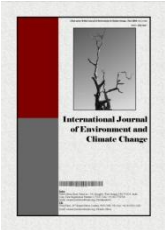

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Jiwamrita: A Low Cost Organic Nutrient Source for Growth, Yield and Economics of Organic Mungbean [*Vigna radiata* (L.) Wilczek] under Changing Agricultural Environment

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AS, MR and RCM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DSM and SK managed the literature searches. Author MR and RCM gave final shape to the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To find a suitable alternate option of nutrient management in organic mungbean with standardization of dose and its mode of application.
Place and Duration of Study: Agricultural Research Station, Mandor, Jodhpur between July 2020 and October, 2020.
Methodology: Treatment comprised of main plots as mode of application: M_1: Soil application, M_2: Foliar application and M_3: Soil and foliar application and sub plots as dose of *Jiwamrita*: S_1: Control, S_2: 50 ml/l, S_3: 100 ml/l and S_4: 150 ml/l were replicated thrice in split plot design. FYM @ 5.0 t/ha was applied on the soil and the field of the experimental site was prepared by disking following

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harrowing and planking. The crop variety GM 6 was sown on 10th July, 2020 at row spacing of 30 cm with seed rate of 15 kg/ha. The plants were kept at 10 cm distance after thinning at 15 days after sowing. *Jiwamrita* was prepared using Palekar [1] method (Photo 1) and was kept in shade for 7 days. It was filtered before using for spray as per treatments. It was applied as soil spray at the time of sowing and 15 days after sowing as per treatments of different doses. Foliar application of *Jiwamrita* was done at 15 and 30 days after sowing as per treatments. Total quantity of solution containing *Jiwamrita* was 500 liter/ha in all the treated plots. In control plots, a quantity of 500 liter/ha was used as spray. Weeding was done manually at 15 and 30 days after sowing. Data on growth attributes, yield attributes and grain yield was recorded from net plot size of 4 m x 1.8 m and converted into hectare basis. The gross return was computed by multiplying current price of mungbean with yield. The net return was estimated by deducting cost of cultivation from gross return. The benefit-cost ratio was worked out by dividing gross return by cost of cultivation.

Results: Maximum plant height of 71.5 cm was recorded with a dose of *Jiwamrita* @ 150 ml/liter which was at par with *Jiwamrita* @ 100 ml/liter. The SPAD chlorophyll meter reading (SCMR) of leaves increased at 50 DAS (53.5) being maximum with *Jiwamrita* @ 150 ml/liter which was significantly higher over SCMR recorded with *Jiwamrita* @ 50 ml/liter (34.7). The significantly maximum number of pods/plant (28.7) and maximum grain yield (1314 kg/ha) was recorded due to combined application of soil and foliar application of *Jiwamrita*. Among doses, maximum number of pods (30.9) was recorded under *Jiwamrita* @ 150 ml/liter which was 30, 24 and 16 percent higher over control and *Jiwamrita* @ 50, 100 ml/liter. The application of *Jiwamrita* @ 150 ml/liter resulted in significantly higher grain yield (1221 kg/ha) which was found at par with *Jiwamrita* @ 100 ml/liter (1179 kg/ha) which were 17 and 13 percent higher, respectively, over control and 9 and 5.6 percent higher, respectively, over *Jiwamrita* @ 50 ml/liter. The maximum net return (₹ 65672 ha^{-1}) was recorded with 150 ml/liter followed by 100 ml/liter (₹ 62686 ha^{-1}).

Conclusion: *Jiwamrita* is a fermented microbial culture which provides essential nutrients to plants. Its application in both soil and plant canopy were found beneficial. The study revealed that twice application of *Jiwamrita* in soil at the time of sowing and 15 days after sowing and twice application of *Jiwamrita* as foliar spray at 15 and 30 days after sowing significantly increased the growth attributes, yield attributes and yield of organic mungbean.

Keywords: Organic mungbean; jiwamrita; dose; mode of application; yield & economics.

1. INTRODUCTION

The overuse of chemical inputs in agriculture has led to soil and environment pollution [2-4]]. Realizing the importance of environmental and human benefits of chemical free farming since 2014, Government of India through Ministry of Agriculture and Farmers Welfare started promoting organic farming through various schemes of Paramparagat Krishi Vikas Yojana and Mission Organic Value Chain Development for North East Region (MOVCD-NER), etc. In India, more than 43 lakh hectares of area were registered under organic certification [5]. According to the International Survey Report (2021), India ranks 5th in terms of area and tops in terms of total number of organic producers (base year 2019) [6]. The COVID 19 pandemic further accelerated the shift in consumption patterns from chemical led agriculture to eco-friendly agriculture because of health scare and thereby the demand for organic food is increasing in the world and India is no exception [7].

Mungbean [*Vigna radiata* (L.) Wilczek] is the third important pulse crop of India after chickpea and pigeon pea which is cultivated in an area of 4.75 million hectares and contributing 2.46 million tonnes of production with productivity of 516 kg/ha in the country [8]. Rajasthan holds about 50 percent (2.32 mha) of total area under mungbean in the country. It is mainly cultivated in arid and semi-arid areas of the State which are identified as potential areas for organic crop production. The efforts to increase productivity of mungbean in the states mainly include use of synthetic and inorganic mode of production which causes hazardous effects to the environment consequently resulting in unsustainability in the long term. Inkling of the situation to be more challenging in future, there is need to find out eco-friendly and sustainable method of production which is socially acceptable and economically feasible to common farmers. Organic farming is one of such practices. There are many components of organic farming management but a formulation called '*Jiwamrita*' has a pivotal role. *Jiwamrita* is

a plant growth promoting substance containing N_2 fixing bacteria that provides the necessary nutritional requirement for growth and yield of crops [1]. It is described as one of four wheels of Zero Budget Natural Farming [1]. The application of *Jiwamrita* improved the physical, chemical and biological properties of soil, besides improving the efficiency of applied manure [9]. It was also reported to be a catalytic agent to promote activity of microorganisms resulting in healthy and nutrient rich soil [10]. Earlier work by Galindo et al., [11] reported that the use of the fermented liquid as organic source of nutrient @ 3% foliar spray recorded significantly higher growth and yield of blackgram. Thus, it was clear that *Jiwamrita* was found beneficial with soil as well as foliar application however, its comparative assessment of benefits under different modes of application was lacking. Similarly, it was also needed to evaluate different doses of *Jiwamrita,* hence an attempt was made in the present study to find out suitable mode of application and optimum dose of *Jiwamrita* for organic mungbean.

2. MATERIALS AND METHODS

The experiment was conducted at ARS, Mandor during *Kharif* 2020 in loamy sand soil of low nitrogen, medium phosphorus and high potassium content with pH 8.2. Treatment comprised of main plots as mode of application: M_1: Soil application, M_2: Foliar application and M_3: Soil and foliar application and sub plots as dose of *Jiwamrita*: S_1: Control, S_2: 50 ml/l, S_3: 100 ml/l and S_4: 150 ml/l were replicated thrice in split plot design. FYM @ 5.0 t/ha was applied on the soil and the field of the experimental site was prepared by disking following harrowing and planking. The crop variety GM 6 was sown on 10th July, 2020 at row spacing of 30 cm with seed rate of 15 kg/ha. The plants were kept at 10 cm distance after thinning at 15 days after sowing. The crop was raised under rainfed condition, however one need based surface irrigation was provided at 15 days after sowing due to lack of soil moisture at two weeks after sowing. A total of 180 mm rainfall was received in 13 rainy days during crop period (Graph. 1).

Jiwamrita was prepared using Palekar [1] method (Photo 1) as follows:

- Two hundred litres of water was put in a plastic barrel. Ten kg of fresh cow dung of Tharparkar breed was added and stirred well, then 10 litres urine of Tharparkar cow was added. A separate plastic tub was taken and 2 kg of pulse flour (gram) was mixed with 2 kg of jaggery and about 500 g soil from bottom of undisturbed farmbund was added. This entire mixture was poured into the barrel and stirred well with the help of a wooden stick. The solution was kept in shade and upper portion of the barrel was covered with a cotton cloth. The solution was stirred clockwise at time to time thrice a day for 7 days till it was ready for use.

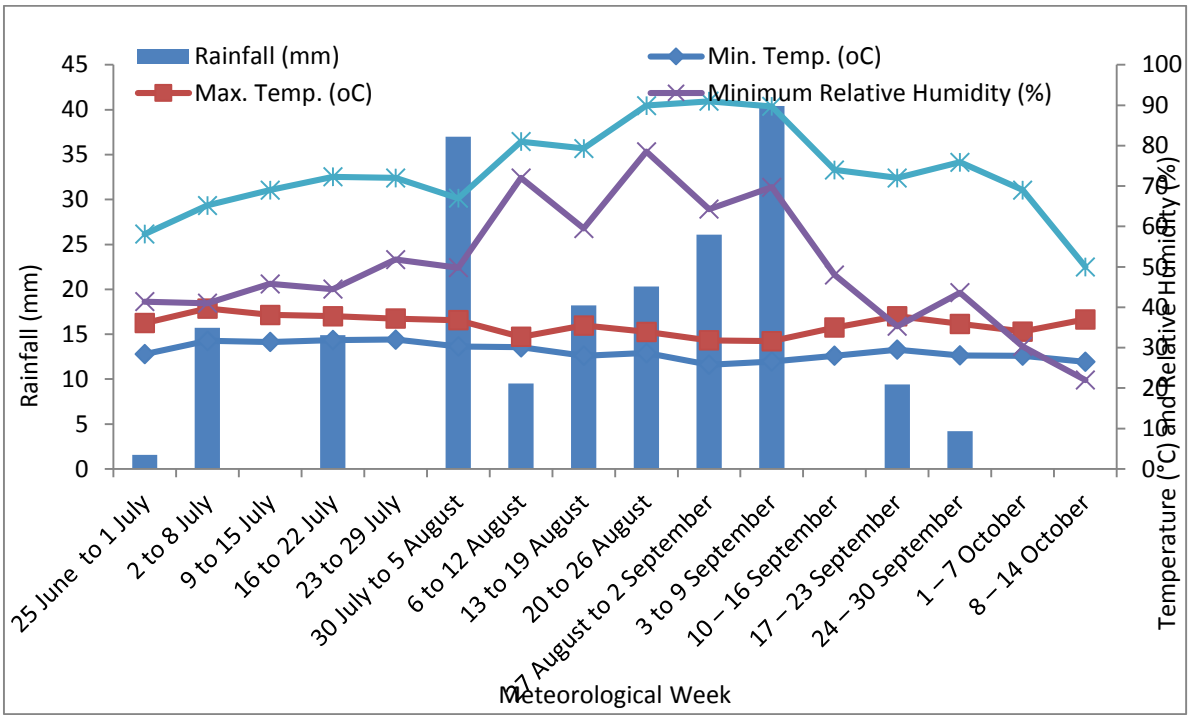
It was filtered after 7 days and used for soil and foliar application as per treatments. It was applied as soil drenching in furrows at the time of sowing and at 15 days after sowing as per treatments of different doses. Foliar application of *Jiwamrita* was done using Knapsack sprayer at 15 and 30 days after sowing as per treatments. Total quantity of solution containing *Jiwamrita* was 500 liter/ha in all the treated plots. In control plots, a quantity of 500 liter/ha was used as spray. Weeding was done manually at 15 and 30 days after sowing. Data on growth attributes, yield attributes and grain yield was recorded from net plot size of 4 m x 1.8 m and converted into hectare basis. The crop was harvested on 4th October, 2020. The gross return was computed by multiplying current price of mungbean with yield. The net return was estimated by deducting cost of cultivation from gross return. The benefit-cost ratio was worked out by dividing gross return by cost of cultivation.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Plant height of mungbean was significantly influenced by mode of application of *Jiwamrita.* Significantly higher plant height (71.9 cm) was recorded due to combination of soil and foliar application over soil application alone (63.4 cm) which was statistically at par with foliar application alone (65.4 cm). Maximum plant height of 71.5 cm was recorded with a dose of *Jiwamrita* @ 150 ml/liter which was at par with *Jiwamrita* @ 100 ml/liter (68.6 cm) but significantly higher than *Jiwamrita* @ 50 ml/liter and control. The combined soil and foliar application of *Jiwamrita* recorded 14 percent higher dry matter accumulation over soil application alone and 6 percent higher over foliar application alone. Maximum dry matter accumulation of 97 g/plant was recorded with dose of *Jiwamrita* @ 150 ml/liter followed by *Jiwamrita* @ 100 ml/liter. The dose of *Jiwamrita*

@ 100 ml/liter recorded 13 percent higher dry matter accumulation over control (84 g/plant) however it was statistically at par with a dose of *Jiwamrita* @ 50 ml/liter. Significantly higher number of branches (6.2) recorded in combination of soil and foliar application. Alone soil (5.2) and alone foliar application (5.6) were at par to each other but significantly lower to their combined application. A dose of *Jiwamrita* @ 150 ml/liter recorded 13 percent higher number of branches/plant over control which was statistically at par with *Jiwamrita* @ 100 ml/liter. These results are in line with earlier work by Baban [12] who reported that application of FYM @ 2.5 t/ha + vermicompost @ 1 t/ha + *Jiwamrita* @ 500 liter/ha at 30 and 45 DAS significantly



Graph 1. Rainfall, air tempearture and relative humidy recorded during crop season

Photo 1. *Jiwamrita* being prepared at ARS, Mandor (*Kharif* 2020)

Table 1. Bio-chemical composition of *Jiwamrita*

S. No.	Parameters	Values
1.	pH	4.04
2.	EC (dS/m)	1.70
3.	Total nitrogen (%)	1.90
4.	Total phosphorus (%)	0.201
5.	Total potassium (%)	0.291
6.	Total zinc (ppm)	4.25
7.	Total iron (ppm)	285
8.	Bacterial count (cfu/ml)	6.33×10^{8}
9.	Fungal count (cfu/ml)	5.1×10^{4}
10.	Actinomycetes (cfu/ml)	3×10^{5}
11.	Acid phosphatase (cfu/ml)	0.931
12.	Alkaline phosphatase (cfu/ml)	1.068
13.	Dehydrogenase (µg/ml)	2.771

increased the plant height (304 cm), number of branches/plant (40), leaf area/plant (18075 dm^2) of pigeon pea over control. Dahal et al. [10] found that the maximum number of branches/plant in mungbean was recorded in bio-accelerated farming wherein *Jiwamrita* was used as compared to conventional farming wherein synthetic fertilizers were used. Combination treatment of soil and foliar application of *Jiwamrita* significantly affected the number of root nodules (94) over alone foliar application and alone soil application (86 and 90, respectively) of *Jiwamrita*. Significantly higher number of root nodules/plant (96) were recorded with a dose of *Jiwamrita* @ 150 ml/liter followed by a dose of *Jiwamrita* @ 100 ml/liter (94) which were 12 percent and 10.5 percent higher, respectively over control and *Jiwamrita* @ 50 ml/liter. Maximum nodules dry weight (305 mg/plant) was recorded with combination treatment of soil and foliar application of *Jiwamrita* which was 12 and 8 percent higher over alone foliar and alone soil application of *Jiwamrita,* respectively. The increase in root nodules due to application of *Jiwamrita* might be due to beneficial effect of bacterial and microbial population present in the Jiwamrita solution (Table 1). Similar results were also obtained by Devakumar et al. [13] who reported that the use of handful of soil for *Jiwamrita* preparation served as source of initial inoculum of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers.

3.2 SPAD Chlorophyll Meter Reading (SCMR)

Significantly maximum chlorophyll reading (54.01) was observed with combined soil and foliar application of *Jiwamrita* at 50 DAS. It was found minimum (34.23) at harvest with soil application of *Jiwamrita*. There was no significant difference found due to mode of application of *Jiwamrita* at 25 DAS. The SCMR increased at 50 DAS and at harvest with dose of *Jiwamrita* @ 100 and 150 ml/lite. Maximum SCMR of the leaves recorded with *Jiwamrita* @ 150 ml/liter at 50 DAS (53.5) which were significantly higher over SCMR recorded with dose of *Jiwamrita* @ 50 ml/liter (34.7).

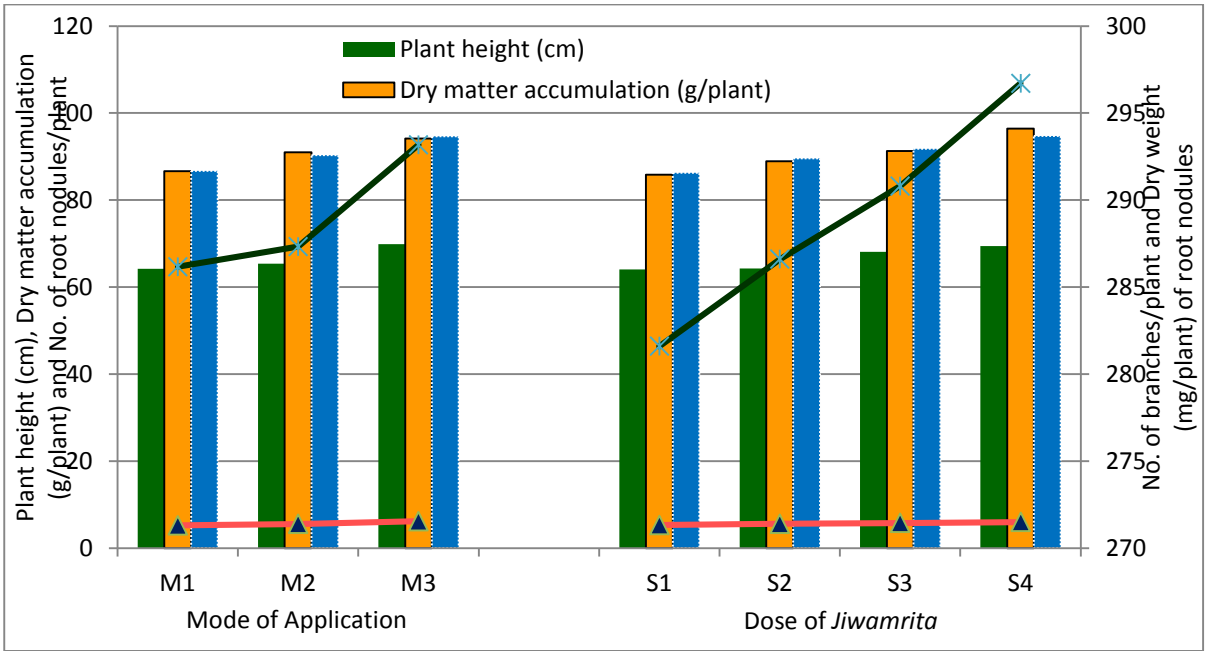
3.3 Yield Attributes

The significantly maximum number of pods/plant (28.7) was recorded due to combined application of soil and foliar application of *Jiwamrita*. The number of pods/plant increased significantly in response to dose of *Jiwamrita*. Maximum number of pods (30.9) was recorded under *Jiwamrita* @ 150 ml/liter which was 30, 24 and 16 percent higher over control and *Jiwamrita* @ 50, 100 ml/liter. Basavaraj et al. [14] reported that soil application of *Jiwamrita* recorded significantly higher pod yield of french bean (141.7 q ha^{-1}) compared to without *Jiwamrita* application (117 q ha^{-1}). In terms of number of grains/pod, combination treatment of soil and foliar application of *Jiwamrita* was statistically at par with alone foliar application (11.85) but significantly higher over alone soil application (10.42) of *Jiwamrita*. Application of *Jiwamrita* @ 150 ml/liter gave maximum number of grain/pod (12.5) and recorded a significant increase of 23, 16 and 9 percent in number of grains/pod of mungbean over the control and *Jiwamrita* @ 50, 100 ml/liter, respectively. Maximum pod length (10.33) was recorded under combination treatment of soil and foliar application of which was significantly maximum over soil application (9.37) alone but at par with foliar application (9.43) alone. The application of *Jiwamrita* @ 100

ml/liter recorded 7.7 and 4.2 percent higher pod length over control and *Jiwamrita* @ 50 ml/liter, respectively and was found at par with a dose of 150 ml/liter (10.5 cm). Combined soil and foliar application of *Jiwamrita* resulted in maximum pod breadth (5.08 mm) followed by foliar application alone (4.46 mm) and soil application alone (4.30 mm). The test weight of mungbean was not significantly affected by mode of application and dose of *Jiwamrita*. These findings are in line with Kasbe et al. [15] who reported that better nutrient status of *Jiwamrita* formulation (2500 l/ha) resulted in profuse growth in the form of higher dry matter accumulation and yield parameters. In the present study, all the yield attributing parameters were significantly higher with application of *Jiwamrita* @ 150 ml/liter of solution which might be due to favorable effects of macro and micro nutrients and also due to presence of beneficial microorganisms in such liquid organic manures [16]. Whenever liquid manures are applied at regular intervals (2 to 3 times), they act as a stimulus in the plant system and in turn increase the production of growth regulators in the cell system. Palekar [1] and Devakumar et al. [13] reported the beneficial effects of *Jiwamrita* which was attributed to huge quantity of microbial load and growth hormones which in turn might

Table 2. SPAD Chlorophyll Meter Reading (SCMR) of green leaves of organic mungbean under *Jiwamrita* treatments

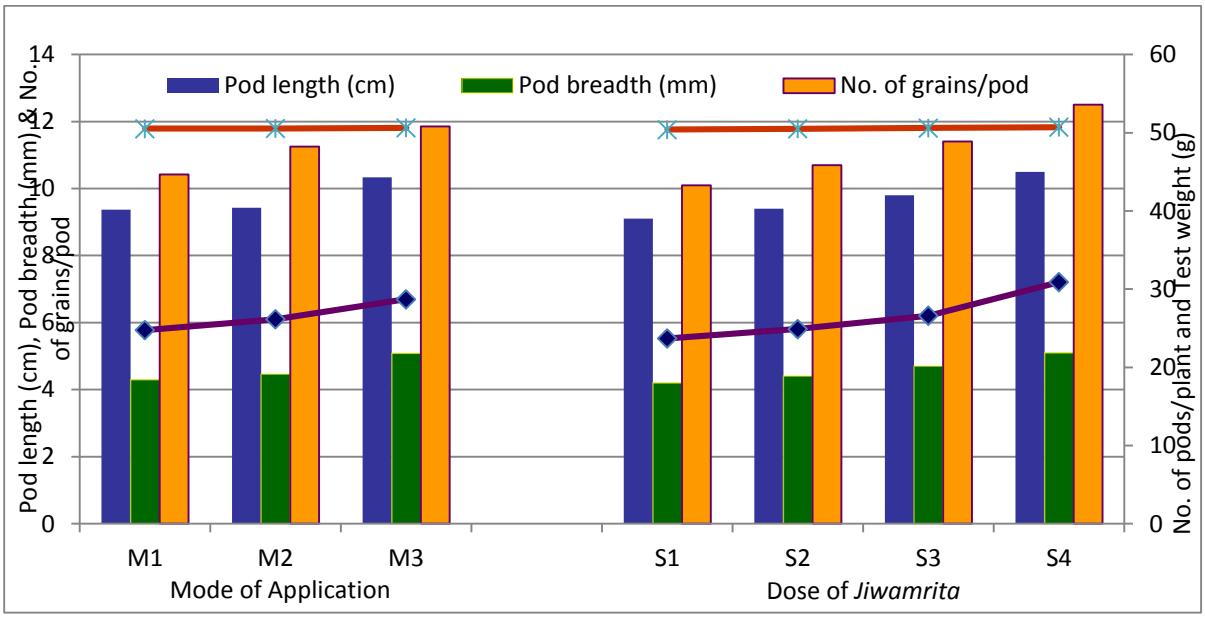
Treatments	SPAD Chlorophyll Meter Reading (SCMR)		
	25 DAS	50 DAS	At harvest
Mode of Application			
Soil application	41.46	51.00	34.23
Foliar application	41.85	51.24	34.33
Soil and foliar application	43.20	54.01	36.53
SEm+	0.31	0.53	0.34
CD (*P*=0.05)	2.6	2.1	1.4
Dose of *Jiwamrita*			
Control	41.1	50.6	33.9
Jiwamrita @ 50 ml/l	41.6	51.9	34.7
Jiwamrita @ 100 ml/l	42.6	52.2	35.4
Jiwamrita @ 150 ml/l	43.3	53.5	36.1
SEm+	0.48	0.63	0.5
CD (*P*=0.05)	1.4	1.9	1.3



Graph 2. Growth attributes of organic mungbean under *Jiwamrita* application

Table 3. Effect of *Jiwamrita* on yield attributes of organic mungbean

Treatments	No. of pods/plant	Pod length (cm)	Pod breadth (mm)	No. of grains/pod	Test weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)
Mode of Application							
Soil application	24.4	9.33	4.30	10.4	50.5	1024	2034
Foliar application	25.4	9.38	4.46	11.3	50.5	1082	2103
Soil and foliar application	28.2	10.28	5.08	11.9	50.6	1314	2481
SEm+	0.75	0.20	0.1	0.2	0.1	42	77
CD (*P*=0.05)	2.95	0.78	0.4	0.9	NS	164	301
Dose of *Jiwamrita*							
Control	23.6	9.08	4.20	10.1	50.4	1043	2051
Jiwamrita @ 50 ml/l	24.8	9.37	4.43	10.7	50.5	1116	2169
Jiwamrita @ 100 ml/l	27.2	9.81	4.71	11.4	50.6	1179	2258
Jiwamrita @ 150 ml/l	28.4	10.39	5.11	12.5	50.7	1221	2347
SEm+	0.77	0.28	0.2	0.5	0.2	43	71
CD (*P*=0.05)	2.30	0.83	0.5	1.4	NS	129	211



Graph 3. Yield attributes of organic mungbean under *Jiwamrita* application

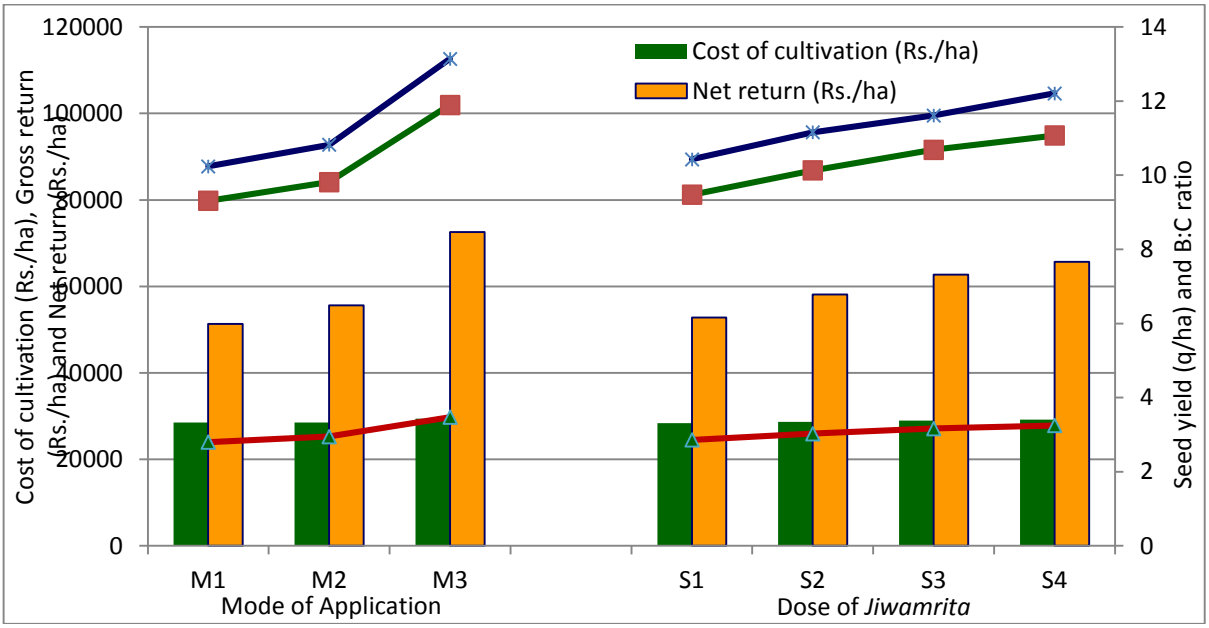
enhance the soil biomass, thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately have resulted in better growth and yield of crops. These findings are in conformity with the results of Sharma and Thomas [17].

3.4 Grain Yield and Economics of Organic Mungbean

The maximum grain yield (1314 kg/ha) was found under combination of soil and foliar application of *Jiwamrita* which was significantly

Table 4. Soil nutrient and microbial status of experimental soil

(i) Initial					
Parameters	**Organic carbon (%)**	**Available N (kg/ha)**	**Available P (kg/ha)**	**Available K (kg/ha)**	**Microbial population (x10^6)**
Value	0.13	174.0	22.2	325.0	58.2
(ii) Residual					
Treatments	**Organic carbon (%)**	**Available N (kg/ha)**	**Available P (kg/ha)**	**Available K (kg/ha)**	**Microbial population (x10^6)**
Mode of application					
Soil application	0.123	168.5	19.5	319.0	65.8
Foliar application	0.120	167.9	19.1	318.9	65.1
Soil and foliar application	0.124	169.4	20.2	319.5	66.8
SEm+	0.003	1.24	0.27	1.22	0.18
CD (*P*=0.05)	NS	NS	NS	NS	0.70
Dose of *Jiwamrita*					
Control	0.121	168.3	19.1	318.8	65.5
Jiwamrita @ 50ml/l	0.122	168.4	19.5	319.0	65.7
Jiwamrita @ 100ml/l	0.122	168.7	19.7	319.2	66.0
Jiwamrita @ 150ml/l	0.124	169.1	20.1	319.5	66.4
SEm+	0.003	1.49	0.31	1.11	0.22
CD (*P*=0.05)	NS	NS	NS	NS	0.66



Graph 4. Grain yield and economics of organic mungbean under *Jiwamrita* application

higher over foliar application alone (1082 kg/ha) and soil application alone (1024 kg/ha) (Table 4). The application of *Jiwamrita* @ 150 ml/liter resulted in significantly higher grain yield (1221 kg/ha) which was found at par with *Jiwamrita* @ 100 ml/liter (1179 kg/ha) which were 17 and 13 percent higher, respectively over control and 9 and 5.6 percent higher, respectively over *Jiwamrita* @ 50 ml/liter. This might be due to increased soil nutrients (NPK) and microbial population of the soil (Table 4) and more supply of nutrients to the plants after *Jiwamrita* application resulting in better yield. Patil et al. [18] also found that seed yield of pigeon pea

significantly increased over control due to application of FYM @ 2.5 t/ha + vermicompost @ 1 t/ha + *Jiwamrita* @ 500 liter/ha at 30 and 45 DAS. Beneficial effects of *Jiwamrita* as foliar spray of 5% at 20, 40 and 60 DAS on yield attributes and yields of maize were reported by Ramesh et al. [19]. Reshma et al. [20] reported that application of *Jiwamrita* at 1000 liter/ha and *Panchgavya* at 7.5 per cent significantly influenced yield parameters in cowpea. Combined soil and foliar application of *Jiwamrita* gave maximum net return (₹ 72597 ha^{-1}) with BC ratio of 3.5. Among different doses of *Jiwamrita,* maximum net return (₹ 65672 ha^{-1}) was recorded with 150 ml/liter followed by 100 ml/liter (₹ 62686 ha^{-1}). The economic benefits due to application of *Jiwamrita* were reported by Laharia et al. [21] and Patil and Udmale [22] in soybean, Chandrarakala et al. [23] in chilli, Baban [12] in pigeon pea and Manjunatha et al. [9] in sunflower. The BC ratio was recorded maximum with *Jiwamrita* @ 100 ml/liter (3.2) which was not increased further due to increased dose of *Jiwamrita* @ 150 ml/liter (Graph 4).

4. CONCLUSION

Jiwamrita is a fermented microbial culture which not only increases the soil microbial population but also provides important nutrients to plants. Its application in both soil and plant canopy were found beneficial. The study revealed that twice application of *Jiwamrita* in soil at the time of sowing and 15 days after sowing and twice application of *Jiwamrita* as foliar spray at 15 and 30 days after sowing significantly increased the growth attributes, yield attributes and yield of organic mungbean. A quantity of 500 liters/ha of solution containing *Jiwamrita* @ 100 ml/liter was found beneficial to increase grain yield and net return of organic mungbean. The findings can be useful in deciding mode of application and dose of *Jiwamrita* for enhancing productivity of organic mungbean.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by Govt. Institutes viz., Agricultural Research Station, Mandor and College of Agriculture, Jodhpur.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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