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Effect of Zero Budget Natural Farming and Conventional Farming Systems on Biological Properties of Soil

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A B S T R A C T

The present study was conducted to study the biological properties of soil under zero budget natural farming (ZBNF) system, where only indigenous cow urine and dung based on-farm produced formulations *viz.* jeevamrit, beejamrit and ghanjeevamrit were used, in comparison to conventional farming (CF) practices with recommended fertilizer and pesticide doses in cauliflower ecosystem. ZBNF resulted in higher population of micro-flora. The population of bacteria, fungus and actinomycetes under ZBNF increased over the cropping period by 11.36, 2.04 and 8.72 in 2018-19, and 23.69, 12.04 and 24.83 per cent in 2019-20, respectively, which was more than that under CF system 8.23, 2.44 and 3.34 per cent in 2018-19 and 12.87, 2.13 and 8.87 per cent in 2019-20, respectively. Activity of soil enzymes *viz.* dehydrogenase, phosphatase and urease under ZBNF increased by 3.01, 0.81, 3.84and 14.73, 1.42 and 14.01per cent, during 2018-19 and 2019-20respectively, which was much higher as compared to the CF system, where respective increase in enzymatic activity was1.85, 0.98, 2.51 and 3.38, 1.37 and 5.08 per cent during 2018-19 and 2019-20. An increment recorded in arthropods population. The increase in Hymenoptera, Hemiptera, Coleoptera, Isoptera, and Isopoda was 66.6, 0, 100, 33.3 and 200 per cent in ZBNF system, while in CF system, only Hymenoptera, Isoptera, and Isopodashowed an increase of 50, 50, and 100 per cent during first year experiment. During the second year also ZBNF showed higher increase in the arthropods population.

Introduction

Soil biological properties are important indicators of soil health. Most of fertile soils are rich in the population of both flora and fauna. Arthropods, fungus, bacteria, actinomycetes are major soil biological components those enrich the soil with various enzymes and increase the soil fertility (Siromani *et al.*, 2013, Zhen *et al.*, 2014 and Henneron *et al.*, 2015). Indiscriminate use of agro-chemicals (toxic herbicides, insecticides, fertilizers) post green revolution has adversely impacted soil biological properties (Daikh *et al.*, 2016; Ghosal and Hati 2019). It is a fact that deterioration of soil biological parameters leads to loss of soil fertility and decreasing yield (Singh and Lal, 2001). Various indigenous formulations such as cow urine and dung based Beejamrit, Jeevamrit and Panchgavya have shown their beneficial effects on soil biological properties (Shubha *et al.,* 2014 and Sreenivasa *et al.,* 2009), and are getting popular among farmers. Beejamrit, ghanjeevamrit and jeevamrit contain a lot of microbial properties and increase the soil micro flora with drastic increase in different soil enzymes. These formulations are rich in bacteria, fungus and actinomycetes population which not only provide basic soil conditioning but also have long lasting effect that leads to improvement in other soil biodiversity like soil arthropods, earthworms and other beneficiary fauna. Cow urine and dung based products are highly effective in improving the soil properties, and they increases the population of beneficial bacteria and fungus which act as antagonist against the plant pathogenic microorganisms (Gangadhar *et al.,* 2020). Similarly these formulations also increase the beneficial arthropods predators in soil that lowers the pest population. In present investigation we observed the effect of beejamrit, ghanjeevamrit and jeevamrit and other organic amendments on soil flora and fauna in comparison with conventional farming practices.

Materials and Methods

Experiment was carried out at Model Farm, Zero Budget Natural Farming (ZBNF) system and the Experimental Farm of Entomology, Dr.Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the years 2018-19 and 2019-20. Cauliflower (PSBK-1) was raised in Conventional Farming (CF) system with recommended doses of fertilizers, viz. urea @ 300kg, SSP @ 675kg and MOP @ 85kg. Full dose of SSP, MOP and one-third of urea were applied at the time of transplanting. Same variety of cauliflower was grown in ZBNF system along with pea (dicot), coriander (cash crop) and mustard (trap crop) were sown as per the geometry in each plot with central row of pea than two rows of cauliflower, two rows of coriander and two marginal rows of Indian mustard**.** These were treated with beejamrit, jeevamrit and ghanjeevamrit. Randomly seven soil samples were taken from each field using soil auger up to 10 cm depth. These were used to determine the micro-flora and enzymatic activity in soil. Bacteria, fungi and actinomycetes were counted (CFU/ml) by plating 0.1 ml of suitable dilution on separate plates, incubated at 28±2°C and cultured in Nutrient agar, Potato dextrose agar and Kenknight and Munaier medium (Subba, 1999). Soil enzyme dehydrogenase (Thimmaiah, 1999), soil Phosphatase (Tabatabai and Bremner, 1969) and urease (Thimmaiah, 1999) activities were determined. For soil arthropods seven random samples were obtained by inserting iron cylinder cores (10 cm length and 12 cm wide) in the soil. Arthropods were collected using the berlese-funnel method and counted after identification (Parisi *et al.,* 2005 and Bano and Roy, 2016). All parameters were recorded before sowing and after harvest of the crop in both farming systems during both the years.

Results and Discussion

Effect of farming systems on soil microbial population

Notable changes in bacterial population were recorded in both systems. During 2018-19, bacterial population increased from 16.29 cfu $g^{-1}$to 18.14 cfu g^{-1} in ZBNF system, while in CF system, it increased from 13.86 cfu g^{-1} to 15 cfu g^{-1}. The per cent increase in bacterial population was (11.36%) in ZBNF system, as compared to 8.23% in CF (Table 1), and during 2019-20, bacterial population increased from 19.29 cfu g^{-1} to 23.86 cfu g^{-1}

in ZBNF system, while in CF system, it increased from 16.71 cfu g^{-1} to 18.86 cfu g^{-1}. The increase in bacterial population was 23.69 per cent in ZBNF system, as compared to 12.87% in CF (Table 2). Similar results were also recorded in case of fungus and actinomycetes population. During 2018-19, fungal population increased from 6.86cfu $g^{-1}$to 7.00cfu g^{-1} in ZBNF system, while in CF system, it increased from 6.14cfu g^{-1} to 6.29 cfu g^{-1}. The per cent increase was almost similar in ZBNF (2.04%) and CF (2.44%). In 2019-20, population increased from 7.14 cfu $g^{-1}$to 8.00 cfu g^{-1} in ZBNF system, while in CF system, it increased from 6.57 cfu g^{-1} to 6.71 cfu g^{-1}. The per cent increase in fungi population was higher (12.04%) in ZBNF system, as compared to CF (2.13%) (Table 2). The actinomycetes population during 2018-19 increased from 16.29 cfu g^{-1} to 17.71 cfu g^{-1} in ZBNF system, while in CF system, it increased from 12.86 cfu g^{-1} to 13.29 cfu g^{-1}. The per cent increase was higher in ZBNF (8.72%) as compared to CF (3.34%). During 2019-20, population increased from 20.14 cfu g^{-1} to 25.14 cfu g^{-1} in ZBNF system, while in CF system, it increased from 14.43 cfu g^{-1} to 15.71 cfu g^{-1}. The per cent increase was 24.83% in ZBNF system, as compared to 8.87% in CF (Table 2).

Table.1 Viable microbial count under ZBNF and CF systems during 2018-19

Viable microbes	Farming systems					
	ZBNF		Change (%)	CF		Change (%)
	Before sowing	After harvest		Before sowing	After harvest	
Bacteria ($\times 10^8$cfu g^{-1} soil)	16.29	18.14	11.36	13.86	15.00	8.23
Fungi ($\times 10^4$cfu g^{-1} soil)	6.86	7.00	2.04	6.14	6.29	2.44
Actinomycetes ($\times 10^3$cfu g^{-1} soil)	16.29	17.71	8.72	12.86	13.29	3.34

Table.2 Viable microbial count under ZBNF and CF systems during 2019-20

Viable microbes	Farming systems					
	ZBNF		Change (%)	CF		Change (%)
	Before sowing	After harvest		Before sowing	After harvest	
Bacteria ($\times 10^8$cfu g^{-1} soil)	19.29	23.86	23.69	16.71	18.86	12.87
Fungi ($\times 10^4$cfu g^{-1} soil)	7.14	8.00	12.04	6.57	6.71	2.13
Actinomycetes ($\times 10^3$cfu g^{-1} soil)	20.14	25.14	24.83	14.43	15.71	8.87

Table.3 Soil enzymatic activities under ZBNF and CF systems during 2018-19

Enzymes	Farming systems					
	ZBNF		Change (%)	CF		Change (%)
	Before sowing	After harvest		Before sowing	After harvest	
Dehydrogenase (µg TPF g^{-1} h^{-1})	9.29	9.57	3.01	7.57	7.71	1.85
Phosphatase (µg PNP g^{-1} h^{-1})	87.43	88.14	0.81	72.29	73.00	0.98
Urease (µg NH_4^+ g^{-1} h^{-1})	7.29	7.57	3.84	5.57	5.71	2.51

Table.4 Soil enzymatic activities under ZBNF and CF systems during 2019-20

Enzymes	Farming systems					
	ZBNF		Change (%)	CF		Change (%)
	Before sowing	After harvest		Before sowing	After harvest	
Dehydrogenase (µg TPF g^{-1} h^{-1})	9.71	11.14	14.73	8.29	8.57	3.38
Phosphatase (µg PNP g^{-1} h^{-1})	90.71	92.00	1.42	72.86	73.86	1.37
Urease (µg NH_4^+ g^{-1} h^{-1})	7.14	8.14	14.01	5.71	6.00	5.08

Table.5 Soil arthropods population per m^2 of soil (0-15 cm depth) under ZBNF and CF systems during 2018-19

Orders	Farming systems					
	ZBNF		Change (%)	CF		Change (%)
	Before sowing	After harvest		Before sowing	After harvest	
Hymenoptera	397.8	663	66.6	265.2	397.8	50
Hemiptera	265.2	265.2	0	132.6	132.6	0
Coleoptera	132.6	265.2	100	132.6	132.6	0
Isoptera	397.8	530.4	33.3	265.2	397.8	50
Prostigmata	265.2	132.6	-50	265.2	265.2	0
Isopoda	132.6	397.8	200	132.6	265.2	100

Table.6 Soil arthropods population per m^2 of soil (0-15 cm depth) under ZBNF and CF systems during 2019-20

Orders	Farming systems					
	ZBNF		Change (%)	CF		Change (%)
	Before sowing	After harvest		Before sowing	After harvest	
Hymenoptera	928.2	1591.2	71.4	530.4	795.6	50
Hemiptera	265.2	397.8	50	265.2	265.2	0
Coleoptera	397.8	928.2	133.3	265.2	530.4	100
Isoptera	397.8	530.4	33.3	530.4	663	25
Prostigmata	265.2	265.2	0	132.6	265.2	100
Isopoda	397.8	663	66.7	265.5	397.8	50
Geomorpha	132.6	397.8	200	0	0	0

The results clearly showed that the cow urine and dung based organic formulations resulted in higher microbial population, which is an indicator of healthy soil. Vishwajeet (2020) also reported increase of 3.83, 10.46 and 7.54 per cent in population of bacteria, fungi and actinomycetes, respectively, under Subhash Palekar Natural Farming (SPNF) system, whereas, in CF system the corresponding values were 4.35, 15.54 and 5.57 per cent. Rana (2019) also recorded 3.03, 12.5 and 12.4 per cent increase in bacteria, fungi and actinomycetes population under ZBNF system, whereas, in CF system the corresponding change was 1.72, 4.44 and 5.96 per cent. Gangadhar *et al.,* (2020) reported higher bacterial population with Jeevamrit (28.27×10^5 and 31.59×10^5 CFU g^{-1} of soil, respectively) as compared to NCOF-decomposer (21.54 and 23.73×10^5 CFU g^{-1} of soil, respectively) in two different seasons. Puneet and Saini (2009) also reported effect of five per cent jeevamriton microbial population and found significantly higher colony forming units (cfu) of bacteria (32.69×10^6), fungi (24.86×10^3) and actinomycetes (6.02×10^2). Sreenivasa *et al.,* (2009) recorded the microbial load of beejamrit and observed bacteria, fungi and actinomycetes were 15.4×10^5, 10.5×10^3 and 6.8×10^3 cfu respectively. Devakumar *et al.,* (2018) also recorded higher bacteria, fungi and actinomycetes40.33×10^5 CFU/g, 20.33×10^4 CFU/g and 15.33×10^3 CFU/g in jeevamrit. Our results are in line with the reported studies and show the beneficial effect of ZBNF in increasing the microbial population and biodiversity, which are important indicators of soil quality. Jeevamrit, ghanjeevamrit and beejamrit are effective formulations to for improving soil biological properties and ameliorate the soils.

Effect of beejamrit, Jeevamrit and ghanjeevamrit on soil enzymes over conventional practices

During 2018-19, dehydrogenase activity was 9.57 µg TPF g^{-1} h^{-1}after harvest as compared to 9.29 µg TPF g^{-1} h^{-1}at the time of sowing in ZBNF system, whereas in CF system, dehydrogenase activity (DHA) was 7.57 µg TPF g^{-1} h^{-1}at the time of sowing and 7.71 µg TPF g^{-1} h^{-1} at the end of the cropping season. The per cent increase was higher in ZBNF system (3.01%) as compared to CF system (1.85%) (Table 3). During 2019-20, the dehydrogenase was higher at harvest (11.14 µg TPF g^{-1} h^{-1}) as compared to the value at the time of sowing (9.71 µg TPF g^{-1} h^{-1}) in ZBNF system. While in CF system, dehydrogenase activity was 8.29 µg TPF g^{-1}

h^{-1} initially at the time of sowing and increased to 8.57 µg TPF g^{-1} h^{-1} at the end of the cropping season. The per cent increase was higher in ZBNF system (14.73%), as compared to CF system (3.38%) (Table 4). During first season, the phosphatase enzyme activity was higher at harvest (88.14 µg PNP g^{-1} h^{-1}) as compared to the value at the time of sowing (87.43 µg PNP g^{-1} h^{-1}) in ZBNF system, whereas in CF system, phosphatase activity was 72.29 µg PNP g^{-1} h^{-1}initially at the time of sowing and increased to 73.00 µg PNP g^{-1} h^{-1} at the end of the cropping season. The per cent increase was lower in ZBNF system (0.81%) as compared to CF system (0.98%) (Table 3). In the second season, the phosphatase enzyme activity was higher at harvest (92 µg PNP g^{-1} h^{-1}) as compared to the value at the time of sowing (90.71 µg PNP g^{-1} h^{-1}) in ZBNF system, whereas in CF system, phosphatase activity was 72.86 µg PNP g^{-1} h^{-1}initially at the time of sowing and increased to 73.86 µg PNP g^{-1} h^{-1}at the end of the cropping season. The per cent increase was higher in ZBNF system (1.42%) as compared to CF system (1.37%) (Table 4). In case of the urease enzyme activity was higher at harvest during first season (7.57 µg NH_4^+ g^{-1} h^{-1}) as compared to the value at the time of sowing (7.29 µg NH_4^+ g^{-1} h^{-1}) in ZBNF system, whereas in CF system, urease enzyme activity was 5.57 µg NH_4^+ g^{-1} h^{-1}initially at the time of sowing and increased to 5.71 µg NH_4^+ g^{-1} h^{-1} at the end of the cropping season.

The per cent increase was higher in ZBNF system (3.84%), as compared to CF system (2.51%) (Table 3). In second season urease enzyme activity was higher at harvest (8.14 µg NH_4^+ g^{-1} h^{-1}) as compared to the value at the time of sowing (7.14 µg NH_4^+ g^{-1} h^{-1}) in ZBNF system, whereas, in CF system, urease activity was 5.71 µg NH_4^+ g^{-1} h^{-1}initially at the time of sowing and increased to 6 µg NH_4^+ g^{-1} h^{-1}at the end of the cropping season. The per cent increase was higher in ZBNF system (14.01%), as compared to CF system (5.08%) (Table 4).

Vishwajeet (2020) also recorded beneficial effect of natural farming formulations on soil enzymatic activity in brinjal ecosystem. He reported23.79, 2.77 and 13.31 per cent increase in the soil activity of dehydrogenase, phosphatase and urease enzymes under SPNF system, whereas, the corresponding value of CF system were 10.11, 0.72 and 17.03 per cent, respectively. Rana (2019) reported similar results in cabbage grown under ZBNF, with 37.29, 7.31 and 10.51 per cent increase in activity of dehydrogenase, phosphatase and urease enzymes in ZBNF system, whereas the corresponding value of CF system were 4.65, 1.37 and 5.78 per cent, respectively. Verma *et al.*, (2018) reported that DHA increased from 6.9 µg TPF g^{-1} h^{-1} under CF to 7.3µg TPF g^{-1} h^{-1} under Organic Farming and was highest under ZBNF i.e. 8.4µg TPF g^{-1} h^{-1}. Similarly alkaline and acid phosphatase activity in ZBNF, the alkaline phosphatase activity increased to 105µg PNP g^{-1} h^{-1} in comparison to 65µg PNP g^{-1} h^{-1} and 71µg PNP g^{-1} h^{-1} under Conventional and Organic Farming systems, respectively. The acid phosphatase activity was also highest under ZBNF (112µg PNP g^{-1} h^{-1}) followed by Organic Farming (99µg PNP g^{-1} h^{-1}) and CF (84µg PNP g^{-1} h^{-1}). Gangadhar *et al.*, (2020) also provided a supportive base to our study with dehydrogenase activity (53.70 TPF formed g^{-1} soil day^{-1}), acid phosphatase activity (31.35 PNP formed g^{-1} soil $hour^{-1}$), alkaline phosphatase activity (21.66 PNP formed g-1 soil $hour^{-1}$) and urease activity (5.97 g NH4-N formed g^{-1} soil $hour^{-1}$) in jeevamrit formulations. Soil enzymes are the basic degradation unit in soil, if their activity reduced that reduces the availability of nutrients in soil. We can justify the importance of soil enzymes and their availability in these indigenous organic formulations by our study. Clearly the recommendation of these formulations will benefit the farmers with long and prosper soil qualities.

Effect on soil arthropods

During 2018-19, the first year of experiment, the data recorded showed an increase in soil arthropods population. Under ZBNF, an increase of66.6, 100, 33.3 and 200 per cent in Hymenoptera, Coleoptera, Isoptera, and Isopoda, respectively, were observed. The Prostigmata population showed a decrease of 50 per cent. Under CF system, the Hymenoptera, Isoptera, and Isopodapopulation increased by 50, 50 and 100 per cent (Table 5). During 2019-20, the soil population of Hymenoptera, Hemiptera, Coleoptera, Isoptera, Isopoda and Geomorpha increased by71.4, 50, 133.33, 33.3, 66.7 and 200 per centunder ZBNF system, while under CF system, the population of Hymenoptera, Coleoptera, Isoptera, Prostigmata and Isopoda were 50, 100, 25, 100 and 50 per cent (Table 6).

During the experimental period the diversity of soil arthropods were almost similar in ZBNF and CF systems, but in ZBNF system, one additional species was found, which belong to the order Geomorpha. Pahari *et al.*, (2007) recorded order Acari had maximum dominance (47.04%), followed by Collembola (38.68%), Hymenoptera (3.40%), Coleoptera (3.3%), Diplura (1.81 %), Diplopoda (1.49%), Isopoda (1.27%), Aranea (1.20%), Chilopoda (1.00%), Dermaptera (0.49%). The order Diptera had minimum dominance (0.26%). Simoni *et al.*, (2013) recorded arthropod density ranged from about 20,000 individuals/m^2 in 16 years old field to about 45,000 in 6 year's old field and recorded higher population of mites. Soil arthropods not only help in improvement of soil quality but also help in reduction of pest population. Generally decomposer and predator arthropods increase due to application of organic formulations as compare to conventional practices.

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