seed rate	120 kg/ha	12 kg/ha
Manures and fertilizer	FYM 7.5 t/ha 12.5-25-25 kg N-P_2O_5-K_2O/ha	FYM 5 t/ha 120-60-60 kg N-P_2O_5-K_2O/ha

3. Results

(A) *Rabi* season

3.1. Soil physical properties (*Rabi*)

The data regarding bulk density, porosity and water holding capacity are presented in Table 3 and a glance of the data revealed that different crop growing modules did not exerted significant impact on soil after harvest during *rabi* 2019-20.

3.2. Soil chemical properties (*Rabi*)

The experimental findings presented in Table 3 revealed that highest available N (254.24 kg/ha), P (36.84 kg/ha) and K (268.56 kg/ha) after harvest of wheat and chickpea were recorded under the conventional farming module (CF), while, module-II that included application of biofertilizer, vermicompost, FYM and *Panchagavya* and bioagents (OF) significantly increased organic carbon (0.547%), heat soluble S (16.12 mg/kg); DTPA-extractable Fe (4.50 mg/kg), Zn (0.51 mg/kg), Cu (0.22 mg/kg) and Mn (10.94 mg/kg), which was statistically comparable to application of 100% RDF through fertilizers along with FYM (CF). While, low cost natural farming (LCNF) recorded significantly the lowest organic carbon and available macro and micronutrients after harvest of wheat intercropped with chickpea.

3.3. Soil biological properties (*Rabi*)

An assessment of the data (Table 4) mentioned that different crop growing modules taken under experimentation exerted significant influence on soil microbes after harvest of the crops. total bacterial, fungal and actinomycetes count after harvest were found significantly higher under organically grown crops under whole package of organic farming (OF), which was found equivalent to conventional farming (CF) and remarkably the lowest bacterial, fungal and actinomycetes count after harvest was reported under the natural farming system that included application cow and plant based supplements (LCNF).

Table 3: Soil physical and chemical properties of soil under low cost natural farming, organic farming and conventional farming (*Rabi*)

Particulars	LCNF	OF	CF	S.Em.±	C. D. at 5%	C.V.%
Bulk density (Mg/m³)	1.474	1.451	1.464	0.016	NS	5.48
Porosity (%)	44.494	45.115	44.656	0.495	NS	5.53
Water holding capacity (%)	41.128	41.453	41.361	0.485	NS	5.87
Organic carbon (%)	0.485	0.547	0.529	0.007	0.021	6.60
Available N (kg/ha)	224.14	230.77	254.24	3.586	11.05	7.59
Available P_2O_5(kg/ha)	28.73	31.86	36.84	0.570	1.76	8.78
Available K_2O (kg/ha)	236.44	243.52	268.56	3.827	11.79	7.67
Available S (mg/kg)	16.120	18.275	17.982	0.265	0.817	7.59
Available Fe (mg/kg)	4.503	5.124	5.031	0.075	0.232	7.71
Available Zn (mg/kg)	0.506	0.586	0.558	0.009	0.028	8.31
Available Cu (mg/kg)	0.218	0.258	0.253	0.004	0.014	9.19
Available Mn (mg/kg)	10.939	12.645	12.167	0.200	0.615	8.37

Table 4: Soil biological properties of soil under low cost natural farming, organic farming and conventional farming (*Rabi*)

Particular	LCNF	OF	CF	S.Em.±	C.D. at 5%	C.V. %
Total bacterial count (x 10^6 CFU/g)						
At 30 DAS	52.16	53.14	52.74	0.94	NS	8.89
After harvest	51.18	58.42	55.86	0.83	2.56	7.54
Total fungal count (x 10^4 CFU/g)						
At 30 DAS	22.24	23.22	22.82	0.38	NS	8.38
After harvest	23.02	27.06	25.63	0.46	1.43	9.20
Total actinomycetes count (x 10^5 CFU/g)						
At 30 DAS	43.45	45.16	44.21	0.77	NS	8.73
After harvest	42.27	47.87	45.98	0.64	1.99	7.10

(A) Summer season

3.1. Soil physical properties (Summer)

Glimpse of the data furnished in Table 5 revealed that effect of different modules on bulk density, porosity and water holding capacity after harvest of groundnut and sesame was not significant during the study.

3.2. Soil chemical properties (Summer)

The concerned data (Table 5) indicated that different farming modules significantly influenced the soil chemical properties during the research year. Significantly the highest available N, P and K was reported with recommended dose of chemical fertilizers for plant nutrition along with FYM and chemical management of weed, insect-pests and diseases (CF). Module-II that included treatment of biofertilizer, vermicompost, FYM, *Panchagavya* and biopesticides (OF) having highest OC, S, Fe, Zn, Cu and Mn which was statistically followed by conventional farming (CF) and significantly the lowest organic carbon and available major and minor nutrients was recorded with the natural farming module (LCNF).

3.3. Soil biological properties (Summer)

An experimental data furnished in Table 6 revealed significant effect of different modules on total bacterial, fungal and actinomycetes count at 30 DAS and at harvest of groundnut and sesame. Significantly the highest bacterial, fungal and actinomycetes count was recorded with the organic farming (OF), which was comparable to the conventional farming that involved fertilizers, FYM and pesticides (CF). Nevertheless, the low cost natural farming module (LCNF) recorded significantly the lowest soil microbial count at 30 DAS and at harvest of crops during summer.

Table 5: Soil physical and chemical properties of soil under low cost natural farming, organic farming and conventional farming (Summer)

Particulars	LCNF	OF	CF	S.Em.±	C. D. at 5%	C.V.%
Bulk density (Mg/m³)	1.463	1.406	1.433	0.016	NS	5.49
Porosity (%)	44.854	46.629	45.742	0.555	NS	6.07
Water holding capacity (%)	41.240	42.842	42.081	0.406	NS	4.83
Organic carbon (%)	0.506	0.611	0.584	0.009	0.028	8.12
Available N (kg/ha)	226.87	235.12	264.96	4.144	12.77	8.55
Available P_2O_5 (kg/ha)	29.828	33.574	40.896	0.606	1.868	8.72
Available K_2O (kg/ha)	237.96	246.87	277.51	4.545	14.01	8.94
Available S (mg/kg)	16.647	19.606	19.057	0.329	1.013	8.92
Available Fe (mg/kg)	4.605	5.429	5.246	0.083	0.257	8.19
Available Zn (mg/kg)	0.519	0.635	0.603	0.011	0.033	9.18
Available Cu (mg/kg)	0.227	0.287	0.274	0.005	0.016	10.09
Available Mn (mg/kg)	11.416	13.530	13.286	0.230	0.709	9.02

Table 6: Soil biological properties of soil under low cost natural farming, organic farming and conventional farming (Summer)

Particular	LCNF	OF	CF	S.Em.±	C.D. at 5%	C.V. %
Total bacterial count (x 10^6 CFU/g)						
At 30 DAS	51.80	60.21	57.42	0.95	2.94	8.43
After harvest	52.86	62.79	59.65	1.07	3.29	9.14
Total fungal count (x 10^4 CFU/g)						
At 30 DAS	24.15	29.52	28.01	0.49	1.51	9.03
After harvest	25.07	31.73	30.08	0.55	1.69	9.45
Total actinomycetes count (x 10^5 CFU/g)						
At 30 DAS	42.87	49.87	47.59	0.78	2.41	8.36
After harvest	43.81	52.05	49.45	0.91	2.80	9.38

(A) *Kharif* season

3.4. Soil physical properties (*Kharif*)

It is inferred from the data presented in Table 7 that the lowest bulk density after harvest (1.334 Mg/m³) and maximum porosity (48.989%) and water holding capacity (44.586%) was recorded with organic farming (OF), which was found at par with conventional farming (CF) in the study.

3.5. Soil chemical properties (*Kharif*)

Different crop growing modules exerted significant influence on post-harvest available nutrients in soil. Conventional farming that included chemical farming recorded significantly the highest available N (273.34 kg/ha), P (45.770 kg/ha) and K (287.43 kg/ha) after harvest. Organic farming module recorded significantly the highest organic carbon (0.689%), S (20.94 mg/kg), DTPA-extractable Fe (5.93 mg/kg), Zn (0.69 mg/kg), Cu (0.33 mg/kg) and Mn (14.81 mg/kg). Lowest organic carbon and available nutrients after harvest was observed when crops were grown under the low cost natural farming (LCNF).

3.6. Soil biological properties (*Kharif*)

A critical examination of the data Table 8 clearly show that organic farming that included biofertilizer, vermicompost, FYM, Panchagavya and biopesticides had markedly the highest bacterial, fungal and actinomycetes count (64.96 x 10^6, 34.47 x 10^4, 54.64 x 10^5 CFU/g of soil) at 30 DAS and (66.51 x 10^6, 36.69 x 10^4, 58.08 x 10^5 CFU/g of soil) at harvest of groundnut and sweet corn. The low cost natural farming module (LCNF) had significantly the lowest soil microbial count at 30 DAS and harvest.

Table 7: Soil physical and chemical properties of soil under low cost natural farming, organic farming and conventional farming (*Kharif*)

Particulars	LCNF	OF	CF	S.Em.±	C. D. at 5%	C.V.%
Bulk density (Mg/m³)	1.454	1.334	1.375	0.014	0.042	4.87
Porosity (%)	45.230	48.989	47.916	0.434	1.337	4.58
Water holding capacity (%)	41.355	44.586	43.644	0.371	1.142	4.29
Organic carbon (%)	0.533	0.689	0.658	0.010	0.031	8.02
Available N (kg/ha)	228.28	238.67	273.34	4.397	13.550	8.91
Available P_2O_5(kg/ha)	31.370	35.428	45.770	0.752	2.316	10.02
Available K_2O (kg/ha)	240.12	250.89	287.43	4.323	13.320	8.33
Available S (mg/kg)	17.240	20.937	20.124	0.356	1.097	9.16
Available Fe (mg/kg)	4.849	5.930	5.665	0.095	0.294	8.69
Available Zn (mg/kg)	0.539	0.694	0.663	0.011	0.035	9.05
Available Cu (mg/kg)	0.243	0.329	0.312	0.006	0.019	10.54
Available Mn (mg/kg)	11.757	14.807	14.291	0.281	0.866	10.32

Table 8: Soil biological properties of soil under low cost natural farming, organic farming and conventional farming (*Kharif*)

Particular	LCNF	OF	CF	S.Em.±	C.D. at 5%	C.V. %
Total bacterial count (x 10^6 CFU/g)						
At 30 DAS	53.63	64.96	61.76	1.11	3.42	9.22
After harvest	54.15	66.51	62.96	1.19	3.65	9.69
Total fungal count (x 10^4 CFU/g)						
At 30 DAS	26.12	34.47	32.62	0.60	1.86	9.74
After harvest	26.81	36.69	34.72	0.66	2.02	10.01
Total actinomycetes count (x 10^5 CFU/g)						
At 30 DAS	44.75	54.64	51.88	0.90	2.78	8.93
After harvest	45.64	58.08	54.93	1.04	3.21	9.86

4. Discussion

4.1. Soil physical properties

The experimental results revealed that during *rabi* and summer season of experiment, non-significant improvement in bulk density, porosity and water holding capacity after harvest. But continuous supply of FYM and vermicompost improved physical properties of soil. Researchers have shown that soil with a high organic content and favourable pore geometry leads to reduced bulk density, increased porosity and water holding capacity. The findings corroborate those of Brar *et al.* (2015) [4] who found similar results for soil with high organic carbon levels.

4.2. Soil chemical properties

Fertility of soil in the production systems of crops is controlled by organic amendments, such as vermicompost and

FYM. Addition of organic manures to an agricultural soil has a variety of effects on enzyme activities, which play an essential role in the mineralization of the soil (Gopinath *et al*., 2008) [5]. conventional and organic farming system reported the higher organic carbon and available nutrients in soil after harvest which might be due to addition of more organic matter and production of carbon dioxide and organic acids released during the process of decomposition of FYM which increase the availability of nutrients from native as well as due to applied fertilizers during crop cycle (Mere *et al*., 2012) [10]. Vermicompost contains more micronutrients itself and also increase available cationic micronutrient concentration in soil solution by soil microbes. Poorer results under the natural farming might be due to addition of smaller quantity of supplements. Same results were also reported by Katkar *et al.* (2011) [7], Arbad *et al.* (2014) [1], Bhatt *et al*. (2017) [3], Sikka *et al.* (2018) [13], Jadhao *et al*. (2019) [6] and Kumar *et al*. (2020) [8].

4.3. Soil biological properties

A soil capacity to support biological fertility is determined by inherent physical and chemical characteristics as well as management practices. The result of present experiment reflects that microbial population was higher in the modules which received enough bulk of organic manure, because the organic matter is the food of microbes (Manna and Ganguly, 2001). Microorganism act as primary driving agents of nutrient cycling, regulating the dymanics of soil organic matter, soil carbon sequestration and greenhouse gas emissions; modifying soil structure and water regimes; enhancing the nutrient acquisition by vegetation; conferring stress tolerance, resisting pathogens and improving plant health (Bhatt *et al*., 2019) [2]. The results are in conformity with the work of Katkar *et al.* (2011) [7], Pawar *et al*. (2013) [11], Arbad *et al.* (2014) [1], Pradeep *et al*. (2018) [12] and Kumar *et al*. (2020) [8].

5. Conclusion

On the basis of three-season experimentation, it may be concluded that whole package of organic farming system comprised of biofertilizers treated seed sowing, soil application of vermicompost and FYM; foliar application of *Panchagavya* and application of chemical fertilizers along with FYM and chemical pest management strategies were found superior in soil available nutrients and soil microbes as compared to low cost natural farming under medium black calcareous clayey soil of South Saurashtra region.

6. Author's contribution: H. V. Korat; investigation, analysis, data curation, writing and R. K. Mathukia; supervision, review and editing. M. R. Faldu; helps during my research work. Authors have read and agreed to the published version of the manuscript.

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