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Performance of Finger Millet under Organic and Natural Production Systems

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Abstract: A field experiment was conducted during the *Kharif* 2019 and 2020 at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to study the yields and economics of finger millet and soil health under organic and natural farming production systems. The experiment was laid out under randomized block design with ten treatments and three replications. The soil was acidic in reaction and silty clay loam in texture. During the first year of studies on finger millet as sole crop, significantly higher seed yield (16.22 q/ha), straw yield (48.03 q/ha), gross returns (Rs.41206) and net returns (Rs.17618) were recorded under natural production system. During the second year of studies when finger millet was intercropped with soybean, the organic production system resulted in the higher seed yield (33.09 q/ha), gross returns (Rs.82891) and net returns (Rs.39191). The application of *Jeevamrit* at 14 days interval was found to be the better treatment in respect of finger millet equivalent yield (26.71 q/ha), gross returns (Rs.73513), net returns (Rs.39125) and benefit cost ratio of 1.14, being at par with the organic production system. The natural production system recorded higher available N, P, K, organic carbon and microbial biomass carbon whereas general bacterial count, phosphate solubilizing bacterial count, actinomycetes count, fungal count and nitrogen fixing bacterial count were higher in the organic production system.

Keywords: Economics; natural; organic; soil health and yields

INTRODUCTION

Fingure millet (*Eleusine coracana* L.) is an under-exploited minor millet with several edible and industrial uses**.** It belongs to the family Poaceae and ranks third in importance after sorghum and pearl millets. Its wide adaptability to diverse environments and cultural conditions makes it a potential food crop. Finger millet accounts for 12% of the global millet area and is grown in more than 25 countries including the major countries like India, Nigeria, Niger, Mali, Burkina and China [4]. The crop has gained focus of scientific research for their extraordinary potential to grow under high temperature, low moisture and poor soils [11] It is no more called a coarse cereal rather referred to as a nutri-cereal or as a nutraceutical crop and is seen as a potential solution for addressing malnutrition and hidden hunger worldwide [7]**.** Finger millet contains proteins (5-8%), ether (1- 2%), carbohydrates (65-75%), 2.5 to 3.5 per cent minerals and 15 to 20 per cent dietary fibres [6]. Phytochemicals present in finger millet act as antioxidants and helps to maintain physiological balance and protect against oxidative damage [9]. The fat content in finger millet was relatively low and it was a rich source of essential amino acids [10]. On the whole, finger millet is a crop which has the capacity to address the global concerns about rising temperature, poor soils, reduction in agricultural productivity, food insecurity and malnutrition. Finger millet is high in Ca, Fe

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and Mg and contains amino acid methionine, which are deficient in the diets of nutritionally insecure households dependent primarily on starchy staples such as polished rice or maize[5]. Crops such as rice and maize might provide food security, but finger millet accounts for manifold securities including food, fodder, fibre, nutrition, health, environment and livelihood at minimal cost, offering great opportunities for food and nutrition security [7]. India continued to be the major producer of finger millet with cultivated area of 0.97 million ha and average yields of 1.62 t/ha[12] and is one of the major staple foods of farming communities in some of the Indian states. The major finger millet growing states of India are Karnataka, Uttarakhand, Maharashtra, Tamil Nadu, Odisha, Andhra Pradesh, Gujarat, Jharkhand, West Bengal, Bihar and Chhattisgarh [1]. It is commonly grown both as sole crop and as mixed crop or in rotation with pulses and oilseeds. Finger millet is mainly grown in Kullu, Mandi, Kangra and Sirmour districts of Himachal Pradesh[8]. The grain is eaten by poor classes as a staple food in the hills. It has excellent storing properties being free from insect attacks and not liable to become mouldy. For this reason it has been used for storage against scarcity and famine.

Finger millet being a potential crop is highly responsive to low input conditions, can prove to be a boon for organic and natural production systems. The excessive use of the chemicals has destroyed the beneficial organisms regulating the populations of harmful insects under natural conditions. In organic as well as natural Farming, special emphasis is being given on the use of natural products and non-chemical methods of pest management. Interventions taken up under organic & natural production systems need lesser inputs, and produce gets better prices resulting in higher farm's profitability besides providing good quality and safe food, and creating healthy environment. Majority of farmers are resource poor with small and marginal scattered land holdings and reside in far flung remote areas having limited access to farm technology. Considering the above said facts, the present investigation was undertaken.

MATERIAL & METHODS

The field experiment was conducted during *Kharif* seasons in 2019 and 2020 at the Zero Budget Natural Farming Centre, Department of Organic Agriculture & Natural Farming, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experiment was laid out in randomized block design with three replications and ten treatments under irrigated ecosystem. The soil of the experimental site was silty clay loam in texture, acidic in reaction with medium organic carbon, medium available nitrogen, higher phosphorus and medium potassium. Recommended package of practices of organic and natural production systems were followed for growing the figure millet crop. During 2019, finger millet was sown as sole crop in both the organic as well as natural production systems. In the organic production system, the seeds of finger millet were treated with biofertilizers (*Rhizobium*+PSB) before sowing. Farm yard manure @ 10 t/ha was applied as the basal dose at the time of sowing during both the years. Three applications of liquid manure (compost tea) were given at 15 days interval commencing from 20 days after sowing. In natural production system, complete package of practices of Subhash Palekar Natural Farming (SPNF) were followed. To make the effective, efficient and judicious use of water and air present in the soil, *Whapsa* was adopted by making raised beds in alternate furrows in all the natural farming treatments. The seeds of finger millet were treated with *Beejamrit* @200 ml/kg seed followed by the basal application of *Ghanjeevamrit* @ 5 q/ha at the time of sowing. Mulching (*Acchadana*) was applied @ 10 t/ha at the time of sowing. Mulching promotes humus formations, suppresses weeds and maintains the water requirement of crops. To promote the microbial activity in the soil and to increase the soil fertility, foliar application of *Jeevamrit* at 14, 21 and 28 days interval after sowing was done. Recommended plant protection practices were adopted both for the organic as well as natural farming systems.

RESULTS AND DISCUSSION

Effect of organic and natural production practices on yields and economics: Different

treatments significantly influenced the yields and economics of figure millet during both the years (Table 1). In 2019, T_1 (Finger millet broadcasted + spray of *Jeevamrit* at 14 days interval) recorded the highest seed yield (16.22 q/ha), straw yield (48.03 q/ha) and net returns (Rs. 17618/-). T_7 (Finger millet broadcasted + organic production practices) was recorded as second best treatment. The lowest values of yields and gross and net returns were observed under absolute control treatment. Three applications of *Jeevamrit* at 14, 21 and 28 days interval in broadcasted finger millet were found to be better than line sown figure millet (Table 1). In 2020, soybean was grown as intercrop with the finger millet. The organic production treatment including finger millet + line sown soybean (T_8) followed by finger millet + broadcasted soybean (T_7) resulted in significantly higher finger millet equivalent seed yield (33.09 q/ha & 31.18 q/ ha, respectively) and net returns (Rs.82891.0 & Rs.77907.0, respectively) over natural production treatments. However, the natural production treatment T_4 (finger millet + line sown soybean + spray of *Jeevamrit* at 14 days interval) was found to be the second best treatment in respect of finger millet equivalent seed yield (26.71 q/ha), gross returns (Rs.73513.0), net returns (Rs.39125.0) and benefit cost ratio (1.14). The higher yields and economics of finger millet recorded either in natural production system or organic production system might be due to better growth and development. The lowest values of yields and economics in absolute control treatment were due to low fertility status of treatment plots as there was no external application of organic or natural sources of nutrients [2&3].

E**ffect of organic and natural production practices on soil health: *Chemical properties*:** In 2019, soil pH was not significantly influenced by different treatments (Table 2). As far as the percent organic carbon is concerned, it was significantly higher under natural production system as compared to its initial value, whereas it was at par with the organic production system. Natural production system recorded higher values of available N, P, K and EC over its initial value. Significantly higher available N (238 kg/ ha), P (30.46 kg/ha), K (129 kg/ha) and EC (0.079) were recorded in T_1 (Broadcasted Finger millet + spray of *Jeevamrit* at 14 days interval) than the organic production system. Natural production treatments also significantly enhanced the microbial biomass carbon (59.01) and dehydrogenase activity (4.74) of the soil which were higher than its initial value and the organic production system. In 2020, Soil pH was in the range of 5.02 to 5.17 whereas EC was in the range of 0.06 to 0.07 in different production systems. The organic production system improved the soil chemical properties. The highest values of organic carbon (0.59 %), microbial biomass carbon (59.30), dehydrogenase activity (4.73) and available P (30.2 kg/ha) were recorded in T_7 (Finger millet + broadcasted soybean + Organic production practices. As far as the soil fertility is concerned, the natural production treatments, T_1 (Finger millet + broadcasted soybean) and T_4 (Finger millet+ line sown soybean both with the application of *Jeevamrit* at 14 days interval produced significantly higher values of available N (234 kg/ha) as compared to the organic production system. The available P (30.2 kg/ha) was found to be at par with organic production as well as natural production practices. In addition to this, the natural production treatment T_2 (Finger millet+ broadcasted soybean + application of *Jeevamrit* at 21 days interval) recorded the highest value of available K (128 kg/ha). The lowest values of nutrients and organic carbon were observed in absolute control which might be due to no application of any organic source of nutrients in the treatment plots[2&3].

Microbiological properties: In 2019**, d**ifferent treatments affected the microbiological properties (Table 3). The highest values of general bacterial count (25.66), phosphate solubilizing bacterial count (8.06), actinomycetes count (8.16), fungal count (8.66) and nitrogen fixing bacterial count (9.06) were recorded in the treatment T_8 (Line sown finger millet) followed by T_7 (Broadcasted fingermillet). In 2020, higher values of soil microbiological properties *viz.* general bacterial count (25.2), phosphate solubilizing bacterial count (9.4) and actinomycetes count (8.2) were recorded in T_7 (Finger millet+broadcasted soybean + organic

Table 1: Effect of treatments on yields and economics of finger millet

Treatments	*Seed Yield (Q/ha)*	*Straw yield (Q/ha)*	*Gross returns (Rs/ha)*	*Net returns (Rs/ha)*	*B:C*
2019					
T_1. Finger millet (Broadcasting) + spray of *Jeevamrit* at 14 days interval	16.22	48.03	41206	17618	0.747
T_2. Finger millet (Broadcasting) + spray of *Jeevamrit* at 21 days interval	15.33	45.61	39001	16164	0.708
T_3. Finger millet (Broadcasting) + spray of *Jeevamrit* at 28 days interval	14.37	43.37	36707	14620	0.662
T_4. Finger millet (Line sowing) + spray of *Jeevamrit* at 14 days interval	14.89	44.93	38032	12695	0.501
T_5. Finger millet (Line sowing) + spray of *Jeevamrit* at 21 days interval	13.81	41.53	35249	10661	0.434
T_6. Finger millet (Line sowing) + spray of *Jeevamrit* at 28 days interval	13.63	40.34	34617	10779	0.452
T_7. Organic package (Broadcasting)	16.07	47.87	40899	6887	0.202
T_8. Organic package (Line sowing)	14.55	44.03	37206	1444	0.040
T_9. Absolute control (Broadcasting)	10.98	32.54	27900	13887	0.991
T_{10}. Absolute control (Line sowing)	10.78	32.82	27604	11842	0.751
CD at 5%	**1.24**	**3.12**	**2906.2**	**1062.3**	**0.052**
2020					
		Fingermillet equivalent Yield (q/ha)	*Gross return (Rs/ha)*	*Net return (Rs/ha)*	*B:C*
T_1. Finger millet+ soybean (Broadcasting) + spray of *Jeevamrit* at 14 days interval		24.63	61481	29194	0.90
T_2. Finger millet+ soybean (Broadcasting) + spray of *Jeevamrit* at 21 days interval		22.89	57161	25624	0.81
T_3. Finger millet+ soybean (Broadcasting) + spray of *Jeevamrit* at 28 days interval		20.43	51193	20405	0.66
T_4. Finger millet+ soybean (Line sowing) + spray of *Jeevamrit* at 14 days interval		26.71	73513	39125	1.14
T_5. Finger millet+ soybean (Line sowing) + spray of *Jeevamrit* at 21 days interval		25.89	64948	31311	0.93
T_6. Finger millet+ soybean (Line sowing) + spray of *Jeevamrit* at 28 days interval		25.62	64470	31583	0.96
T_7. Organic package + soybean (Broadcasting)		31.18	77907	36307	0.87
T_8. Organic package + soybean (Line sowing)		33.09	82891	39191	0.90
T_9. Absolute control + soybean (Broadcasting)		17.08	42989	21389	0.99
T_{10}. Absolute control + soybean (Line sowing)		15.38	39019	15319	0.65
CD at 5%		4.37	-	-	-

Table 2: Effect of treatments on soil health at harvest of finger millet

Treatment	% OC	MBC	DHA (µg TPFg-1 soil hr-1)	Available (kg/ha)			pH	EC (s/m)
				N	P	K		
T_1. Finger millet (Broadcasting) + spray of *Jeevamrit* at 14 days interval	0.59	59.01	4.74	238	30.46	129	5.17	0.079
T_2. Finger millet (Broadcasting) + spray of *Jeevamrit* at 21 days interval	0.57	59.01	4.72	231	30.31	128	5.15	0.078
T_3. Finger millet (Broadcasting) + spray of *Jeevamrit* at 28 days interval	0.56	57.45	4.71	227	30.01	128	5.13	0.078
T_4. Finger millet (Line sowing) + spray of *Jeevamrit* at 14 days interval	0.58	59.01	4.73	239	30.38	129	5.16	0.078
T_5. Finger millet (Line sowing) + spray of *Jeevamrit* at 21 days interval	0.56	59.01	4.70	234	30.31	129	5.15	0.075
T_6. Finger millet (Line sowing) + spray of *Jeevamrit* at 28 days interval	0.55	57.97	4.68	229	30.01	128	5.14	0.075
T_7. Organic package (Broadcasting)	0.59	57.45	4.72	231	30.24	127	5.12	0.072
T_8. Organic package (Line sowing)	0.58	57.45	4.65	225	30.01	127	5.11	0.071
T_9. Absolute control (Broadcasting)	0.49	54.35	4.58	220	28.00	118	5.03	0.069
T_{10}. Absolute control (Line sowing)	0.47	51.76	4.56	218	27.47	118	5.10	0.064
CD at 5%	0.005	1.09	0.03	4.92	0.17	0.22		0.001
2020								
T_1. Finger millet (Broadcasting) + spray of *Jeevamrit* at 14 days interval	0.58	59.01	4.71	234	29.9	126	5.17	0.07
T_2. Finger millet (Broadcasting) + spray of *Jeevamrit* at 21 days interval	0.57	58.90	4.71	227	29.6	128	5.15	0.07
T_3. Finger millet (Broadcasting) + spray of *Jeevamrit* at 28 days interval	0.56	57.35	4.70	223	29.6	127	5.13	0.07
T_4. Finger millet (Line sowing) + spray of *Jeevamrit* at 14 days interval	0.58	58.96	4.72	234	30.2	125	5.15	0.07
T_5. Finger millet (Line sowing) + spray of *Jeevamrit* at 21 days interval	0.56	58.90	4.69	231	30.2	125	5.14	0.07
T_6. Finger millet (Line sowing) + spray of *Jeevamrit* at 28 days interval	0.55	53.73	4.67	225	30.0	126	5.14	0.07
T_7. Organic package (Broadcasting)	0.59	59.30	4.73	227	30.2	124	5.12	0.07
T_8. Organic package (Line sowing)	0.57	56.83	4.64	221	30.1	123	5.10	0.07
T_9. Absolute control (Broadcasting)	0.49	52.17	4.57	218	27.9	118	5.02	0.06
T_{10}. Absolute control (Line sowing)	0.47	50.62	4.56	215	27.3	118	5.08	0.06
CD at 5%	0.01	4.50	0.03	6.09	0.75	0.46	0.02	0.001
Initial in 2019	0.46	51.73	4.55	218	27.44	118	5.10	0.062

Table 3. Effect of treatments on the microbial count at harvest of finger millet

Treatments	*Nutrient Agar* $\times 10^3$	*P Solubilizing bacteria* $\times 10^3$	*Actinomycetes* $\times 10^3$	*Fungus* $\times 10^2$	*Nitrogen fixing bacteria* $\times 10^3$
T_1. Finger millet (Broadcasting) + spray of *Jeevamrit* at 14 days interval	24.63	5.06	4.73	2.00	5.33
T_2. Finger millet (Broadcasting) + spray of *Jeevamrit* at 21 days interval	23.73	4.93	4.36	1.00	3.53
T_3. Finger millet (Broadcasting) + spray of *Jeevamrit* at 28 days interval	14.53	4.26	3.63	1.00	3.30
T_4. Finger millet (Line sowing) + spray of *Jeevamrit* at 14 days interval	19.30	5.33	4.43	5.33	3.33
T_5. Finger millet (Line sowing) + spray of *Jeevamrit* at 21 days interval	19.03	4.70	3.53	1.33	3.46
T_6. Finger millet (Line sowing) + spray of *Jeevamrit* at 28 days interval	15.70	3.83	3.43	3.00	3.43
T_7. Organic package (Broadcasting)	22.96	9.26	7.00	2.00	2.93
T_8. Organic package (Line sowing)	25.66	8.06	8.16	8.66	9.06
T_9. Absolute control (Broadcasting)	7.93	2.26	4.03	3.33	7.96
T_{10}. Absolute control (Line sowing)	3.03	1.70	8.00	4.33	1.43
Initial	3.01	1.50	3.20	2.00	1.41
2020					
T1. Finger millet (Broadcasting) + spray of Jeevamrit at 14 days interval	25.0	5.2	4.8	3	4.5
T_2. Finger millet (Broadcasting) + spray of *Jeevamrit* at 21 days interval	23.9	5.1	4.5	2	3.6
T_3. Finger millet (Broadcasting) + spray of *Jeevamrit* at 28 days interval	14.7	4.5	3.7	2	3.4
T_4. Finger millet (Line sowing) + spray of *Jeevamrit* at 14 days interval	19.5	5.5	4.5	9	4.8
T_5. Finger millet (Line sowing) + spray of *Jeevamrit* at 21 days interval	19.2	4.9	3.7	3	3.7
T_6. Finger millet (Line sowing) + spray of *Jeevamrit* at 28 days interval	15.9	3.9	3.5	3	3.6
T_7. Organic package (Broadcasting)	25.2	9.4	8.2	3	3.1
T_8. Organic package (Line sowing)	23.8	8.2	7.2	6	5.2
T_9. Absolute control (Broadcasting)	8.0	2.4	4.1	4	4.1
T_{10}. Absolute control (Line sowing)	5.2	3.2	3.2	4	3.6

package) and nitrogen fixing bacterial count (5.2) was higher in T_8 (Fingermillet+ line sown soybean + organic production practices). The natural production treatment T_4 (Finger millet+ line sown soybean + application of *Jeevamrit* at 14 days interval) resulted in higher fungal count (9) as compared to the organic production system (Table 3). Application of organic or natural sources of nutrients enhances the microbial population in the soil which results in better nutrients availability in the soil. The lowest microbial population in the control treatment plots might be due to low organic matter in the soil [2&3].

CONCLUSION

The conclusive studies of two years conducted on finger millet revealed that when finger millet was broadcasted with the application of *Jeevamrit* at 14 days interval resulted in significantly higher grain yield which was closely followed by the organic package with broadcasting method of sowing. In the legume based intercropping system of finger millet the organic cultivation of crops produced significantly higher grain equivalent yield of fingermillet and net returns as compared to natural farming treatments. The soil health in terms of its chemical properties *i.e.* percent organic carbon (%OC), microbial biomass carbon (MBC), electrical conductivity (EC), DHA and available N, P, K is influenced under the natural farming system. However, the soil microbial properties in terms of general bacterial count, Phosphate Solubilizing Bacteria (PSB), actinomycetes, fungal count, and nitrogen fixing bacterial count were higher with the application of organic sources of nutrients. Natural Farming practices enhanced the productivity and profitability in finger millet over organic farming practices by reducing the cost of cultivation.

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