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RESEARCH ARTICLE

Potential of natural farming-improves soil health and reduces production cost: Study of Solan District, Himachal Pradesh, India

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Abstract

A survey of three blocks in Solan District of Himachal Pradesh was carried out during 2020-2021 with the objective to evaluate the soil quality and plant nutrient contents under Zero Budget Natural Farming (ZBNF) and Conventional farming systems. 30 representative surface soil and plant samples (15 each of conventional and ZBNF farming systems) were collected and analyzed from farmers' fields practicing ZBNF and conventional farming, respectively, in the same block. N, P, and K were recorded 5.21, 14.69 and 10.27% higher, respectively, under conventional farming as compared to the ZBNF farming system. Similarly, maximum Ca, Mg and S were also recorded 7.62, 12.21 and 16.64% higher, respectively, under conventional farming system as compared to ZBNF farming system. In contrast, soil under the ZBNF system recorded 22.85% higher organic carbon as compared to the conventional farming system. Viable microbial count (45.72×10^5 cfu g^{-1} bacteria, 6.73×10^3 cfu g^{-1} Fungi and 9.28×10^3 cfu g^{-1} Actinomycetes) were also recorded higher under ZBNF compared to conventional farming system. Further, conventional farming system recorded higher leaf macronutrients as well as micronutrients in leaf compared to the ZBNF farming system. Resultantly, yield of pea was significantly higher (109.67 q ha^{-1}) under conventional farming system as compared to ZBNF (92.07 q ha^{-1}). However, 47% higher production cultivation cost under the conventional farming system resulted in better B:C Ratio of ZBNF farming system (2.13) as compared to a conventional farming system (1.52).

Keywords: Pea, Zero budget natural farming (ZBNF) system, Soil nutrients status, Yield, cost economics.

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Introduction

Pea (*Pisum sativum* L.) is a cool-season vegetable of the leguminosae family and is grown all over the world in temperate areas, at higher elevations, or during the cool seasons in warm climates. It is a rich source of protein (25%), amino acids, sugars (12%), carbohydrates, vitamins A and C, calcium and phosphorus. Major pea-growing states in India are Bihar, Haryana, Punjab, Himachal Pradesh, Orissa and Karnataka. It is grown commercially in Himachal Pradesh in the districts of Sirmaur, Lahul Spiti, Solan, and Shimla, with a total area of 568 thousand hectares and an annual production of 5848 thousand MT in 2021-22 (DoA&FW, 2022). Of late, concerns about food quality and safety in respect to human health, along with the deterioration of soil health, have forced agriculturists to relook at the sustainable agricultural systems around the world that we may have abandoned in greed for more production and productivity. Though the green revolution with hybrids was the need of the hour for India to meet its food requirements, chemical-intensive conventional agriculture over the years resulted in irreversible ecological catastrophes such as widespread soil erosion and salinization, declined groundwater tables and water pollution, deterioration of soil health and biodiversity, etc. This had detrimental consequences on heirloom crops and, consequently, on small and marginal farmers in India (Eliazer et al., 2019). Where conventional farming represents one extreme of agriculture, sustainable farming represents the other. In principle, organic farming can reduce the environmental impact of farming but can result in a reduction in crop yield (Ponisio et al., 2015) and lower temporal yield stability (Knapp and Van der Heijden, 2018). India, now the most populous country as of today, cannot afford to increase the area under crop. Though farmers in India have been practicing sustainable agriculture for ages, due to urgency and the need for higher food requirements, farmers were lured into the green revolution through heavily subsidized fertilizers, seeds, water and electricity. Zero Budget Natural Farming (ZBNF) or sustainable agriculture is a reinvented agrarian movement through which twin goals of global food security and conservation of the environment can be achieved by using low-cost and locally sourced home-made amendments instead of agrochemicals or agribusiness (RySS, 2020). Widespread adoption of Zero Budget Natural Farming would aid in the reduction of harmful and poisonous substances released into the soil, plants, water and atmosphere and the government is now again trying to promote ZBNF through different schemes and trained official manpower (Vashishat et al., 2021). As a result, the negative impacts on consumer health, as well as biodiversity, will be minimized. To fully realize the potential of Zero Budget Natural Farming, advanced research is required, which can help in meeting the greatest challenge of the twenty-first century i.e., to feed the increasing population while also improving and maintaining soil health and environmental quality.

Materials and Methods

In Himachal Pradesh, About 1.5 lakh farmers are practising natural farming (ET, 2023a). According to a starred question in Loksabha, 12000 ha area is covered under natural farming in Himachal Pradesh (DoA&WF, 2022). However, a total of only 727 farmers are registered under the Prakritik Kheti Khushhal Kisan Yojana under the Subhash Palekar Natural Farming project, out of which 467 are male and 250 are female. In Solan district, Study areas were identified with the help of the Department of Agriculture, Government of Himachal Pradesh, Solan. Out of a total of 5 blocks in Solan district, Solan, Kandaghat and Kunihar blocks were selected for study where pea cultivation is taken as a major cash crop. At present, a total of 50 farmers are registered in Prakritik Kheti Khushhal Kisan Yojana under Subhash Palekar Natural Farming project in Solan district (SPNF, 2023b). For ZBNF, only those farmers were selected who were practicing ZBNF for at least four years, while for a conventional farming system, farmers involved in growing peas as a commercial crop for the last four or more years were selected. A total of 30 farmers (5 farmers each for ZBNF and conventional farming system in each block) were selected from three blocks of Solan district, i.e., Solan, Kandaghat and Kunihar. Soil samples at 0-15 cm depth were taken before sowing of the crop and after harvesting of the crop i.e., in November and April, respectively (following standard operating procedure). Plant samples were taken at the first bloom stage during March-April. Yield data was taken at the time of harvesting from the fields of respective farmers. Farmers under the conventional farming system used urea, SSP and MOP @ 27kg/ha, 187kg/ha and 100kg/ha, respectively, while farmers adopting ZBNF used ghanjeevamrti and jeevamrit (constituent of jaggery, pulse flour, cow dung and cow urine at 5, 5, 25 kg/ha and 25l/ha, respectively) for a nutrient supplement. Soil texture under both conventional and ZBNF farming systems varied from sandy clay loam to sandy loam. The soil and plant samples were subjected to standard analytical procedure viz. Soil texture was determined by the hydrometer method. Soil pH EC were estimated in 1: 2 soil: water suspension, Organic carbon was estimated by wet digestion method, Available nitrogen was analyzed by alkaline potassium permanganate method, available phosphorus by Olsen's method, available potassium by ammonium acetate method, Exchangeable calcium and magnesium were determined by atomic absorption spectrophotometer. Available sulfur was determined by turbidity method (0.15 % $CaCl_2$) of and DTPA extractable Fe, Mn, Cu, Zn by atomic absorption spectrophotometer. Nitrogen content in pea leaves was estimated by microkjeldhal distillation, phosphorus by vanado-molybdo-phosphoric yellow color method, potassium and calcium by flame photometer, and magnesium and micronutrients by atomic absorption spectrophotometer. The data was analyzed through the statistical software SPSS-18 using T test values for different parameter compression.

Results and Discussion

pH, EC and OC

The pH and EC of soils under conventional farming system ranged from 6.49-7.15 and 0.143-0.255 (dS m^{-1}), respectively, while the soil pH and EC of ZBNF practice ranged from 6.42-7.56 and 0.142-0.272 (dS m^{-1}), respectively. The OC was 22.85% lower under conventional farming system (15.88 g kg^{-1}) as compared to ZBNF practice (19.51 g kg^{-1}). No significant difference was recorded in pH and EC of the farming systems. However, higher organic carbon content in the ZBNF soil may be due to increased microbial and enzymatic activity and might have led to lower bulk density and, subsequently increase in organic carbon content. The present results are in accordance with the findings of Kumari et al. (2012); Te Pas and Rees (2014) and Choudhary et al. (2022).

Soil Macronutrients

Available nitrogen content (Table 1) was 5.21% higher under conventional farming system (329.07 kg ha^{-1}) as compared to ZBNF farming system (312.76 kg ha^{-1}). Similarly, available P and K content were recorded at 14.69 land, 10.27% lower under ZBNF practice, which recorded 37.63 and 330.48 kg ha^{-1} P and K as compared to conventional farming system, which recorded 43.16 and 364.45 kg ha^{-1}, respectively. Higher build-up of N P, and K in conventional farming system may be due to higher amounts of nutrients being added through synthetic fertilizers and FYM (Umadevi et al., 2019; Duddigan et al., 2023). The exchangeable Ca (4.85 [cmol (p^+) kg^{-1}]) and Mg (4.42 [cmol (p^+) kg^{-1}]) content were recorded 7.62 and 12.21% lower under ZBNF farming system as compared to conventional farming system which recorded (5.22 [cmol (p^+) kg^{-1}]) and (4.96 [cmol (p^+) kg^{-1}]), exchangeable Ca and Mg, respectively (Table 1). Prasad et al. (1996) has also reported a jump in exchangeable Ca and Mg in continuously fertilized soils.

Soil micronutrients (Table 2) also followed the same trend. Conventional farming system recorded 4%, 6%, 6% and 22% higher Zn (2.30 mg ha^{-1}), Fe (20.83 mg ha^{-1}), Cu (2.68 mg ha^{-1}) and Mn (10.65 mg ha^{-1}) contents over ZBNF practice which recorded Zn (2.21 mg ha^{-1}), Fe (19.59 mg ha^{-1}), Cu (2.52 mg ha^{-1}) and Mn (8.67 mg ha^{-1}). The higher build-up of nutrients in the conventional farming system may be due to the fact that inorganic sources might have fulfilled the initial requirement of nitrogen for pea crops and subsequently from organic sources. Marathe et al. (2009) and Shahid et al. (2015) reported a significant increase in available Fe, Mn, Cu, and Zn with organic manure, either alone or in combination with inorganic fertilizers. The increase in these micronutrients may be due to the mineralization of organically bound forms and the formation of stable complexes or organic chelates of higher stability, which decreased their susceptibility to adsorption and fixation.

Leaf Nutrient Contents

Nitrogen (2.73%), phosphorus (0.45%) and potassium (1.35%) leaf content (Table 3) were also recorded higher in the conventional farming system as compared to ZBNF farming system (2.45, 0.43 and 1.23% of N, P and K, respectively). Yadav et al. (2023) also reported maximum leaf NPK in the treatment combination of recommended doses of fertilizers along with FYM and biofertilizers. Similarly, maximum Ca (1.74%), Mg (0.34%) and S (0.34%) content of leaf (Table 3) were recorded in the conventional farming system as compared to the ZBNF farming system, which recorded 1.58, 0.32 and 0.29% of Ca, Mg and S, respectively. Sharma and Subehia (2014) reported an increase in exchangeable Ca and Mg under conventional farming systems.

Conventional farming systems also recorded higher Zn, Ca, Mg and Mn leaf content as compared to ZBNF (Table 4). Zn content was recorded to be lower under the ZBNF farming system (20.85 ppm) as compared to a conventional farming system (26.07 ppm). Under conventional farming system the Fe content was recorded to be higher (278.73 ppm) as compared to the ZBNF (261.06 ppm) farming system. Similarly, Cu (53.65 ppm) and Mn (74.60 ppm) content were recorded to be higher under conventional farming systems as compared to ZBNF 49.51 ppm and 73.97 ppm of Cu and Mn, respectively.

Microbial Count

The ZBNF farming system scored significantly over the conventional system on an increase in microbial count (Table 5). The bacterial population was lower under the conventional farming system (8.65×10^5 cfu g^{-1}) as compared to ZBNF farming system (9.28×10^5 cfu g^{-1}). ZBNF farming system had a higher fungi population (6.73×10^3 cfu g^{-1}) as compared to conventional farming system (6.42×10^3 cfu g^{-1}). Similarly, the population of actinomycetes were recorded higher in ZBNF (9.28×10^3 cfu g^{-1}) as compared to conventional farming system (8.65×10^3 cfu g^{-1}). The higher microbial population might be due to the addition of natural farming concoctions like ghanjeevamrit and jeevamrit into the soil, which might have created congenial microenvironment for beneficial microbes to multiply as compared to conventional farming system where use of synthetic fertilizers harm the growth of microbes irrespective of their usefulness. Nagar et al. (2016) reported an increase in beneficial microbes under a sustainable agricultural system. Jain et al. (2014) reported that the application of different concentrations of *Panchagavya* increased microbial activity compared to FYM and vermicompost-applied soil on seed of cereal (wheat and rice) and legumes (pea, gram, green gram, black gram, dry bean, lentil, and soybean). However, effect of the microbe population on making nutrients available for uptake by the plants need to be examined critically.

Yield and Cost Economics

Higher yield (Table 6) was recorded under the conventional farming system (109.67 q/ha) as compared to the ZBNF (92.07 q/ha) farming system. Increased yield under the conventional farming system may be due to the availability of nutrients in high quality as farmers were applying inorganic fertilizer to supplement the nutrients taken up by the plants. In contrast, in ZBNF, the nutrient requirement might not have been fulfilled by the organic supplements like FYM, *Jeevamrit Ghanjeevamrit* etc. Yadav et al. (2004) reported that the application of NPK was effective in increasing the yield of tomatoes when applied along with FYM. B: C Ratio of the ZBNF farming system (2.13) was higher as compared to a conventional farming system (1.52) as the cost of cultivation (Rs 130207) under the conventional farming system was higher as compared to the ZBNF farming system (Rs 88175). Chandel et al. (2021) also reported a 14 to

Table 1: Soil macronutrient content under conventional and ZBNF farming system

Block	Farmer	Conventional						ZBNF					
		N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca [cmol (p^+) kg^{-1}]	Mg [cmol (p^+) kg^{-1}]	S (kgha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca [cmol (p^+) kg^{-1}]	Mg [cmol (p^+) kg^{-1}]	S (kgha^{-1})
Solan	F1	341.824	40.32	316.96	4.96	4.33	20.58	335.552	31.36	282.24	4.68	3.77	18.06
	F2	316.736	35.84	278.88	5.23	5.12	21.56	291.648	33.60	283.76	4.76	4.66	15.54
	F3	335.552	49.28	370.72	5.49	5.91	27.72	316.736	38.08	328.16	4.45	5.12	23.24
	F4	332.416	44.80	355.04	5.34	6.31	23.52	291.648	42.56	296.80	5.24	4.98	23.10
	F5	338.688	47.04	402.08	5.04	4.13	24.36	341.824	40.32	321.44	4.65	4.34	21.98
Kandaghat	F6	319.872	49.28	337.12	5.35	4.29	19.74	332.416	35.84	364.00	4.79	4.45	18.48
	F7	335.552	35.84	430.08	5.21	7.46	29.54	288.512	31.36	318.08	4.55	3.72	24.08
	F8	329.280	42.56	367.36	4.91	4.56	15.68	316.736	33.60	341.60	5.19	4.51	11.48
	F9	316.736	44.80	388.64	5.16	4.74	25.62	329.28	47.04	383.04	4.93	4.66	21.14
	F10	332.416	56.00	437.92	5.03	4.43	16.94	310.464	47.04	350.56	4.86	4.51	26.46
Kunihar	F11	319.872	47.04	378.56	5.34	5.11	24.08	294.784	42.56	352.80	5.11	3.82	18.48
	F12	341.824	40.32	312.48	5.15	4.33	25.90	307.328	33.60	333.76	4.96	4.75	22.82
	F13	338.688	29.12	406.56	5.79	4.58	13.86	316.736	33.60	381.92	4.51	4.07	10.78
	F14	326.144	38.08	304.64	5.29	5.08	27.44	310.464	35.84	344.96	5.16	4.65	20.58
	F15	310.464	47.04	379.68	4.94	4.09	23.94	307.328	38.08	275.52	4.84	4.33	15.68
Range		310.464-341.824	29.12-56.00	278.88-437.92	4.91-5.49	4.09-7.46	13.86-29.54	288.51-341.824	31.36-47.04	275.52-383.04	4.45-5.24	3.72-5.12	10.78-26.46
Mean		329.07	43.16	364.45	5.22	4.96	22.70	312.76	37.63	330.48	4.85	4.42	19.46
SE		2.62	6.74	12.08	0.06	0.24	1.19	4.33	1.68	8.91	0.07	0.11	1.18
T		3.22	2.51	2.26	4.16	2.04	1.94						
P		0.0032	0.0183	0.0321	0.0003	0.0512	0.0630						

Table 2: Soil micronutrient content of pea grown under conventional and ZBNF farming system

Block	Farmer	*Conventional*				*ZBNF*			
		Zn (mg kg⁻¹)	*Fe (mg kg⁻¹)*	*Cu (mg kg⁻¹)*	*Mn (mg kg⁻¹)*	*Zn (mg kg⁻¹)*	*Fe (mg kg⁻¹)*	*Cu (mg kg⁻¹)*	*Mn (mg kg⁻¹)*
Solan	F1	3.01	23.21	2.83	8.91	2.73	22.78	2.37	8.79
	F2	2.19	19.82	2.84	9.73	2.84	22.76	2.73	9.23
	F3	2.91	22.51	2.47	12.93	2.49	22.35	2.34	8.37
	F4	3.02	22.78	2.95	11.29	2.76	22.58	2.45	7.23
	F5	2.43	21.07	2.73	11.22	2.36	21.76	2.73	8.38
Kandaghat	F6	1.06	22.45	2.83	9.87	2.04	21.23	2.79	9.87
	F7	2.13	19.86	2.43	12.14	1.84	17.86	2.86	9.47
	F8	1.45	21.22	2.39	8.59	1.57	19.82	2.63	7.68
	F9	2.23	19.78	2.45	9.82	1.93	17.28	2.38	8.79
	F10	2.39	18.41	2.78	11.74	1.87	14.72	2.63	8.27
Kunihar	F11	1.84	21.02	2.76	9.15	1.91	19.23	2.34	8.78
	F12	1.93	18.59	2.82	11.32	1.64	18.34	2.74	8.29
	F13	2.83	20.14	2.91	13.29	2.57	16.38	2.21	9.27
	F14	2.38	18.62	2.38	9.85	2.06	19.37	2.31	9.85
	F15	2.76	23.01	2.56	9.91	2.57	17.39	2.32	7.84
Range		1.06-3.02	18.41-23.21	2.38-2.95	8.59-13.29	1.57-2.84	14.72-22.78	2.21-2.86	7.23-9.85
Mean		2.30	20.83	2.68	10.65	2.21	19.59	2.52	8.67
SE		0.15	0.43	0.05	0.38	0.11	0.67	0.06	0.20
T		0.50	1.57	2.01	4.65				
P		0.6210	0.1288	0.0543	0.0001				

Table 3: Leaf macronutrient content of pea grown under conventional and ZBNF farming system

Block	Farmer	*Conventional*						*ZBNF*					
		N(%)	*P (%)*	*K (%)*	*Ca (%)*	*Mg(%)*	*S(%)*	*N(%)*	*P(%)*	*P(%)*	*Ca (%)*	*Mg (%)*	*S(%)*
Solan	F1	2.07	0.49	1.33	1.48	0.37	0.39	1.76	0.44	1.16	1.35	0.33	0.26
	F2	2.77	0.46	1.37	1.89	0.32	0.35	2.41	0.41	1.23	1.57	0.29	0.32
	F3	2.86	0.44	1.36	1.53	0.36	0.31	2.36	0.43	1.14	1.57	0.33	0.27
	F4	3.07	0.45	1.58	2.12	0.31	0.29	2.54	0.43	1.15	1.76	0.30	0.23
	F5	2.86	0.44	1.29	1.87	0.38	0.45	2.30	0.43	1.23	1.68	0.35	0.42
Kandaghat	F6	2.89	0.44	1.23	1.62	0.33	0.35	2.80	0.43	1.08	1.47	0.31	0.32
	F7	3.28	0.44	1.34	1.44	0.31	0.31	1.96	0.43	1.29	1.51	0.28	0.29
	F8	2.47	0.43	1.09	1.65	0.37	0.36	2.33	0.41	1.03	1.49	0.34	0.34
	F9	2.52	0.45	1.29	1.75	0.34	0.32	2.18	0.44	1.34	1.53	0.32	0.28
	F10	2.24	0.48	1.26	2.11	0.31	0.36	2.86	0.44	1.23	1.64	0.30	0.31
Kunihar	F11	3.20	0.44	1.31	1.82	0.38	0.31	2.44	0.44	1.27	1.72	0.35	0.26
	F12	2.46	0.46	1.37	1.57	0.35	0.29	2.32	0.44	1.32	1.46	0.31	0.23
	F13	2.90	0.44	1.41	1.72	0.32	0.38	2.54	0.43	1.37	1.62	0.32	0.32
	F14	2.89	0.45	1.56	1.87	0.36	0.31	2.66	0.41	1.27	1.75	0.33	0.28
	F15	2.52	0.44	1.46	1.69	0.32	0.30	3.28	0.41	1.37	1.63	0.31	0.26
Range		2.07-3.28	0.43-0.49	1.09-1.58	1.44-2.12	0.31-0.38	0.29-0.45	1.76-2.86	0.41-0.44	1.03-1.37	1.35-1.76	0.28-0.35	0.23-0.42
Mean		2.73	0.45	1.35	1.74	0.34	0.34	2.45	0.43	1.23	1.58	0.32	0.29
SE		0.09	0.00	0.03	0.05	0.01	0.01	0.09	0.00	0.03	0.03	0.01	0.01
t		2.18	4.17	2.85	2.58	2.76	2.71						

45% reduction in labor and production costs. Higher gross returns under Natural Farming systems as compared to Conventional Farming systems in all the crop combinations were also reported by Te Pas and Rees (2014) and Laishram et al. (2022).

Pea growing soils of Solan district under the conventional farming system have significantly higher available primary and secondary macronutrients as well as micronutrients compared to the ZBNF farming system. However, organic matter and beneficial microorganisms were recorded higher

Table 4: Leaf micronutrient content of pea grown under conventional and ZBNF farming system

Block	Farmer	Conventional				ZBNF			
		Zn(ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn(ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Solan	F1	33.7	443.2	49.7	71.7	28.00	275.4	45.2	69.4
	F2	32.1	431.2	50.3	71.5	23.30	231.9	48.7	69.5
	F3	29.8	374.3	50.6	77.2	20.10	269.3	48.9	71.9
	F4	30.1	214.9	49.6	79.2	21.30	278.5	50.2	73.5
	F5	23.1	374.3	52.3	71.2	22.50	245.2	48.9	76.7
Kanadaghat	F6	17.8	367.4	56.4	67.1	14.20	358.7	51.4	73.4
	F7	22.1	297.1	47.1	79.3	21.30	339.6	48.9	78.1
	F8	27.6	220.9	55.7	63.9	13.10	250.9	50.8	74.3
	F9	24.8	286.2	58.3	79.2	10.80	298.9	53.2	78.7
	F10	18.7	226.8	54.5	79.5	18.70	231.9	47.9	75.1
Kunihar	F11	21.2	287.4	51.2	73.2	19.70	337.3	49.2	77.1
	F12	25.4	276.8	59.5	78.6	24.30	325.1	51.2	71.8
	F13	29.8	226.5	58.7	80.3	28.60	246.3	49.1	76.3
	F14	27.2	235.8	56.1	75.2	26.70	276.4	51.1	71.5
	F15	27.6	293.7	54.7	71.9	20.10	285.9	47.9	72.2
Range		17.8-33.7	214.9-443.2	47.1-59.5	63.9-80.3	10.80-28.60	231.9-339.6	45.2-53.2	69.4-78.7
Mean		26.07	278.73	53.65	74.60	20.85	261.06	49.51	73.97
SE		1.23	12.07	0.99	1.30	1.34	5.75	0.49	0.77
T		2.87	1.32	3.76	0.42				
P		0.0078	0.1969	0.0008	0.6774				

Table 5: Viable Microbial Count in conventional and ZBNF Pea growing soils

Block	Farmer	Conventional			ZBNF		
		Bacteria (10^5 cfu g^{-1} soil)	Fungi (10^3 cfu g^{-1} soil)	Actinomycetes (10^3 cfu g^{-1} soil)	Bacteria (10^5 cfu g^{-1} soil)	Fungi (10^3 cfu g^{-1} soil)	Actinomycetes (10^3 cfu g^{-1} soil)
	F1	49.50	6.11	9.13	53.70	7.23	9.64
	F2	48.90	6.55	8.32	51.48	7.12	9.45
Solan	F3	38.60	6.85	9.15	47.32	6.91	9.26
	F4	41.40	6.12	9.25	45.60	6.23	9.32
	F5	40.20	6.32	8.38	42.60	6.43	8.48
	F6	38.70	6.18	9.56	41.70	6.43	9.78
	F7	38.42	6.42	9.34	42.57	6.54	9.51
Kandaghat	F8	36.20	6.88	9.23	43.72	6.94	9.87
	F9	38.20	6.18	8.43	43.76	6.33	8.85
	F10	38.10	6.76	8.92	47.42	7.31	9.21
	F11	42.80	6.34	8.67	41.26	6.48	8.87
	F12	43.52	6.13	9.24	52.80	7.12	9.32
Kunihar	F13	40.50	6.84	9.32	47.65	7.23	9.55
	F14	40.49	6.41	6.27	42.54	6.49	9.15
	F15	30.52	6.24	6.56	41.70	6.21	8.88
Range		30.52-49.50	6.11-6.88	6.27-9.56	41.26-53.70	6.21-7.31	8.48-9.87
Mean		40.40	6.42	8.65	45.72	6.73	9.28
SE		1.21	0.07	0.25	1.08	0.10	0.10
T		3.28	2.46	2.29			
P		0.0028	0.0212	0.0345			

Table 6: Cost Economics of pea grown under conventional and ZBNF farming system

Farming system	*Gross Return (Rs. Lakh ha^{-1})*	*Cost of Cultivation (Rs. Lakh ha^{-1})*	*Net Return (Rs. Lakh ha^{-1})*	*Yield q ha^{-1}*	*B:C Ratio*
Conventional	329010.0	130207	198803	109.67	1.52
ZBNF	276210.0	88175	188035	92.07	2.13

under ZBNF compared to conventional farming systems. The leaf nutrient content of peas under conventional farming also recorded a high content of primary and secondary macronutrients as well as micronutrients compared to the ZBNF farming system. The yield of peas was significantly higher under the conventional farming system as compared to ZBNF. However, due to the lesser cost of cultivation, the ZBNF farming system was more economical as compared to the conventional farming system. The study, therefore, verifies the fact that application of inorganic fertilizer up to the desired level is good for maximizing crop production if soil health is maintained properly, whereas ZBNF helps in improving the soil health, especially physic-chemical and biological properties of the soil, although there is a reduction in yield which, however, is compensated by lower cost of cultivation and hence, being more economical. However, to fully realize the potential of Zero Budget Natural Farming, advanced research is required to ascertain the effect of microbes in making the nutrients available for uptake on yield enhancement so that a conclusion can be drawn in favor of ZBNF in meeting the challenge to feed increasing population while also improving and maintaining soil health and environmental quality.

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References

Chandel, R. S., Gupta, M., Sharma, S., Sharma, P. L., Verma, S., & Chandel, A. (2021). Impact of Palekar's natural farming on farmers' economy in Himachal Pradesh. Indian Journal of Ecology, 4, 873–878.

Choudhary, R., Kumar, R., Sharma, G. D., Sharma, R. P., Rana, N., & Dev, P. (2022). Effect of natural farming on yield performances, soil health and nutrient uptake in wheat + gram inter cropping system in sub-temperate regions of Himachal Pradesh. Journal of Crop and Weed, 18(2), 01-08.

DoAF&W. (2022). (Accessed 13 May, 2023).Available online naturalfarming.dac.gov.in/Initiative/Achievements.

Duddigan, S., Shaw, L. J., Sizmur, T., Gogu, D., Hussain, Z., Jirra, K., Kaliki, H., Sanka, R., Sohail M., Soma R., Thallam V., Vattikuti, H., & Collins, C. D. (2023). Natural farming improves crop yield in SE India when compared to conventional or organic systems by enhancing soil quality. Agronomy for Sustainable Development, 43, 31-36. doi.org/10.1007/s13593-023-00884-x.

Eliazer, N. A. R. L., Ravichandran, K., & Antony, U. (2019). The impact of the Green Revolution on indigenous crops of India. Journal of Ethnic Foods, 6,1–11. doi: 10.1186/s42779-019-0011-9.

ET. (2023a). Available online economictimes.indiatimes.com/news/economy/agriculture/about-1-5-lakh-farmers-practising-natural-farming-in-himachal-to-be-certified-under-pk3y-in fy24/articleshow/99314688.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst (Accessed 24 June, 2023).

Jain, P., Sharma, R., Bhattacharyya, P., & Banik, P. (2014). Effect of new organic supplement (Panchgavya) on seed germination and soil quality. Environmental Monitoring and Assessment, 4,186-189.

Knapp, S., & Van der Heijden, M. G. A. (2018). A global meta-analysis of yield stability in organic and conservation agriculture. Nature Communications, 9,1–9. doi.org/10.1038/s41467-018-05956-1.

Kumari, A., Singh, O. N., & Kumar, R. (2012). Effect of integrated nutrient management on growth, seed yield and economics of field pea (*Pisum sativum* L) and soil fertility changes. Journal of Food legumes, 25, 121-124.

Laishram, C., Vashishat, R. K., Sharma, S., Rajkumari, B., Mishra, N., Barwal, P., Vaidya, M. K., Sharma, R., Chandel, R.S., Chandel, A., Gupta, R. K., & Sharma, N. (2022). Impact of Natural Farming Cropping System on Rural Households—Evidence From Solan District of Himachal Pradesh, India. Frontiers in Sustainable Food Systems, 6, 878015. doi: 10.3389/fsufs.2022.878015

Marathe, R. A., Bharamble, P. R., Sharma, R., & Sharma, U. C. (2009). Soil properties of vertisols and yield of sweet orange as influenced by integrated use of organic manures, inorganic and bio fertilizer. Indian Journal of Agricultural Sciences, 79, 3-7.

Nagar, R. K., Goud, V. V., Kumar, R., & Kumar, R. (2016). Effect of organic manures and crop residue management on physical, chemical and biological properties of soil under pigeonpea based intercropping system. International Journal of Farm Sciences, 6, 101-13.

Prasad, J., Srivastava, N. C., & Mathur, B. S. (1996). Available nutrient status of a continuously fertilised and cropped acid soil. Journal of Indian Society of Soil Science, 44, 171-173.

Ponisio, L. C., M'gonigle, L. K., & Mace, K. C. (2015). Diversification practices reduce organic to conventional yield gap. Proceedings of the Royal Society B: Biological Sciences, 282, doi.org/10.1098/rspb.2014.1396.

RySS. (2020). Zero budget natural farming: official website of ZBNF programme of Rythu Sadhikara Samstha, Government of Andhra Pradesh. http://apzbnf.in.

Shahid, M., Shukla, A. K., Bhattacharya, P., Tripthi, R., Mohanty, S., Das, B., Gautam, P., & Nayak, A. K. (2015). Micronutrients (Fe, Mn, Zn and Cu) balance under long-term application of fertilizer and manure in a tropical rice-rice system. Journal of Soils and Sediments, 16(3), 737-747. doi. 10.1007/ s 11368-015-1272-6.

Sharma, U., & Subehia, S. K. (2014). Effect of long term integrated nutrient management on rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) productivity and soil properties in north-western Himalaya. Journal of Indian Society of Soil Science, 62, 248-54.

Te Pas, C. M., & Rees, R. M. (2014). Analysis of Differences in Productivity, Profitability and Soil Fertility Between Organic and Conventional Cropping Systems in the Tropics and Sub-tropics. Journal of Integrative Agriculture, 13(10), 2299-2310.

Umadevi, G. D., Sumathi, V., Reddy, A. P., Sudhakar, P., & Kumari, K. L. (2019). Effect of organic manures and phosphorus on cowpea and their residual effect on succeeding little millet. Journal of Pharmacognosy and Phytochemistry, 8(3), 2236-2239.

Vashishat, R. K., Laishram, C., & Sharma, S. (2021). Problems and factors affecting adoption of natural farming in Sirmaur District of Himachal Pradesh. Indian Journal of Ecology. 48, 944–949.

Yadav, B. D., Balraj, S., & Sharma, Y. K. (2004). Production of tomato under organic conditions. Haryana Journal of Horticulture Science 33, 306-307.

Yadav, P., Sharma, S. K., Choudhary, R., Jat, G., Upadhayay, B., Sisodia, S. S., & Athnere, S. (2023). Effect of different Natural Farming Practices on NPK and Chlorophyll Content of Cowpea (*Vigna unguiculata* L.) under Sub humid Southern plains of Rajasthan. Biological Forum – An International Journal, 15(1), 289-293.

SPNF. (2023b). (Accessed 24 June, 2023). Registered farmers' list in Prakritik Kheti Khushhal Kisan Yojana under Subhash Palekar Natural Farming project in Solan district. Available online spnfhp.nic.in/SPNF/en-IN/RegisteredFarmersList.aspx.

सारांश

जीरो बजट प्राकृतिक खेती (जेडबीएनएफ) और पारंपरिक खेती प्रणालियों के तहत मिट्टी की गुणवत्ता और पौधों की पोषक तत्वों की सामग्री का मूल्यांकन करने के उद्देश्य से 2020-2021 के दौरान हिमाचल प्रदेश के सोलन जिले में तीन ब्लॉकों का सर्वेक्षण किया गया था। उसी ब्लॉक में क्रमशः जेडबीएनएफ और पारंपरिक खेती करने वाले किसानों के खेतों से 30 प्रतिनिधि सतही मिट्टी और पौधों के नमूने (15 पारंपरिक और जेडबीएनएफ खेती प्रणाली के प्रत्येक) एकत्र किए गए और उनका विश्लेषण किया गया। पारंपरिक कृषि प्रणाली के तहत सोलन जिले की मटर उगाने वाली मिट्टी में जेडबीएनएफ कृषि प्रणाली की तुलना में प्राथमिक और माध्यमिक मैक्रोन्यूट्रिएंट्स के साथ-साथ सूक्ष्म पोषक तत्व काफी अधिक उपलब्ध थे। जेडबीएनएफ कृषि प्रणाली की तुलना में पारंपरिक खेती के तहत एन, पी और के क्रमशः 5.21%, 14.69% % और 10.27% % अधिक दर्ज किया गया। इसी प्रकार(जेडबीएनएफ कृषि प्रणाली की तुलना में पारंपरिक कृषि प्रणाली के तहत अधिकतम कैल्शियम, मैगनीशियम और गंधक भी क्रमशः 7.62%, 12.21% % और 16.64% अधिक दर्ज किया गया। जबकि, जेडबीएनएफ प्रणाली के तहत मिट्टी में पारंपरिक कृषि प्रणाली की तुलना में 22.85% अधिक कार्बनिक कार्बन दर्ज किया गया। व्यवहार्य माइक्रोबियल गिनती (45.72×105 सीएफयू जी$^{-1}$ बैक्टीरिया 6.73×103 सीएफयू जी$^{-1}$ कवक और 9.28×103 सीएफयू जी$^{-1}$ एक्टिनोमाइसेट्स) भी पारंपरिक कृषि प्रणाली की तुलना में जेडबीएनएफ के तहत अधिक दर्ज की गई। इसके अलावा पारंपरिक कृषि प्रणाली में जेडबीएनएफ कृषि प्रणाली की तुलना में पत्ती में उच्च मैक्रोन्यूट्रिएंट्स के साथ-साथ सूक्ष्म पोषक तत्व भी दर्ज किए गए। परिणामस्वरूप जेडबीएनएफ 92.07 क्विंटल हेक्टेयर$^{-1}$ की तुलना में पारंपरिक कृषि प्रणाली के तहत मटर की उपज काफी अधिक (109.67 क्विंटल हेक्टेयर$^{-1}$) थी। हालाँकि पारंपरिक कृषि प्रणाली के तहत 47% अधिक उत्पादन लागत के परिणामस्वरूप पारंपरिक कृषि प्रणाली (1.52)की तुलना में जेडबीएनएफ कृषि प्रणाली का बेहतर लाभ लागत अनुपात (2.13) प्राप्त हुआ।