Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 2039-2043
Received: 01-01-2020
Accepted: 03-02-2020

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Impact of eco-friendly organic formulations and inorganic fertilizations on enzymatic activity and microbial population in soils grown under tomato

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Abstract
Organic agriculture is increasingly used as an alternative to conventional agriculture due to its positive impact on the health of ecosystems and agroecosystems. However, the outcome of organic agriculture in terms of the production of various crops remains uncertain due to the influence of many variables, rising questions about its advantages over conventional agriculture. So that the field experiments were planned and conducted during *kharif* 2017-18 and 2018-19 to evaluate the "Impact of eco-friendly organic formulations and inorganic fertilizations on enzymatic activity and microbial population in soils grown under tomato". The field experiments were conducted at the research farm, College of Agriculture, Golegaon, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiments were laid out in randomized block design with three replications. There were twelve treatments comprising of organic formulations and inorganic fertilizers. The soil samples were collected before sowing, at the time of flowering and at the time of harvesting of crop for calculating the microbial count and enzymatic activity of the soil. From the results obtained it is indicated that among the different treatment combinations, application of RDF + Beejamruth + Jeevamruth + Panchagavya recorded the highest fungi, actinomycetes and bacteria count as well as dehydrogenase, urease and acid phosphatase content in the flowering as well as post harvest status of the soil.

Keywords: Organic formulations, inorganic fertilizations, enzyme activity, microbial population

Introduction
In India tomato is cultivated in almost all parts of country. It is grown in an area of 1204 thousand hectare with a production and productivity 19042 metric tonnes and 21.2 metric tonne ha^{-1}, respectively (NHB, 2014). The major tomato producing states are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal. In Maharashtra, it is grown in an area of 35000 hectare with a production 987 metric tonnes and productivity of 28 tonnes ha^{-1}. In Maharashtra, it is grown in Nasik, Ahmednagar, Pune, Solapur, Satara, Sangali, Beed, Chandrapur, Latur, Parbhani and Nagpur districts.
The current global scenario firms emphasize the need to adopt eco-friendly agricultural practices for sustainable practices and food production. The cost of inorganic fertilizers is increasing enormously to an extent that they are out of reach to small and marginal farmers. The Panchagavya, Jeevamruth and Beejamruth are eco-friendly organic preparations made from cow products. The use of organic formulations, prepared from cow dung, urine, milk, curd, ghee, legume flour and jaggary contains macro nutrient, essential micronutrients, many vitamins, essential amino acids, growth promoting factors like IAA, GA beneficial microorganisms. The results are similar with Palekar (2006) [2], Natarajan (2007) [9] and Sreenivasa *et al*. (2010) [3]. Thus, integration of organic formulations with chemical fertilizers appears to be an alternate offer for plant nutrition.

Materials and Methods
The field experiments were carried out during *kharif* 2017-18 and 2018-19 using tomato (var. *Akash Ganga*) at experimental farm, College of Agriculture, Golegaon, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiments were laid out in randomized block design, twelve treatments with three replications. The treatments comprising of organic formulations and inorganic fertilizers viz., T_1 RDF (100% NPK through fertilization), T_2 Panchagavya only, T_3 Jeevamruth only, T_4 Beejamruth only, T_5 Panchyagavya + Beejamruth, T_6 Beejamruth + Jeevamruth, T_7 Panchagavya + Jeevamruth, T_8 RDF + Beejamruth + Panchagavya, T_9 RDF + Beejamruth + Jeevamruth, T_{10} RDF + Beejamruth + Jeevamruth + Panchagavya, T_{11} Beejamruth + Jeevamruth + Panchagavya, T_{12} 100% N through FYM.

Soil is characterized by black colour dominated by montmorillonite clay with high coefficient of expansion and shrinkage leads to deep cracking. The soils are formed from basaltic material. According to 7th approximation, the soils are classified as Smectitic Isohyperthermic Typic Haplusterts (Malewar, 1977) [10] and are included in Parbhani series. The topography of experimental plot was fairly level. Growth and yield contributions characters were recorded at different growth stages. From each plot, 5 random plants were selected to record biometric observations on growth and yield attributes. Five plants uprooted from the observation unit for recording the dry matter studies and after removing the roots, plant samples were kept in well labelled brown paper bag. First the samples were dried in shade and after that kept in oven at 65 °C ± 2 °C, and then weight of dry matter was taken and expressed on per plant basis. All the data on enzymatic activity and microbial population were pooled and statistically analyzed by using statistical analysis.

Results and Discussion

Effect of organic formulations and inorganic fertilization on enzyme activity in soil under tomato.

Dehydrogenase activity in soil

Dehydrogenase is considered as an indicator of microbial activity because it occurs intracellularaly in all living microbial cell. Dehydrogenase enzymes oxidize soil organic matter by transforming proton and electron from substrate to acceptors. Data regarding dehydrogenase enzyme is presented in Table 1. Dehydrogenase activity was high in tomato grown soil when treatment with different organic formulations along with RDF. Dehydrogenase activity in soil was maximum at flowering stage of tomato (61.44, 66.29 and 63.87 µg TPF g^{-1} soil hr^{-1}) The activity of dehydrogenase enzymes declined at harvesting stage of tomato (56.02, 60.52 and 58.27 µg TPF g^{-1} soil hr^{-1}). during both the years and pooled mean, respectively. The lowest value was registered in (T_4) only Beejamruth application at flowering 29.48, 32.47 and 30.97 µg TPF g^{-1} soil hr^{-1} and at flowering 24.39, 28.44 and 26.41 µg TPF g^{-1} soil hr^{-1} during both the years of experiment and pooled analysis, respectively. The enhancement in activity of dehyrogenase in tomato soil may be due to altered composition of its root exudates. Root exudates have a profound qualititative and quantitative effect on the rhizospheric microorganism.

In the present study, it was found that RDF + Beejamruth + Jeevamruth + Panchagavya had positive influence on the enzymatic activities as compared to other treatments at both the stages of crop growth. This can be attributed to cumulative effect of organic formulations in proliferating microbial population by providing carbon and energy sources. This is in conformity with the findings of Chandrakala (2008) [1], Palekar (2006) [2] and Sreenivasa *et al*. (2010) [3].

Alkaline phosphatase activity in soil

The data pertaining to alkaline phosphatase enzyme activity is presented in Table 2. These activities were significantly affected by organic formulation treatments. The activity of alkaline phosphatase was high in soil at flowering stage 88.66, 97.75, and 93.21 µg PNP g^{-1} soil hr^{-1}. Thereafter it decreased at harvest stage 80.73, 90.64 and 85.69 µg PNP g^{-1} soil hr^{-1}. Significantly highest values at alkaline phosphatase enzyme activities were found with RDF + Beejamruth + Jeevamruth + Panchagavya 80.73, 90.64 and 85.69 µg PNP g^{-1} soil hr^{-1}. and lowest value was found in only Beejamruth application 35.62, 42.62 and 39.12 µg PNP g^{-1} soil hr^{-1}, at flowering and 30.74, 37.64 and 34.19 µg PNP g^{-1} soil hr^{-1}, at harvest stage of tomato during both the years of experiment and pooled mean, respectively. Alkaline phosphatase is associated with microorganisms. So increase in microbial biomass might have attributed to the highest alkaline phospatase activity. The results of present study is in accordance with those of Rai and Yadav (2011) [4]. These enzymes help in mineralization and bound phosphorous into soluble form and make it available to plant. Similar findings were reported by Saha *et al.* (2007) [5], Reddy and Reddy (2009) [6] and Shridhar *et al*. (2014) [7].

Acid phosphatase activity in soil

Acid phosphatase activity is mostly plant and associated fungal origin. The acid phophatase activity would be more dependent upon the nutritional status of the plant. The acid phosphatase activity was significantly influenced by different organic formulation and data is tabulated in Table 3. Acid phosphatase activity was high at flowering stage of tomato 63.43, 71.03 and 67.23 µg PNP g^{-1} soil hr^{-1}. The activity of acid phosphatage enzyme declined at harvesting stage of tomato 59.68, 63.91, and 61.80 µg PNP g^{-1} soil hr^{-1} during both the years of study and pooled mean. whereas, lowest acid phosphatge activity was observed with only Beejamruth application 35.48, 43.36 and 39.42 µg PNP g^{-1} soil hr^{-1} at flowering and 30.74, 39.28 and 35.01 µg PNP g^{-1} soil hr^{-1} at harvesting during both the years of study and pooled mean, respectively. The increase in acid phosphatase activity in organic formulations along with RDF treatment might be due to the organic acids produced during solubilization of nutrients tend to reduce soil reaction slightly which enhance the enzyme activity. Result in present investigation is in agreement with that of Saha *et al.* (2007) [5].

Effect of organic formulations and inorganic fertilization on microbial population in soil under tomato

Bacterial population in soil

Perusal of the data presented in Table 4. indicates the effect of different organic formulations on soil bacterial population in soil.

Bacterial population was found to be maximum at flowering stage of tomato (43.39, 47.85 and 45.62 CFU X $10^{-7}g^{-1}$ of soil) there after it decreased at harvest stage of crop (40.54, 42.47, and 41.50 CFU X $10^{-7}g^{-1}$ of soil) during both the years of experiment and pooled data. During 2017, 2018 and pooled data, treatment T_{10} recorded significantly highest bacterial population receiving RDF + Beejamruth + Jeevamruth + Panchagavya and lowest population was observed in treatment T_4 at flowering 21.36, 24.46 and 22.91 CFU X $10^{-7}g^{-1}$ of soil, 17.43, 22.42 and 19.92 CFU X $10^{-7}g^{-1}$ of soil with only application of Beejamruth (T_4) at the harvesting stage, respectively. The magnitude of such increased in bacteria population in soil being about 26.96, 27.19 and 28.04 percent during 2017, 2018 and pooled mean, respectively at harvest over only RDF. The organic formulation viz., Panchagavya, Jeevamruth and Beejamruth prepared by using cow product are known to contain beneficial microflora in abundant number. The results are confirmed with Sreenivasa (2009) [8], Maheswari (2007) [9], Pathak and Ram (2007) and Palekar (2006) [2]. In the present investigation also, beneficial microfloral population differed significantly at both the stage of crop growth. The rhizosphere population were highest when all three-organic formation along with RDF as compared to individual application of organic formulation at both the stages of crop growth.

Fungal population in soil

The data on fungal population in soil as influenced by the application of different organic formulations are presented in Table 5. The results clearly indicated that fungal population in soil was highest at flowering stage of crop (8.01, 8.00 and 8.00 CFU 10^{-4} g^{-1} of soil) and declined at harvest 7.00, 8.00 and 7.50 CFU 10^{-4} g^{-1} of soil during 2017, 2018 and pooled analysis, respectively. Minimum fungal population was noted in treatment only Beejamruth application at flowering 2.00, 2.00 and 2.00 CFU X $10^{-7}g^{-1}$ of soil where 1.80, 2.00 and 1.90 CFU X $10^{-4}g^{-1}$ of soil at harvesting stage of crop during both the years and pooled mean, respectively. The organic formulations viz. Panchagavya, Beejamruth and Jeevamruth prepared by using cow products are known to contain some useful fungi and actinomycets. The results are confirmed with Sreenivasa (2009) [8], Maheshwari *et al*. (2007) [9] and Palekar (2006) [2]. Highest fungal population was recorded due to chemical fertilizers and organics due to good soil microenvironment as noted by Munji *et al.* (2010).

Actinomycetes population in soil

In order to study the changes in actinomycetes population at flowering and harvest stage of tomato crop, the analysis of actinomycetes population was made and results are narrated in Table 6. The actinomycetes population in soil was highest at flowering stage of the crop 27.52, 30.53 and 29.02 CFU X $10^{-4}g^{-1}$of soil and thereafter decline at harvesting stage of the crop 24.42, 25.26 and 24.84 CFU X $10^{-4}g^{-1}$ during 2017, 2018 and pooled mean, respectively, followed by RDF + Beejamruth + Panchagavya 21.46, 22.22 and 25.92 CFU X $10^{-4}g^{-1}$ of soil. Whereas, lowest population was noticed into treatment T_4 Beejamruth only at flowering 9.68, 10.45 CFU X $10^{-4}g^{-1}$ of soil where 12.12, 8.44, 10.43 and 10.06 CFU X $10^{-4}g^{-1}$ of soil at harvesting during both the years and pooled mean, respectively. There was gradual build up of actinomycetes population in the plants treated with organics. The results are confirmed with Munji *et al.* (2010).

Table 1: Effect of organic formulations and inorganic fertilizations on Dehydrogenase activity (µg TPF g^{-1} soil 24 hr^{-1}) in soil.

Treatment	Dehydrogenase activity					
	2017-18		2018-19		Pooled	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: RDF (100% NPK through fertilizer)	56.36	50.44	58.39	53.17	57.38	51.81
T_2: Panchagavya only	36.67	31.48	39.40	34.74	38.03	33.11
T_3: Jeevamruth only	34.53	30.74	37.37	31.38	35.95	31.06
T_4: Beejamruth only	29.48	24.39	32.47	28.44	30.97	26.41
T_5: Panchagavya + Beejamruth	45.53	39.48	48.43	41.10	46.98	40.29
T_6: Beejamruth + Jeevamruth	37.41	32.35	40.47	36.49	38.94	34.42
T_7: Panchagavya + Jeevamruth	40.40	36.60	44.70	40.79	42.55	38.69
T_8: RDF + Beejamruth + Panchagavya	58.51	53.59	63.41	57.38	60.96	55.49
T_9: RDF + Beejamruth + Jeevamruth	57.37	51.57	61.11	54.43	59.24	53.00
T_{10}: RDF + Beejamruth + Jeevamruth + Panchagavya	61.44	56.02	66.29	60.52	63.87	58.27
T_{11}: Beejamruth + Jeevamruth + Panchagavya	49.35	44.92	52.43	48.91	50.89	46.92
T_{12}: 100% N through FYM	47.48	42.59	51.14	46.47	49.31	44.53
SEm ±	2.55	1.64	1.66	2.45	1.52	1.47
CD at 5%	7.48	4.81	4.86	7.18	4.34	4.20
Grand mean	46.21	41.18	49.63	44.48	47.92	42.83

Table 2: Effect of organic formulations and inorganic fertilizations on alkaline phosphatase enzyme activity (µg PNP g^{-1} soil hr^{-1}) in soil

Treatment	Alkaline phosphatase					
	2017-18		2018-19		Pooled	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: RDF (100% NPK through fertilizer)	72.58	68.52	78.52	74.26	75.55	71.39
T_2: Panchagavya only	43.64	39.67	47.59	42.67	45.62	41.17
T_3: Jeevamruth only	37.64	34.65	44.51	41.58	41.08	38.12
T_4: Beejamruth only	35.62	30.74	42.62	37.64	39.12	34.19
T_5: Panchagavya + Beejamruth	58.59	53.76	66.45	60.58	62.52	57.17
T_6: Beejamruth + Jeevamruth	49.49	45.43	55.54	51.66	52.52	48.55
T_7: Panchagavya + Jeevamruth	54.48	49.67	60.50	57.65	57.49	53.66
T_8: RDF + Beejamruth + Panchagavya	80.39	76.65	88.60	81.72	84.49	79.19
T_9: RDF + Beejamruth + Jeevamruth	78.45	72.71	85.65	78.49	82.05	75.60
T_{10}: RDF + Beejamruth + Jeevamruth + Panchagavya	88.66	80.73	97.75	90.64	93.21	85.69
T_{11}: Beejamruth + Jeevamruth + Panchagavya	69.55	63.49	76.43	70.74	72.99	67.12
T_{12}: 100% N through FYM	65.39	60.55	73.37	68.61	69.38	64.58
SEm ±	3.25	1.35	3.21	1.50	2.28	1.01
CD at 5%	9.52	3.97	9.42	4.41	6.51	2.88
Grand mean	61.21	56.38	68.13	63.02	64.67	59.70

Table 3: Effect of organic formulations and inorganic fertilizations on acid phosphatase enzyme activity (µg PNP g^{-1} soil hr^{-1}) in soil.

Treatment	Acid phosphatase					
	2017-18		2018-19		Pooled	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: RDF (100% NPK through fertilizer)	50.39	45.62	56.52	50.47	53.46	48.05
T_2: Panchagavya only	42.28	38.66	50.58	44.54	46.43	41.60
T_3: Jeevamruth only	37.44	32.75	45.42	41.58	41.43	37.17
T_4: Beejamruth only	35.48	30.74	43.36	39.28	39.42	35.01
T_5: Panchagavya + Beejamruth	44.47	39.48	51.25	46.62	47.86	43.05
T_6: Beejamruth + Jeevamruth	43.37	37.47	48.29	42.71	45.83	40.09
T_7: Panchagavya + Jeevamruth	52.52	46.68	60.33	53.68	56.43	50.18
T_8: RDF + Beejamruth + Panchagavya	61.19	57.60	67.44	63.49	64.32	60.54
T_9: RDF + Beejamruth + Jeevamruth	55.47	51.57	63.51	58.59	59.49	55.08
T_{10}: RDF + Beejamruth + Jeevamruth + Panchagavya	63.43	59.68	71.03	63.91	67.23	61.80
T_{11}: Beejamruth + Jeevamruth + Panchagavya	54.29	49.62	63.20	56.60	58.75	53.11
T_{12}: 100% N through FYM	40.43	33.61	48.55	43.53	44.49	38.57
SEm ±	2.35	1.99	2.70	2.30	1.79	1.51
CD at 5%	6.88	5.84	7.93	6.73	5.10	4.33
Grand mean	48.40	43.62	55.79	50.42	52.09	47.09

Table 4: Effect of organic formulations and inorganic fertilizations on Bacterial population in soil (CFU X 10^7 g^{-1} soil).

Treatment	Bacterial population					
	2017-18		2018-19		Pooled	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: RDF (100% NPK through fertilizer)	34.37	31.43	36.56	33.39	35.47	32.41
T_2: Panchagavya only	24.42	22.43	27.50	24.45	25.96	23.44
T_3: Jeevamruth only	23.35	21.53	29.60	26.43	26.48	23.98
T_4: Beejamruth only	21.36	17.43	24.46	22.42	22.91	19.92
T_5: Panchagavya + Beejamruth	30.62	26.47	33.68	30.55	32.15	28.51
T_6: Beejamruth + Jeevamruth	27.39	24.43	30.59	27.73	28.99	26.08
T_7: Panchagavya + Jeevamruth	29.12	27.46	31.44	28.58	30.28	28.02
T_8: RDF + Beejamruth + Panchagavya	40.47	34.40	44.37	40.39	42.42	37.39
T_9: RDF + Beejamruth + Jeevamruth	39.58	32.34	42.38	38.46	40.98	35.40
T_{10}: RDF + Beejamruth + Jeevamruth + Panchagavya	43.39	40.54	47.85	42.47	45.62	41.50
T_{11}: Beejamruth + Jeevamruth + Panchagavya	37.61	30.37	40.44	35.55	39.03	32.96
T_{12}: 100% N through FYM	38.49	38.47	43.59	39.56	41.04	39.02
SEm ±	1.62	1.48	2.73	1.43	1.15	1.02
CD at 5%	4.76	4.33	7.99	4.19	3.29	2.92
Grand mean	32.52	28.94	36.04	32.50	34.28	30.72

Table 5: Effect of organic formulations and inorganic fertilizations on Fungal population in soil (CFU X 10^4 g^{-1} soil).

Treatment	Fungal population					
	2017-18		2018-19		Pooled	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: RDF (100% NPK through fertilizer)	5.00	4.07	6.00	5.00	5.50	4.53
T_2: Panchagavya only	2.80	2.20	2.80	2.40	2.80	2.30
T_3: Jeevamruth only	2.50	2.00	2.50	2.50	2.50	2.25
T_4: Beejamruth only	2.00	1.80	2.00	2.00	2.00	1.90
T_5: Panchagavya + Beejamruth	4.70	4.00	4.77	4.70	4.73	4.35
T_6: Beejamruth + Jeevamruth	3.00	2.80	3.00	3.00	3.00	2.90
T_7: Panchagavya + Jeevamruth	4.00	3.70	4.00	4.00	4.00	3.85
T_8: RDF + Beejamruth + Panchagavya	7.00	6.50	7.00	7.00	7.00	6.75
T_9: RDF + Beejamruth + Jeevamruth	6.50	6.00	6.50	6.50	6.50	6.25
T_{10}: RDF + Beejamruth + Jeevamruth + Panchagavya	8.01	7.00	8.00	8.00	8.00	7.50
T_{11}: Beejamruth + Jeevamruth + Panchagavya	6.00	5.37	6.00	6.00	6.00	5.68
T_{12}: 100% N through FYM	7.80	7.00	7.73	7.80	7.77	7.40
SEm ±	0.28	0.24	0.19	0.28	0.16	0.18
CD at 5%	0.81	0.71	0.57	0.81	0.48	0.52
Grand mean	4.94	4.37	5.03	4.91	4.98	4.64

Table 6: Effect of organic formulations and inorganic fertilizations on Actinomycetes population in soil (CFU X 10^4 g^{-1} soil).

Treatment	Actinomycetes population					
	2017-18		2018-19		Pooled	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: RDF (100% NPK through fertilizer)	20.53	18.48	21.50	19.32	21.01	18.90
T_2: Panchagavya only	11.45	10.51	13.90	13.20	12.67	11.86
T_3: Jeevamruth only	10.60	9.50	12.23	11.90	11.41	10.70
T_4: Beejamruth only	9.68	8.44	10.45	10.43	10.06	9.44
T_5: Panchagavya + Beejamruth	15.55	13.30	16.33	14.20	15.94	13.75
T_6: Beejamruth + Jeevamruth	13.67	12.29	14.70	13.40	14.18	12.85
T_7: Panchagavya + Jeevamruth	15.50	13.90	16.00	14.20	15.75	14.05
T_8: RDF + Beejamruth + Panchagavya	24.34	21.46	27.50	22.22	25.92	21.84
T_9: RDF + Beejamruth + Jeevamruth	21.33	19.25	24.72	20.70	23.02	19.98
T_{10}: RDF + Beejamruth + Jeevamruth + Panchagavya	27.52	24.42	30.53	25.26	29.02	24.84
T_{11}: Beejamruth + Jeevamruth + Panchagavya	17.51	15.23	19.58	16.73	18.54	15.98
T_{12}: 100% N through FYM	16.13	14.32	17.31	15.40	16.72	14.86
SEm ±	0.89	0.77	0.98	0.85	0.94	0.57
CD at 5%	2.61	2.26	2.86	2.48	2.93	1.63
Grand mean	16.98	15.09	18.48	16.41	17.85	15.75

Conclusion

It can be conclude that the good quality organic inputs with the recommended dose of fertilizers have a potential to augment soil enzyme activities and improve microbial count. Among the different treatments, the use of RDF + Beejamruth + Jeevamruth + Panchagavya demonstrated the impact on the enzyme activity and microbial count for improving soil conditions. The lowest enzyme activity and microbial count is found in Beejamruth only.

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