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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

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ABSTRACT

A field experiment was conducted during rabi 2019-20 and 2020-21 at Zero Budget Natural Farm (ZBNF), Holta, Department of Organic Agriculture and Natural Farming, CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur H.P to evaluate the comparative efficacy of different components of natural farming in wheat + gram cropping system under Subhash Palekar natural farming (SPNF). The experiment consisted of 8 treatments in randomized block design with three replications. Results revealed that ghanjeevamrit + jeevamrit + mulching was found to produce significantly highest available nitrogen (275 kg ha^{-1}) and NPK content and uptake, viable microbial count {bacterial (28.3 106 cfu g^{-1}soil), actinomycetes (22.0 105 cfu g^{-1}soil), fungi (8.5 103 cfu g^{-1}soil), dehydrogenase activity (4.81 µg TPF g^{-1}soil hr^{-1})} and highest seed yield {wheat (1767.3 kg ha^{-1}), gram (734.1 kg ha^{-1}}.Treatment comprises of ghanjeevamrit + jeevamrit recorded highest available phosphorus (17.6 kg ha^{-1}) and potassium (293.5 kg ha^{-1}).Ghanjeevamrit + jeevamrit + mulching treatment was found having greater influence over soil properties followed by ghanjeevamrit + jeevamrit and it was significantly lowest in control treatments.

Keywords: Available NPK, Ghanjeevamrit, Jeevamrit, mulching, SPNF.

Intensification of conventional farming systems has led to extensive usage of agrochemicals, agricultural machinery, high-demanding varieties resulting in negative impacts on the environment such as groundwater pollution and atmospheric contamination that amplifies the greenhouse effect. The environmental pressure generates a negative effect not only on human health and natural resources but also on the sustainability of agriculture production itself (Mylonas *et al*., 2020). Despite the intense use of inputs in Indian agriculture from nearly half a century, the yield difference in diverse crops remains considerable even when best practices are followed. Furthermore, agricultural lands are shrinking, posing a bigger threat to the global ecosystem and soil resources. These dangers include biodiversity loss, desertification, climate change and contamination of the environment, soil, air, water and food. Human health is also harmed due to the use of synthetic farm chemicals as residues of chemicals sprayed on crops wind up in the stomachs of those who consume these foods.

As a result of this, negative health impacts such as disruption of the hormone, neurological and immune systems are being observed in the human body. To achieve sustainable development goals, all countries confronting poverty, hunger and malnutrition will need to accelerate their agricultural growth, particularly while aiming for no poverty, zero hunger and a safe environment for all (Paroda, 2017).

For farmers with limited access to nutrient supplies, incorporating legumes into cereal-based cropping systems has long been recommended as a way to improve soil fertility and agroecological resilience (Snapp *et al.,* 1998; Thierfelder *et al*., 2012). Cereal-legume based intercropping system is known to increase yield stability and is efficient at resource conservation and maintaining soil fertility. While agriculture directly contributes to 20% of greenhouse gas emissions in the country primarily due to livestock rearing and the use of nitrogenous fertilizers (Ministry of Environment, 2015). These fertilizers are also the largest source of nitrate contamination in surface waterbodies (Swaney *et al.*, 2015). More than 30 per cent of the total geographic area of the country is also undergoing land degradation (ISRO, 2016).

A new farming system came into light courtesy of Subhas Palekar natural farming system that is tailored fit for small and marginal farmer and Indian farmers that uses local indigents for farming like desi cow (*Bos indicus)* urine, cow dung, lime, gram flour and handful of soil and after fermentation it is used for foliar spray or fertigation. According to Subhas Palekar, natural farming components have high microbial load which upon application increase the soil flora that mineralise the soil macro and micro nutrients and make them available for plant use. Natural farming saw enormous

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rise with several state adoption as state policy or grass root movement in southern states. With adoption as state policies of several state government to move towards organic farming it needs scientific validation in terms of its impacts on productivity in different agroclimatic conditions, different cropping systems and different soil types. Conjoint use of cereal-legume intercropping and natural farming systems can be ideal to reduce greenhouse gas emission and increase yield stability while maintaining soil fertility. Keeping these in mind the present study was conducted to examine natural farming in terms of soil health research.

MATERIALS AND METHODS

Field experiment was conducted at CSK HPKV, Palampur (32°09´ N, 76°5´ E), during *rabi* 2019-20 and 2020-21. Soil was silty clay loam in texture (pH 5.18, EC 0.098 d S m^{-1}, organic C 0.84%, N (255 kg ha^{-1}), P (15.3 kg ha^{-1}) and K (287 kg ha^{-1}) before the start of the experiment. The experiment was laid out in randomized block design comprising of eight treatments *i.e.*, T_1- *ghanjeevamrit* @ 5 q ha^{-1} before sowing, T_2 - *jeevamrit* (foliar application at 21 days interval), T_3 - mulching @ 10 t ha^{-1}, T_4 - *ghanjeevamrit* + *jeevamrit*, T_5- *ghanjeevamrit* + mulching, T_6 - *jeevamrit* + mulching, T_7 - *ghanjeevamrit* + *jeevamrit* + mulching, T_8 - control. Table 1 shows the standardized techniques for preparing the different agricultural inputs namely *jeevamrit*, *beejamrit* and *ghanjeevamrit.* Wheat was intercropped with chick pea crop under HPW 368 and Him channa 2 variety, respectively. Plant samples were analysed using Kjeldahl digestion method (Jackson, 1973). The potassium content of grain and straw samples was determined using the wet digestion method (Black, 1965). The population of soil bacteria, fungi and actinomycetes was counted using the serial dilution plate count method. The media used were with nutrient agar for bacteria, actinomycete isolation agar for actinomycetes and potato dextrose agar for fungi (Wollum, 1982).Whereas dehydrogenase activity of soil was determined by 2,3,5 TTC method (Casida *et al*., 1964). Nutrient uptake was estimated by multiplying nutrient concentrations in per cent with grain and straw yields. The total quantity of nutrients removed by crop was calculated by adding the uptake of nutrients obtained from grain and straw. Data obtained in the experiment were subjected to analysis of variance (ANOVA) appropriate to the experimental design as described by Gomez and Gomez (1984).

Nutrient analysis of traditional inputs

Nutrient analysis of different traditional inputs was carried out as standard procedure. Maximum N, P and K content was recorded under *ghanjeevamrit* (1.05, 0.87, 0.68%, respectively) followed by *beejamrit* (0.72, 0.14, 0.23%, respectively) and *jeevemarit* (0.25, 0.13, 0.16%, respectively).

RESULTS AND DISCUSSION

Soil chemical properties

Soil pH and EC after the harvest of wheat and gram did not vary significantly (Table 3) with the application of different treatments of natural farming. Although there was improvement in their values over the years. Different treatments influenced organic carbon content of the soil significantly after harvest of the crops. Application of *ghanjeevamrit*+ *jeevamrit* + mulching recorded significantly higher organic carbon (0.94 and 1.08%, respectively) and was remained at par with *ghanjeevamrit* + mulching, *jeevamrit* + mulching. The lowest organic carbon (0.79 and 0.81%, respectively) was observed in control (Chadha *et al*., 2012).The increase in organic carbon content with application of liquid manure may be attributed to the higher direct incorporation of organic materials and better root growth. The subsequent decomposition of these materials might have resulted in enhanced organic carbon content of soil (Rai *et al.,* 2014 and Singh *et al.,* 2014).

Available nitrogen

During both the years significantly highest available nitrogen (275 and 282 kg ha^{-1}, respectively) was recorded in *ghanjeevamrit* + *jeevamrit*+ mulching which was statistically at par with *ghanjeevamrit* + *jeevamrit* and was followed by *jeevamrit*+ mulching, *ghanjeevamrit* + mulching, *ghanjeevamrit* alone. Significantly lowest available nitrogen (237 and 239 kg ha^{-1}, respectively) was recorded in control treatment during both the years. This might be due to rapid mineralization of available pool of nitrogen due to higher microbial activity in these treatments with application of jeevamrit. Shwetha (2008) in wheat and Kiran (2014) in chickpea reported higher available nitrogen in soil with application of either *jeevamrit* alone or in combination with *ghanjeevamrit*.

Available phosphorus

In *rabi* 2019-20,2020-21 application of *ghanjeevamrit* + *jeevamrit* recorded significantly highest available phosphorus (17.3 and 18 kg ha^{-1}, respectively) which was statistically at par with *ghanjeevamrit* + *jeevamrit* + mulching, *jeevamrit* + mulching. Significantly lowest available phosphorus (13.2 and 12.4 kg ha^{-1}, respectively) was recorded in control treatment during both the years. In case of *ghanjeevamrit* + *jeevamrit*, it increased the release of organic acid during mineralization that helped in the solubility of native phosphates, thus increased available phosphorus pool in the soil.

Table 1: Ingredients and method of preparation of SPNF inputs

Sr. No	Input	Ingredients	Method of preparation
1.	*Beejamrit*	Cow dung – 5 kg Cow urine – 5 l Lime – 50 g Water – 20 l Handful of soil	• Soaked cow dung for 12 hours • Squeezed in the water tub • Added lime, soil, water and cow urine and stirred well
2.	*Jeevamrit*	Cow urine – 10 l Cow dung – 10 kg Gram flour – 2 kg Jaggery – 2 kg Water – 200 l Handful of soil	• In 200 l water, added 10 l cow urine,10 kg cow dung, 2 kg jaggery,2 kg gram flour • Mixed all above materials with stirrer • Stirred 2 times daily in the clockwise direction and kept it for 48 hours under the shade
3.	*Ghanjeevamrit*	Cow urine – 10 l Cow dung – 100 kg Gram flour – 100 g Jaggery – 100 g	• Took 100 kg cow dung, 10 l cow urine, 100 g jaggery, 100 g gram flour. • Mixed all the contents, made balls with hand and dried under shade

Table 2: Nutrients concentration in SPNF inputs

Sr. No.	Input	N (%)	P (%)	K (%)
1	*Beejamrit*	0.72	0.14	0.23
2	*Jeevamrit*	0.25	0.13	0.16
3	*Ghanjeevamrit*	1.05	0.87	0.68

Table 3: Effect of different components of natural farming on soil properties after harvest of crops

Treatment	pH		EC (d S m^{-1})		Organic carbon (%)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1 *Ghanjeevamrit* @ 5 q ha^{-1} before sowing	5.25	5.33	0.097	0.102	0.83	0.88
T_2 *Jeevamrit* (foliar application at 21 days interval)	5.28	5.35	0.098	0.103	0.81	0.85
T_3 Mulching @ 10 t ha^{-1}	5.43	5.52	0.101	0.104	0.85	0.94
T_4 *Ghanjeevamrit + jeevamrit*	5.26	5.50	0.105	0.108	0.87	0.90
T_5 *Ghanjeevamrit* + mulching	5.40	5.43	0.103	0.106	0.91	1.03
T_6 *Jeevamrit* +mulching	5.36	5.53	0.108	0.110	0.89	1.02
T_7 *Ghanjeevamrit + jeevamrit* + mulching	5.26	5.42	0.107	0.112	0.94	1.08
T_8 Control	5.20	5.24	0.095	0.097	0.79	0.81
Initial	**5.18**					
SEm (±)	**0.09**	**0.07**	**0.005**	**0.007**	**0.02**	**0.05**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**0.07**	**0.15**

Available potassium

Different treatments significantly influenced available potassium in soil (Table 4). Significantly higher available potassium (292 and 295 kg ha^{-1}, respectively) was recorded in *ghanjeevamrit + jeevamrit* which was statistically at par with g*hanjeevamrit + jeevamrit*+ mulching followed by *ghanjeevamrit* + mulching, g*hanjeevamrit* and *jeevamrit* during both the years. Significantly lowest (248 and 232 kg ha^{-1}, respectively) available potassium was recorded in control treatments. An application of liquid manure provides substantially more available N, P, and K than an application of no liquid manure. This is due to the favorable soil conditions under these treatments, as well as the application of *jeevamrit*, which may have aided in the mineralization of soil N, resulting in higher available nitrogen and greater multiplication of soil microbes capable of converting organically bound nitrogen to inorganic form (Kaur, 2018). Significantly lower values were recorded with rest of the treatments, which might be due to lack

Table 4: Effect of different components of natural farming on available primary nutrients in soil (kg ha $^{-1}$) after harvest of crops

Treatment		Nitrogen		Phosphorus		Potassium	
		2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
T_1	*Ghanjeevamrit* @ *5* q ha^{-1} before sowing	262	268	15.7	15.5	274	272
T_2	*Jeevamrit* (foliar application at 21 days interval)	259	264	15.1	14.9	272	269
T_3	Mulching @ 10 t ha^{-1}	258	262	14.4	14.2	268	263
T_4	*Ghanjeevamrit* + *jeevamrit*	265	273	17.3	18.0	292	295
T_5	*Ghanjeevamrit* + mulching	264	271	15.9	16.7	281	282
T_6	*Jeevamrit* +mulching	265	272	16.5	17.5	283	284
T_7	*Ghanjeevamrit* + *jeevamrit* + mulching	275	282	17.1	17.9	287	292
T_8	Control	237	239	13.2	12.4	248	232
SEm (±)		**3.5**	**4.1**	**0.3**	**0.2**	**4.3**	**5.2**
LSD(0.05)		**10.8**	**12.7**	**1.1**	**0.8**	**13.1**	**16.0**

Table 5: Effect of different components of natural farming on biological properties (dehydrogenase activity and microbial count) of soil at the end of experiment

Treatment		Bacteria (10^6cfu g^{-1} soil)		Fungi (10^3cfu g^{-1} soil)		Actinomycetes (10^5cfu g^{-1} soil)		Dehydrogenase activity (μg TPF g^{-1} soilhr^{-1})	
		2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
T_1	*Ghanjeevamrit* @ *5* q ha^{-1} before sowing	16.1	16.7	5.2	6.2	15.4	16.6	2.76	2.80
T_2	*Jeevamrit* (foliar application at 21 days interval)	19.3	20.1	6.0	6.8	16.2	17.7	3.36	3.33
T_3	Mulching @ 10 t ha^{-1}	17.2	18.2	5.7	6.3	15.8	17.0	3.05	3.12
T_4	*Ghanjeevamrit* + *jeevamrit*	23.3	25.1	6.5	7.0	18.1	20.8	3.97	4.15
T_5	*Ghanjeevamrit* + mulching	21.0	21.6	6.0	6.6	17.0	18.7	3.62	3.72
T_6	*Jeevamrit* +mulching	22.8	23.6	7.0	7.9	19.3	19.8	3.46	3.59
T_7	*Ghanjeevamrit* + *jeevamrit* + mulching	27.9	28.7	8.3	8.7	21.2	22.8	4.48	5.15
T_8	Control	15.0	16.2	4.7	5.3	14.3	14.6	2.61	2.67
SEm (±)		**0.32**	**0.43**	**0.27**	**0.25**	**0.26**	**0.31**	**0.06**	**0.06**
LSD(0.05)		**0.98**	**1.31**	**0.84**	**0.77**	**0.78**	**0.96**	**0.19**	**0.18**
Initial		**16.3**	**5.8**	**15.7**	**2.66**				

of addition of external potassium source and there by depletion of native pool of available potassium by plants, which was mineralized by build-up of microflora and fauna due to supplementation of *jeevamrit*.

Microbiological properties

i. *Bacterial population*

Application of *ghanjeevamrit* + *jeevamrit* + mulching (27.9 and 28.7 x10^{6}cfu g^{-1} soil, respectively) recorded significantly highest bacterial population which was followed by *ghanjeevamrit* + *jeevamrit* application (23.3 and 25.1 x10^{6}cfu g^{-1} soil, respectively) during both the years. Significantly lowest bacterial population was recorded in the control treatment.

ii. *Fungal and actinomycetes population*

Perusal of Table 5 revealed that population of fungi in the soil after harvest of crop during 2019-20 and 2020-21. Significantly highest fungal and actinomycetes population (8.3 and 8.7 x 10^{3}cfu g^{-1} soil and 21.2 and 22.8 x 10^{3}cfu g^{-1} soil, respectively, was recorded in *ghanjeevamrit* + *jeevamrit* + mulching followed by *jeevamrit* + mulching, *ghanjeevamrit* + *jeevamrit* and *ghanjeevamrit* + mulching. Significantly lowest fungal and actinomycetes population (4.7 and 5.3 x 10^{3}cfu g^{-1} soil and 14.3 and 14.6 x 10^{3}cfu g^{-1} soil) was recorded in control treatment. There was increase in microbial count over a period of time as compared to initial values.

Table 6: Effect of different components of natural farming on total nitrogen uptake

Treatment		Total nitrogen uptake (Wheat) (kg ha^{-1})			Total nitrogen uptake (Gram)(kg ha^{-1})		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	*Ghanjeevamrit* @ 5 q ha^{-1} before sowing	29.82	26.69	28.26	17.13	21.43	19.28
T_2	*Jeevamrit* (foliar application at 21 days interval)	33.65	31.82	32.74	17.00	24.99	21.00
T_3	Mulching @ 10 t ha^{-1}	33.99	30.88	32.44	17.69	23.37	20.53
T_4	*Ghanjeevamrit + jeevamrit*	44.12	44.34	44.23	25.26	34.20	29.73
T_5	*Ghanjeevamrit* + mulching	36.34	36.78	36.56	20.13	28.73	24.43
T_6	*Jeevamrit* +mulching	38.80	38.97	38.89	22.01	29.19	25.60
T_7	*Ghanjeevamrit + jeevamrit* + mulching	49.29	49.80	49.55	27.67	39.14	33.41
T_8	Control	26.63	22.96	24.80	14.47	20.40	17.44
SEm(±)		**1.78**	**1.25**	**0.91**	**1.05**	**1.56**	**1.01**
LSD(0.05)		**5.40**	**3.81**	**2.78**	**3.18**	**4.75**	**3.07**

Table 7: Effect of different components of natural farming on total phosphorus uptake

Treatment		Total phosphorus uptake (Wheat) (kg ha^{-1})			Total phosphorus uptake (Gram)(kg ha^{-1})		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	*Ghanjeevamrit* @ 5 q ha^{-1} before sowing	6.65	5.31	5.98	2.28	2.63	2.45
T_2	*Jeevamrit* (foliar application at 21 days interval)	7.49	6.48	6.99	2.43	2.96	2.70
T_3	Mulching @ 10 t ha^{-1}	7.56	6.41	6.99	2.45	2.75	2.60
T_4	*Ghanjeevamrit + jeevamrit*	10.19	8.23	9.21	3.50	3.82	3.66
T_5	*Ghanjeevamrit* + mulching	8.19	6.93	7.56	2.62	3.18	2.90
T_6	*Jeevamrit +mulching*	8.53	7.42	7.97	2.87	3.26	3.07
T_7	*Ghanjeevamrit + jeevamrit* + mulching	11.41	9.05	10.23	3.71	4.32	4.02
T_8	Control	5.97	4.94	5.45	2.21	2.46	2.33
SEm(±)		**0.53**	**0.27**	**0.29**	**0.14**	**0.17**	**0.11**
LSD(0.05)		**1.63**	**0.84**	**0.87**	**0.45**	**0.53**	**0.35**

Table 8: Effect of different components of natural farming on total potassium uptake

Treatment		Total potassium uptake (Wheat) (kg ha^{-1})			Total potassium uptake (Gram)(kg ha^{-1})		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	*Ghanjeevamrit* @ 5 q ha^{-1} before sowing	34.74	28.56	31.65	8.81	10.85	9.83
T_2	*Jeevamrit* (foliar application at 21 days interval)	38.41	35.58	37.00	9.05	12.30	10.67
T_3	Mulching @ 10 t ha^{-1}	38.01	33.02	35.52	9.26	11.53	10.40
T_4	*Ghanjeevamrit + jeevamrit*	51.54	44.37	47.96	12.54	16.15	14.34
T_5	*Ghanjeevamrit* + mulching	41.63	37.50	39.57	9.76	12.89	11.33
T_6	*Jeevamrit* + mulching	42.43	40.08	41.26	10.60	13.15	11.88
T_7	*Ghanjeevamrit + jeevamrit* + mulching	56.75	47.94	52.35	13.56	18.35	15.96
T_8	Control	30.06	26.06	28.06	7.82	10.15	8.99
SEm(±)		**2.74**	**1.82**	**1.67**	**0.64**	**0.70**	**0.48**
LSD(0.05)		**7.77**	**5.52**	**5.07**	**1.95**	**2.14**	**1.45**

Microbial population was significantly higher in the soil with combined application of *ghanjeevamrit,jeevamrit* and mulching than sole application of either of them. This might be due to cumulative effect of *ghanjeevamrit,jeevamrit* and mulching. As jeevamrit contains enormous amount of microbial load which multiplies in the soil and acts as a tonic to encourage the microbial activity in the soil (Palekar,2006) and

Table 9: Effect of different components of natural farming on grain yield

Treatment		Grain yield (Wheat) (kg ha^{-1})			Grain yield (Gram) intercrop (kg ha^{-1})		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	*Ghanjeevamrit* @ 5 q ha^{-1} before sowing	1259.7	1145.5	1202.6	431.3	554.6	493.0
T_2	*Jeevamrit* (foliar application at 21 days interval)	1375.7	1291.4	1333.5	442.1	602.2	522.2
T_3	Mulching @ 10 t ha^{-1}	1380.8	1335.7	1358.2	455.0	583.9	519.4
T_4	*Ghanjeevamrit* + *jeevamrit*	1694.8	1551.1	1622.9	601.2	736.2	668.7
T_5	*Ghanjeevamrit* + mulching	1484.4	1363.6	1424.0	494.7	665.4	580.0
T_6	*Jeevamrit* + mulching	1552.6	1460.4	1506.5	535.6	682.0	608.8
T_7	*Ghanjeevamrit* + *jeevamrit* + mulching	1852.5	1682.1	1767.3	638.7	829.5	734.1
T_8	Control	1186.5	1090.9	1138.7	405.1	519.3	462.2
SEm(±)		**93.2**	**48.5**	**47.7**	**23.3**	**42.4**	**26.1**
LSD (0.05)		**282.8**	**147.2**	**144.9**	**70.8**	**128.7**	**79.2**

ghanjeevamrit has favorable effects on the soil properties which might have lowered the bulk density (Ravusaheb, 2008), improved soil aeration and also provided carbon as source of energy for microbes present in *jeevamrit* for their rapid multiplications and survival (Shwetha, 2008). Significantly lower microbial activity with application of jeevamrit alone (Siddappa, 2015) might be attributed to the absence of source of organic carbon for further multiplication of fungi, bacteria and actinomycetes and that with application of only *ghanjeevamrit* might be due to lack of microbial inoculum (which is present in *jeevamrit*).

Dehydrogenase activity

Dehydrogenase activity under control was recorded as 2.61 and 2.67 TPF g^{-1} soil hr^{-1}, respectively, which was increased maximum up to 4.48 and 5.15 TPF g^{-1}soil hr^{-1}, respectively with the application of *ghanjeevamrit* + *jeevamrit* + mulching during both the years 2019-20 and 2020-21 which was followed by treatment *ghanjeevamrit* + *jeevamrit*, *ghanjeevamrit* + mulching and *jeevamrit* + mulching. Significantly lowest dehydrogenase activity (2.61 and 2.67 TPF g^{-1} soil hr^{-1}, respectively) was found in control treatments.The amount of organic matter in the soil has a strong correlation with enzyme activity. The use of balanced quantities of fertilisers and manures enhanced soil organic matter and microbial biomass carbon status, which was accompanied by increased enzyme activity (Mandal *et al.*, 2007). Dehydrogenase activity may be linked to increased substrate availability in the soil when organic sources are used. This is due to increased biological activity in the soil and the stability of extracellular enzymes via humic substance complexation (Basak *et al.*, 2013). Dehydrogenase activity is influenced more by the quality than by the quantity of organic matter incorporated into soil. Thus, the stronger effects of vermicompost or microbial inoculants on dehydrogenase activity might be due to the more easily decomposable components of crop residues on the metabolism of soil microorganisms (Pramanik *et al.*, 2010).

Plant analysis

i. Nitrogen uptake by wheat and gram crops

In wheat,*ghanjeevamrit* + *jeevamrit* + mulching recorded significantly highest nitrogen uptake(49.29 and 49.80 kg ha^{-1}, respectively) during 2019-20, 2020-21 which was followed by *ghanjeevamrit* + *jeevamrit*, *jeevamrit* + mulching and *ghanjeevamrit* + mulching. Significantly lowest nitrogen uptake was recorded in control treatments (26.63 and 22.96kg ha^{-1}) during both the years (Table 6).

Significantly highest nitrogen uptake in gram (27.7 and 39.1 kg ha^{-1}, respectively) was observed with application of *ghanjeevamrit* + *jeevamrit* + mulching and was followed by*ghanjeevamrit* + *jeevamrit, jeevamrit* + mulching and *ghanjeevamrit* + mulching. Control treatment recorded significantly lowest nitrogen uptake(14.5 and 20.4 kg ha^{-1}, respectively) during both the years.

The uptake of nitrogen was higher in treatments *ghanjeevamrit* + *jeevamrit* + mulching receiving more number of soil drenchings of jeevamrit which might be ascribed to the rapid mineralization of native and applied nutrients due to build-up of microflora, as the microbial inoculum i.e. *jeevamrit* when soil drenched at different intervals, resulted in increased availability of nutrients and consequently increased the enzymatic activity and helped in increased uptake of nutrients. Gore and Sreenivasa (2011) reported that *jeevamrit* promotes immense biological activity in soil and enhance nutrient availability to crop.

ii. Phosphorus uptake by wheat and gram crops

In 2019-20, 2020-21 highest phosphorus uptake in wheat (11.41 and 9.05 kg ha^{-1}, respectively) was recorded with application of *ghanjeevamrit* + *jeevamrit* + mulching followed by *ghanjeevamrit* + *jeevamrit, jeevamrit* + mulching, *ghanjeevamrit* + mulching and control treatments recorded significantly lowest phosphorus uptake (5.97 and 4.94 kg ha^{-1}, respectively) during both the years.Control treatment recorded significantly lowest phosphorus uptake (2.21 and 2.46 kg ha^{-1}, respectively) during both the years (Table 7). Higher phosphorus uptake is because of increased microbial activity which might have helped in solubilization of native and applied phosphorus and provided greater quantity of available phosphorus for plant uptake.

iii. Potassium uptake by wheat and gram crops

In wheat crop, significantly highest total uptake of potassium (Table 8) was recorded under *ghanjeevamrit* + *jeevamrit* + mulching(56.7 and 47.9kg ha^{-1}, respectively) in two years of experimentation which was followed by *ghanjeevamrit* + *jeevamrit, jeevamrit* + mulching and *ghanjeevamrit* + mulching. Significantly lowest potassium uptake (30.1 and 26.1kg ha^{-1}, respectively) was recorded under control treatment.

Total uptake of potassium in gram (13.6 and 18.3kg ha^{-1}, respectively) was resulted with application of *ghanjeevamrit* + *jeevamrit* + mulching during both the years and was followed by *ghanjeevamrit* + *jeevamrit, jeevamrit* + mulching and *ghanjeevamrit* + mulching. Significantly lowest total potassium uptake (7.8 and 10.1kg ha^{-1}, respectively) was recorded during both the years. Nutrient uptake is dependent on nutrient concentration and dry matter yield of plant. *Ghanjeevamrit, jeevamrit* and mulching have important roles in increasing nutrient concentration in plant and dry matter yield through the increased availability and solubility of nutrients in soil and thus enhancing their accumulation and transportation in plant. With application of *ghanjeevamrit, jeevamrit* and mulching microbial population was enhanced which ultimately helped in the solubilization of potassium in the root zone.

Seed Yield

i. Wheat

Application of *ghanjeevamrit* + *jeevamrit* + mulching produced significantly higher grain yield of wheat 8.8, 17.3, 21.1 and 30.1 per cent higher grain yield over treatment *ghanjeevamrit* + *jeevamrit, jeevamrit* + mulching, *ghanjeevamrit* + mulching and mulching respectively. This may be due to increased availability of nutrients due to build-up of soil micro flora resulting from increased bacteria, fungi, actinomycetes, P-solubilizers and N fixers population in the soil which resulted in high nutrient concentration and better growth and yield (Table 9).

ii. Gram

Different components of natural farming significantly influenced the seed yield of gram. *Ghanjeevamrit* + *jeevamrit* + mulching recorded significantly highest seed yield during 2019-20, 2020-21 and in pooled analysis (630.7, 829.5 and 734.1 kg ha^{-1}) which was at par with *ghanjeevamrit* + *jeevamrit* (601.2, 736.2 and 668.7 kg ha^{-1}) as compared to other treatments. The highest seed yield recorded with application of *ghanjeevamrit*+ *jeevamrit* + mulching might be due to fulfillment of nutritional needs of gram crop, the better availability of nutrients throughout the crop life cycle that ultimately improved the growth and yield contributing characters of gram and hence resulted in higher seed yield of gram.These results are similar to the findings of Sutar *et al*. (2018) founded similar results with the application of *jeevamrit* @ 1000 l ha^{-1}(Table 9).

Considering the hazards of fertilisers and pesticides, farmers can employ these environmentally beneficial traditional agricultural outputs as a production alternative. Based on the results it could be concluded that application of *ghanjeevamrit* + *jeevamrit* + mulching in wheat + gram intercropping system with alternate row (replacement series) under zero budget natural farming was proved very productive and also improved soil healthas compare to other treatments. Farmers under mid hills conditions of Himachal Pradesh can adopt wheat + gram intercropping for improving soil health.

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