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Optimization of *Jeevamrit* doses and application time for enhancing productivity of wheat under natural farming system

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Abstract
Jeevamrit is claimed to be a panacea for natural farming to fulfill the nutritional requirement of crops as well as for pest management. For reducing the indiscriminate use of chemicals in field crop production, there is a need of adopting *jeevamrit* based natural farming. Considering this rationale, a field experiment was conducted during *Rabi* 2017-18 at organic farm of Department of Organic Agriculture, CSK HPKV, Palampur to evaluate the doses and application time of *Jeevamrit* in wheat under natural farming system. Ten treatments comprising of *jeevamrit* application @ 5 per cent at 2, 3 & 4 weeks interval (T_1, T_2 & T_3), *jeevamrit* @ 10 per cent at 2, 3 & 4 weeks interval (T_4, T_5 & T_6), *jeevamrit* @ 20 per cent at 2, 3 & 4 weeks interval (T_7, T_8 & T_9) and vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha (T_{10}) were randomly allocated and replicated thrice under randomized block design. As per the findings, significantly higher grain yield (3117 kg/ha) was recorded with *jeevamrit* application @ 20 per cent at 2 weeks interval (T_3), which was at par with application of *jeevamrit* @ 10 per cent at 2 (T_2) & 3 (T_5) weeks interval, *jeevamrit* @ 20 per cent at 3 weeks interval (T_6) and to the check (vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha). Maximum B:C ratio (1.69) was recorded with application of *jeevamrit* @ 10 per cent at 3 weeks interval which was followed by application of *jeevamrit* @ 10 per cent at 2 weeks interval. The results showed that application of *jeevamrit* in natural farming system is capable of producing high yields of good quality and is commercially viable since it registered better net returns and B:C ratio.

Keywords: *Jeevamrit*, *ghanjeevamrit*, sieved FYM, economics, wheat, natural farming system

Introduction
Green revolution technologies played a great role in alleviating hunger but have also resulted in some adverse effects on our natural resources. Post green revolution, usage of chemical fertilizers involved single or combinations of nitrogen, phosphorus and potassium components in the fertilizers have hampered soil health by reducing organic content, increasing salinity, disturbing local pH (Wang *et al.*, 2008) [13] leading to disruption of microbial populations that support crop growth. Inspite of the intensive use of inputs for about half a century in Indian agriculture, the yield gap in various crops still remains large even after following the best practices (Nelson *et al.*, 2019) [8]. Also, the agricultural lands continue to shrink and there is a greater threat to global environment and soil resources. All the nations facing problems of poverty, hunger and malnutrition will need to accelerate their agricultural growth for achieving sustainable development goals, especially while aiming at no poverty, zero hunger and safe environment for all. Hence, there is now a great concern to maintain soil health and protect environment by popularizing eco-friendly and cost effective organic manures.
Wheat (*Triticum aestivum* L.) is foremost among cereals and indeed among all crops, as direct source of food for human beings. Wheat is the second most important food after rice in India and contributes nearly 35% to the national food basket. In India, wheat occupies an area of 29.14 million hectares with a production of 102.19 million tonnes and average productivity of 3507 kg/ha (Anonymous 2019) [1].
Agriculture is the main stay of small and marginal farmers in Himachal Pradesh for their livelihood. Because of the topographically inaccessible areas, farmers are already practicing traditional agriculture with low or no use of chemical inputs. Taking one step ahead, there is a need to promote the natural farming in the state, which will promote agriculture on profitable and sustainable basis.
Natural farming is a holistic method in which farmers are discouraged to buy market based inputs like chemical fertilizers, chemical pesticides etc. for growing plants within low budget and encourage to grow healthy soil with friendly earthworms and thereby grow healthy plants. *Jeevamrit* is claimed to be a panacea for natural farming. Palekar (2006) [9] revealed that

availability and uptake of nutrients by crops was increased by the application of *jeevamrit*. The *jeevamrit* should be prepared from dung and urine of Indian cow only and dung and urine of one cow is sufficient for organic cultivation of 12 ha (Palekar, 2009) [10]. Natural farming uses a variety of methods to improve soil fertility including application of *Jeevamrit* which is one of the most important component for nutrient management. Chandrakala (2008) [3] reported that the combined application of *beejamrit*, *jeevamrit* and *panchagavya* increased yield and drymatter production in chilli. Gore (2009) [5] observed that application of a combination of *beejamrit*, *jeevamrit* and *panchagavya* (1:1:2 ratio) at 75 and 160 days after sowing (DAS) increased tomato yield. Consortium of beneficial micro-organisms in *jeevamrit* converts the nutrients which are in non-available form into dissolved form, when it is inoculated to the soil. *Jeevamrit* is either sprayed or sprinkled on the crop field or added to the irrigation tank in regular interval of 15 days until the soil is enriched. Since, there is no scientific information available on the application time and effect of doses of *'Jeevamrit'* on the productivity of the crops under 'natural farming system', the present study was conducted to evaluate the efficacy of *jeevamrit* on growth, yield attributes and yield of wheat and to work out the economics of the treatments.

Materials and Methods

The experiment was conducted at organic farm, Department of Organic Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experiment site is located at an elevation of 1224 metre above mean sea level. The soil of experiment site was silty clay loam in texture and acidic in reaction (pH 5.20), medium in organic carbon (0.72%), low in available nitrogen (208.05 kg/ha), high in available phosphorus (31.50 kg/ha) and medium in available potassium (185.33 kg/ha). The experiment was laid out in randomized block design comprising of ten treatments; application of *jeevamrit* @ 5 per cent at 2, 3 & 4 weeks interval (T_1, T_2 & T_3), *jeevamrit* @ 10 per cent at 2, 3 & 4 weeks interval (T_4, T_5 & T_6), *jeevamrit* @ 20 per cent at 2, 3 & 4 weeks interval (T_7, T_8 & T_9) and vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha (T_{10}). Each treatment was allocated randomly and replicated three times under randomized block design. Prior to sowing, *Ghanjeevamrit* @ 250 kg/ha + sieved FYM @ 250 kg/ha was applied and incorporated in plots of treatments except organic check where vermicompost @ 10 t/ha was applied and incorporated, respectively.

Organically produced seeds of 'HPW-368' variety of wheat were used for sowing. It was sown at a spacing of 20 cm with the seed rate of 100 kg/ha. Seeds of wheat were treated with *beejamrit* @ 10 litres/100 kg of seeds. In organic check, seeds of wheat were treated with *beejamrit* @ 10 litres/100 kg of seeds and *Azotobacter* + PSB culture @ 50 g/3 kg of seeds each. In order to check the weeds, hand weeding was done with khurpi or handhoe. For nutrient management, soil was drenched with *jeevamrit* at regular intervals, as per the treatments till the initiation of grain filling. In organic check, three sprays of vermiwash @ 750 l/ha was done, respectively at 10, 25 and 45 days after sowing.

Results and Discussion

Plant height

Significantly taller plants were recorded in T_3 (*Jeevamrit* @ 20% at 2 weeks interval) which behaved statistically similar with T_2 (*Jeevamrit* @ 10% at 2 weeks interval), T_{10} (VC @ 10 t/ha at sowing + 3 sprays of vermiwash) and T_6 (*Jeevamrit* @ 20% at 3 weeks interval). This might be attributed to more solubilisation of nutrients by increased beneficial microbes in soil with higher concentrations and frequencies of *jeevamrit* drenching.

Number of shoots

Application of *jeevamrit* @ 20 per cent at 2 weeks interval (T_3) recorded significantly higher number of shoots per square. This treatment behaved statistically similar to application of *jeevamrit* @ 10 per cent at 2 weeks interval (T_2), *jeevamrit* @ 10 (T_5) & 20 per cent (T_6) at 3 weeks interval and to the check (vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha).

Dry matter accumulation

Application of *jeevamrit* @ 20 per cent at 2 weeks interval (T_3) recorded significantly higher dry matter accumulation per square meter and this treatment behaved statistically similar to application of *jeevamrit* @ 10 per cent at 2 weeks interval (T_2), check (vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha) and *jeevamrit* @ 20 per cent at 3 weeks interval (T_6).

Similar results were reported by Sutar *et al.* (2018) [12] in cowpea, where application of *jeevamrit* @ 1000 l/ha resulted in significantly taller plants, higher number of branches per plant than the application of *jeevamrit* @ 500 l/ha. In fieldbean, Siddappa (2015) [11] also reported taller plants, more number of branches and higher dry matter accumulation with application of *jeevamrit* @ 1500 l/ha which was statistically superior to the application of *jeevamrit* @ 500 l/ha.

Table 1: Effect of treatments on plant height (cm), number of shoots per square meter and dry matter accumulation in wheat crop at harvest

Treatment	Plant height (cm)	Number of shoots per square meter	Dry matter accumulation (g/m^2)
T_1-Jeev. @ 5% (2 weeks interval)	96.07	189.26	1006.50
T_2-Jeev. @ 10% (2 weeks interval)	101.52	202.74	1098.56
T_3-Jeev. @ 20% (2 weeks interval)	102.76	206.80	1127.48
T_4-Jeev. @ 5% (3 weeks interval)	94.91	181.76	980.84
T_5-Jeev. @ 10% (3 weeks interval)	97.41	192.82	1017.97
T_6-Jeev. @ 20% (3 weeks interval)	98.92	194.16	1043.30
T_7-Jeev. @ 5% (4 weeks interval)	94.37	179.52	960.23
T_8-Jeev. @ 10% (4 weeks interval)	96.78	183.97	995.23
T_9-Jeev. @ 20% (4 weeks interval)	97.31	187.13	1000.02
T_{10}-VC @ 10 t/ha at sowing + 3 sprays of vermiwash (Check)	101.27	200.74	1095.98
SEm±	1.74	5.11	29.36
CD at 5%	5.17	15.19	87.24

Jeev. – *Jeevamrit*, VC – Vermicompost.

Yield attributes

Significantly higher spike length, higher number of spikelets per spike, effective tillers per square meter and number of grains per spike was recorded with the application of *jeevamrit* @ 20 per cent at 2 weeks interval (T_3), which was at par to the application of *jeevamrit* @ 10 per cent at 2 (T_2) & 3 (T_5) weeks interval, *jeevamrit* @ 20 per cent at 3 weeks interval (T_6) and to the check (vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha). There was no significant effect of the treatments on the 1000-grain weight of the wheat crop.

These results are in conformity with those of Siddappa (2015) [11], who found higher yield attributing characters of fieldbean with the application of *jeevamrit* @ 1500 l/ha followed by *jeevamrit* @ 1000 l/ha and *jeevamrit* @ 500 l/ha, respectively. Higher yield attributing characters might be due to steady supply of nutrients through organics (vermicompost) in check, which are known to have a favourable effect on soil structure, texture, tilth and thus facilitate quick and greater availability of plant nutrients (Avnimelech, 1986) [2], and organic solutions (*jeevamrit*), which may not provide enough nutrients in area of application, but they help in the quick build-up of soil fertility through enhanced activity of soil microflora and fauna (Yadav and Mowade, 2004) [14].

Table 2: Effect of treatments on yield attributes of wheat crop

Treatment	Spike length (cm)	No. of spikelets per spike	No. of effective tillers per sq. m	No. of grains per spike	1000-grain weight (g)
T_1-Jeev. @ 5% (2 weeks interval)	9.14	17.40	145.35	44.16	40.91
T_2-Jeev. @ 10% (2 weeks interval)	9.84	20.70	153.65	50.30	41.27
T_3-Jeev. @ 20% (2 weeks interval)	10.23	21.25	160.64	54.21	41.70
T_4-Jeev. @ 5% (3 weeks interval)	8.93	15.96	141.10	40.83	40.66
T_5-Jeev. @ 10% (3 weeks interval)	9.35	18.03	150.82	47.83	40.82
T_6-Jeev. @ 20% (3 weeks interval)	9.56	19.25	152.78	49.21	41.01
T_7-Jeev. @ 5% (4 weeks interval)	8.20	15.77	136.30	39.99	40.07
T_8-Jeev. @ 10% (4 weeks interval)	8.94	16.74	139.25	42.04	40.25
T_9-Jeev. @ 20% (4 weeks interval)	9.14	17.26	139.96	44.14	40.36
T_{10}-VC @ 10 t/ha at sowing + 3 sprays of vermiwash (Check)	9.77	20.23	153.60	49.80	41.24
SEm±	0.29	1.23	3.32	2.15	0.45
CD at 5%	0.88	3.64	9.88	6.38	NS

Jeev. – *Jeevamrit*, VC – Vermicompost.

Yield

Application of *jeevamrit* @ 20 per cent at 2 weeks interval (T_3) recorded significantly higher grain yield (3117 kg/ha) being statistically at par with the application of *jeevamrit* @ 10 per cent at 2 (T_2) & 3 (T_5) weeks interval, *jeevamrit* @ 20 per cent at 3 weeks interval (T_6) and to the check (vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha) over rest of the treatments. There was 35.76 per cent and 29.23 per cent increase in the grain yield with the application of *jeevamrit* @ 20 per cent at 2 weeks interval (T_3) and application of *jeevamrit* @ 10 per cent at 2 weeks interval (T_2) over the application of *jeevamrit* @ 5 per cent at 4 weeks interval (T_7).

Significantly higher straw yield (6193 kg/ha) was recorded with application of *jeevamrit* @ 20 per cent at 2 weeks interval (T_3). It behaved statistically similar to the application of *jeevamrit* @ 10 per cent at 2 weeks interval (T_2), *jeevamrit* @ 20 per cent at 3 weeks interval (T_6) and vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha (T_{10}). There was no significant effect of the treatments on the harvest index of the wheat crop.

Yield increase might be due to favourable effects of IAA, GA_3, macro and micronutrients (Devakumar *et al.*, 2014) [4]. The increase in grain yield and straw yield of wheat in treatments T_3, T_2, T_5, T_6 and T_{10} could be due to better availability of nutrients throughout the crop growth which might be the result of improved microbial activity in the soil.

These findings are in accordance with Kasbe *et al.* (2009) [6] wherein, it is reported that higher nutrient status of *jeevamrit* formulation (2500 l/ha) resulted in profused growth in the form of higher dry matter accumulation and yield parameters. Whenever liquid manures are applied at regular intervals, they act as a stimulus in the plant system and in turn increase the production of growth regulators in the cell system and growth hormones which in turn might have enhanced the soil biomass, thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately have resulted in better growth and yield of crops. Application of organic inputs like vermicompost in combination with vermiwash resulted in better yield of crops by slow release of nutrients for absorption and supplementation of gibberellins, cytokinins and auxins (Lalitha *et al.*, 2000) [7].

Table 3: Effect of treatments on biological, grain & straw yield and harvest index of wheat crop

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
T_1-Jeev. @ 5% (2 weeks interval)	2528	5657	0.31
T_2-Jeev. @ 10% (2 weeks interval)	2967	5926	0.33
T_3-Jeev. @ 20% (2 weeks interval)	3117	6193	0.33
T_4-Jeev. @ 5% (3 weeks interval)	2379	5582	0.30
T_5-Jeev. @ 10% (3 weeks interval)	2861	5723	0.33
T_6-Jeev. @ 20% (3 weeks interval)	2958	5907	0.33
T_7-Jeev. @ 5% (4 weeks interval)	2296	5490	0.29
T_8-Jeev. @ 10% (4 weeks interval)	2468	5584	0.31
T_9-Jeev. @ 20% (4 weeks interval)	2625	5682	0.32
T_{10}-VC @ 10 t/ha at sowing + 3 sprays of vermiwash (Check)	2891	5918	0.33
- SEm±	134	133	0.01
- CD at 5%	398	397	NS

Jeev. – *Jeevamrit*, VC – Vermicompost.

Economics

Highest cost of cultivation (Rs 50686/ha) was incurred in check involving application of vermicompost @ 10 t/ha + 3 sprays of vermiwash @ 750 l/ha followed by application of *jeevamrit* @ 20 per cent at 2 weeks interval (Rs 40070/ha), *jeevamrit* @ 20 per cent at 3 weeks interval (Rs 36470/ha), *jeevamrit* @ 10 per cent at 2 weeks interval (Rs 34070/ha) and *jeevamrit* @ 20 per cent at 4 weeks interval (Rs 33070/ha). The lowest cost of cultivation (Rs 28570/ha) was incurred with application of *jeevamrit* @ 5 per cent at 4 weeks interval. The highest cost in the check can be attributed to the application of bulky organic manure (vermicompost) whereas in other treatments increased number of drenchings of *jeevamrit* lead to higher cost of cultivation.

Application of *jeevamrit* @ 10 per cent at 2 weeks interval resulted in higher net returns which was followed by application of *jeevamrit* @ 10 per cent at 3 weeks interval and application of *jeevamrit* @ 20 per cent at 2 weeks interval. Higher B:C ratio was recorded with application of *jeevamrit* @ 10 per cent at 3 weeks interval which was followed by application of *jeevamrit* @ 10 per cent at 2 weeks interval.

Table 4: Effect of treatments on economics of wheat crop

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1-Jeev. @ 5% (2 weeks interval)	31070	78855	47785	1.54
T_2-Jeev. @ 10% (2 weeks interval)	34070	88976	54906	1.61
T_3-Jeev. @ 20% (2 weeks interval)	40070	93321	53251	1.33
T_4-Jeev. @ 5% (3 weeks interval)	29720	75496	45776	1.54
T_5-Jeev. @ 10% (3 weeks interval)	31970	85845	53875	1.69
T_6-Jeev. @ 20% (3 weeks interval)	36470	88695	52225	1.43
T_7-Jeev. @ 5% (4 weeks interval)	28570	73391	44821	1.57
T_8-Jeev. @ 10% (4 weeks interval)	30070	77293	47223	1.57
T_9-Jeev. @ 20% (4 weeks interval)	33070	80913	47843	1.45
T_{10}-VC @ 10 t/ha at sowing + 3 sprays of vermiwash (Check)	50686	87423	36737	0.72

Jeev. – *Jeevamrit*, VC – Vermicompost.

Conclusion

Application of *jeevamrit* increases growth, yield attributes and yield of wheat crop under natural farming system. Among all the treatments application of *jeevamrit* @ 20 per cent at 2 weeks interval being at par with the application of *jeevamrit* @ 10 per cent at 2 & 3 weeks interval and application of *jeevamrit* @ 20 per cent at 3 weeks interval recorded significantly higher wheat grain yield over rest of the treatments however, due to comparatively lower cost of cultivation and higher net return & benefit cost ratio *jeevamrit* @ 10 per cent at 3 weeks interval was the most effective and economical.

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