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Potential of Vermiwash Prepared from Different Combinations of Organic Wastes to Improve the Growth, Yield and Quality of Organic Black Gram

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ABSTRACT

Background: Excessive and unbalanced chemical fertilization in crop husbandry has attracted much attention because of soil health issues, reducing crop quality, increasing production cost and environmental risks. Organic farming is perceived as the best-known alternative method and has numerous environmental benefits. "Vermiwash" is liquid manure extracted from earthworms rich-vermicompost containing soluble nutrients, growth hormones, enzymes and many micro-organisms. As a result, the purpose of this study was to see how vermiwash affected the production and quality of black gram.

Methods: During the *kharif* 2018, a field experiment was set up in a randomized block design to assess the effect of nine vermiwash treatments prepared from different organic wastes like cow dung, buffalo dung, green and dry field wastes and their combinations on growth, yield attributes and yield, nutrients and protein content of organic black gram (var. PU-31) and biochemical properties of vermiwash.

Result: The neutral to slightly alkaline pH (7.72), E.C. (1.39 dSm^{-1}) and maximum nutrients content, greatest average microbiological count (total number of bacteria, fungi and actinomycetes) and enzyme activity (acid phosphatase, alkaline phosphatase and dehydrogenase) were significantly found in treatment (T_1) among the various vermiwash treatments at 35 days after collection. Moreover, the foliar application of vermiwash treatment (T_1) significantly recorded highest growth, seed yield, nutrients and protein content. Based on-field results, it is possible to infer that treatment T_1 (foliar spray in two equal split applications at a rate of 10% at the onset of flowering and 15 days following the first spray) is a better fertilizer practice for organic black gram cultivation.

Key words: Black gram, Organic, Quality, Vermiwash, Yield.

INTRODUCTION

Black gram or Urdbean is the fourth most crucial pulse crop in India, being cultivated over about 4.6 million hectares and producing about 24.5 lakh tonnes annually, with average productivity of 533 Kg per hectare in 2020-21 (Anonymous, 2020-21). In Rajasthan, it is cultivated in 5.02 lakh hectares with 1.28 lakh tonnes of production (Anonymous, 2020-21). Being a leguminous crop, it can fix atmospheric nitrogen in its root nodules and can be used as a green manuring crop after picking the pods. Many intensive crop cycles, such as the rice-wheat cropping system, it will fit nicely due to its short duration and photo-insensitive varieties. The black gram plant possesses a deep root system that binds soil particles and thereby reduces soil erosion. The productivity of black gram is low compared to the world's average because of mainly cultivated under rainfed conditions with inadequate nutrient management on marginal lands that are unfitted for cereals/cash crops.

To improve the productivity and quality of black gram, better nutrient management practices that are economically viable and ecologically sound, such as cultivating black gram under organic conditions with potential organic sources of essential plant nutrients. Soil application of essential plant nutrients is often insufficient to meet the crop's nutrition demand, particularly in short-duration crops like black gram. Therefore, foliar application of organic liquid manures is the value option. Vermiwash is potential liquid manure extracted from earthworms rich vermicomposts. It contains essential plant nutrients and growth hormones like auxin and cytokinine, as well as other secretions, enzymes and a variety of beneficial microbes like heterotrophic bacteria and fungus (Gopal *et al*., 2010). Furthermore, the composition of the raw materials used to prepare vermicompost affects the quality of vermiwash produced by earthworms (Rai and Bansiwal, 2008). Foliar spray of vermiwash significantly

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increased the crops' growth, yield and quality (Nath and Singh, 2016; Senthilmuruga *et al.,* 2018; Kumar *et al.,* 2021).

Several vermiwash studies have been carried out in horticulture crops and only a few studies are available on food crops. The study's objectives were to analyze the nutrient status, beneficial microbial population and enzymatic activity of the liquid manure and evaluate the effect of liquid manure application on the crop's growth, yield and quality. The study will lend scientific credence to this low-cost approach because the materials for making liquid manure are readily available locally.

MATERIALS AND METHODS

Experiment layout and treatments details

The experiment was carried out at Organic Farm, Rajasthan College of Agriculture, Udaipur, with a latitude/longitude of 24°35′N/73°42′E at an altitude of 582.17 m above mean sea level. The mean weekly meteorological data collected at the Agro Meteorological Observatory in Udaipur during the cropping season shows in Fig 1. The soil of the experimental plot was clay loam having pH 8.1, organic carbon 0.55%, available N, P_2O_5 and K_2O 241.2, 20.9 and 351.3 kg ha^{-1}, respectively. The experiment was laid down in a randomized block design with three replication comprising nine treatments, *i.e.* (T_1= vermiwash from 100% cow dung, T_2 = vermiwash from 100% buffalo dung, T_3= vermiwash from 50% cow dung + 25% dry farm waste + 25% green farm waste, T_4= vermiwash from 50% buffalo dung + 25% dry farm waste + 25% green farm waste, T_5= vermiwash from 90% green waste incubated with 10% cow dung, T_6= vermiwash from 90% green waste incubated with 10% buffalo dung, T_7= vermiwash from 90% dry waste incubated with 10% cow dung and T_8= vermiwash from 90% dry waste incubated with 10% buffalo dung and T_9= control (water spray). The black gram crop (var. PU- 31) was sown in the plot (4.0 m × 3.0 m) by adopting a seed rate of 16 kg ha^{-1} with a spacing of 30 cm × 10 cm and fertilization as a basal dose of 4 tonnes ha^{-1} of vermicompost applied to all the treatments before 15 days of sowing and the rest of was applied through vermiwash liquid manure except control.

Vermiwash unit

Vermicasts were prepared from different organic wastes, *i.e.,* cow dung, buffalo dung, green and dry farm waste, using the earthen pot method. Take an earthen pot of 10-liter capacity and a layer of bricks 2-3 cm was laid in the pot bottom. The pot is filled with organic wastes according to the treatments. Then, 1000 numbers (around 1 kg of earthworm's culture) of *Eisenia foetida* in the vermicompost pot. One more pot filled with water was hung above it so that water came out from the pot into the vermicompost pot drop by drop to keep the surface wet. The third pot was placed below it. The Assembly of these three earthen pots was established in a shady place (Fig 2). After 30-35 days, the liquid vermiwash was collected in the third pot and taken to the lab for chemical analysis. The biochemical analysis of vermiwash was done as per the standard procedure shown in Table 1. Foliar spray of 35 days old vermiwash was applied into two splits- first, at the initiation of flowering and second, at the 15 days interval.

Microbial analysis of vermiwash

The total bacterial count (TBC), total fungal count (TFC) and total actinomycetes count (TAC) were calculated in triplicate using the standard spread-plate dilution method. T.B.C., T.F.C. and T.A.C. were calculated using nutrient agar, potato

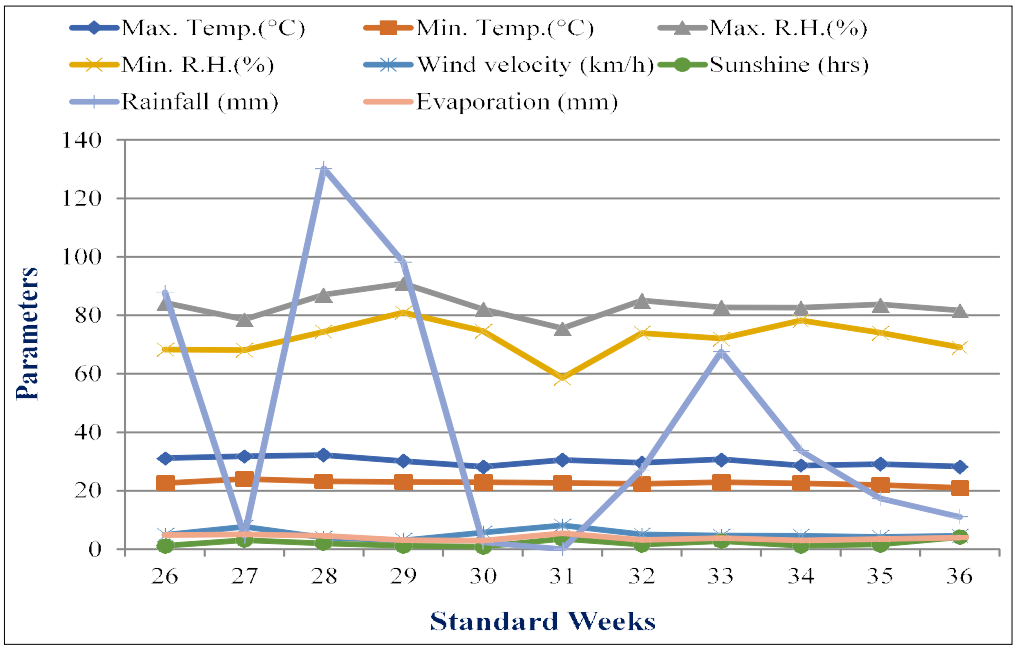

Fig 1: Weekly average of Meteorological data during experimental period during *kharif*, 2018-19.

dextrose and actinomycetes isolation agar media, respectively (Sharma *et al.,* 2021).

Measurement of plant growth parameters, yield and quality analysis

Growth parameters *viz.* root length, nodulation, total chlorophyll, yield and yield attributes and quality content were recorded as per standard procedures/methods (Table 2). Five plants in each plot were selected randomly and labeled for recording observations in all three replications. The most extended root length from the plant's base to the root's tip was measured 45 and 60 days after sowing and in centimeters. At the 50% flowering stage, five plants were uprooted randomly without disturbing their roots and nodules. Then dry and clean the plant's root, a number of the node were separated from the root with the help of forceps and their numbers were recorded. Yield components, namely number of pods plant^{-1}, number of seeds pod^{-1}, test weight and seed yield, were recorded at harvest.

Fig 2: Vermiwash assembly.

Statistical analysis

The data were subjected to statistical analysis of variance as outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Vermiwash biochemical analysis

Data indicate (Table 3) that the neutral to slightly alkaline pH (7.72), E.C. (1.39 dSm^{-1}) and maximum content of nitrogen (0.464%), phosphorus (0.530%) and potassium (0.189%) nutrients were reported in vermiwash treatment T_1 over other treatments. Moreover, high pH and E.C. were recorded in vermiwash treatment T_6 and the lowest N, P and K nutrient content were found in vermiwash treatment T_8. Similar fundings were also reported by Zambare *et al.* (2008); Hatti *et al.* (2010); Gopal *et al.* (2010).

Significant differences in the microbial population and enzyme activity were observed in different vermiwash treatments (Table 4).

Total bacterial counts

Total bacterial counts (T.B.C.) of various vermiwash treatments ranged from 0.54 to 3.07× 10^8 colony forming units (cfu) per milliliter of organic liquid. The highest counts

Table 1: Methods used for vermiwash bio-chemical analysis.

Determination	Reference/method of analysis
pH (1:10 w/v)	Garg *et al.* (2006)
Electrical conductivity	Garg *et al.* (2006)
Nitrogen	Bremmer and Mulvaney procedure (1982)
Phosphorus	Flame photometer method (Jackson, 1973)
Potassium	Flame photometer method (Bansal and Kapoor, 2000)
Phosphatase activity	Tabatabai and Bremner procedure (1969)
Dehydrogenase activity	TTC (2-3-5-Triphenyl tetrazolium chloride) reduction method (Casida *et al.,* 1964)

Table 2: Methods adopted for plant analysis.

Determination	Methods	Reference
Total chlorophyll	Total Chlorophyll (mg g^{-1}) = 20.2 (OD 645) + 8.02 (OD 663) × V/1000 × W Where, OD = Optical density V = Final vol. of 80% acetone (10 ml) W = Wt. of sample taken (0.025 g)	Arnon (1949)
Nitrogen	Colorimetric method	Snell and Snell (1959)
Phosphorus	Vanadomolybdo phosphoric acid yellow colour method	Jackson (1973)
Potassium	Flame photometer method	Jackson (1973)
Protein content in seed	Nitrogen content in seed multiplied by factor 6.25	A.O.A.C. (1975)

were found in vermiwash treatment T_1 (3.07×10^8), while the lowest were found in treatment T_8 (0.54×10^8).

Total fungal counts

Vermiwash treatments had total fungal counts (T.F.C.) ranging from 0.12 to 0.79×10^5 cfu per millilitre of organic liquid. The highest counts were found in vermiwash treatment T_1 (0.79×10^5), while the lowest concentrations were found in T_7 (0.12×10^8).

Total actinomycetes counts

The mean total actinomycetes counts (T.A.C.) of various vermiwash treatments ranged from 0.05- 2.96×10^5 cfu per milliliter of organic liquid. The highest counts were observed in vermiwash treatment T_1 (2.96×10^5) and the lowest counts were observed in T_8 (0.05×10^5).

Enzyme activity

The acid phosphatase activity of vermiwash treatments ranged from 2.93 to 7.55 µg ml^{-1}, alkaline phosphatase activity ranged from 0.74 to 2.54 µg ml^{-1} and dehydrogenase activity from 1.27 to 2.77 µgml^{-1} and these differences were statistically significant. The highest activity of these enzymes in treatment T_1 and the lowest was observed in treatment T_8. In different vermiwash treatments, the kind of input material used, resulting in diverse microbial populations and enzymatic activity that were significantly altered. Similar result was also reported by Sharma *et al.,* 2021. According to Sreenivasa *et al*. (2009), organic liquid manures developed using cow products contain many beneficial bacteria, as well as certain useful actinomycetes and fungus. The vermiwash contains an enzyme cocktail and nitrogen fixing bacteria and some phosphate solubilizing bacteria (Zambare *et al*., 2008).

Table 3: Chemical analysis of vermiwash prepared from different organic wastes.

Treatments symbol	pH	EC (dSm^{-1})	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T1	7.72	1.39	0.464	0.530	0.189
T2	7.79	1.47	0.445	0.522	0.178
T3	7.83	1.53	0.458	0.525	0.184
T4	7.88	1.59	0.439	0.518	0.173
T5	8.43	1.89	0.435	0.517	0.169
T6	8.46	1.92	0.430	0.511	0.167
T7	8.25	1.75	0.425	0.505	0.162
T8	8.29	1.79	0.419	0.502	0.157
S.Em±	0.009	0.011	0.001	0.001	0.001
C.D. (P = 0.05)	0.019	0.023	0.002	0.002	0.001

Growth parameters

All the vermiwash treatments significantly influenced growth parameters (root length, nodulation and total chlorophyll content of black gram over the control. Significantly maximum root length of 17.00 and 22.00 cm was recorded at 45 and 60 days after sowing, with vermiwash treatment (T_1), which was found to be at par with treatments T_3, T_4 and T_2, respectively and recorded an increase of 21.42 and 25.71 per cent root length at 45 and 60 days after sowing respectively, over control (Table 5). Enhanced root growth can be attributed to readily available essential plant nutrients and growth-promoting hormones in vermiwash, responsible for plants' rapid growth and development. Similar results were also obtained by Maya *et al.* (2015).

Similarly, like the growth of root length, no. of nodes per plant (65.50) at 50% flowering stage showed the maximum in number for vermiwash treatment (T_1) with an increase of 18.38 percent over control and at par with treatment T3 while the other vermiwash treatments showed a consistent number of nodes. The vermiwash treatment (T_1) showed the maximum chlorophyll content since nutrients available in vermiwash contributed to healthier plants (Table 5) and recorded an increase of 14.87 percent total chlorophyll of black gram over control. Since chlorophyll pigments synthesis in the plants is directly related to the availability of the physio-chemically active N, P, K, S and Fe nutrients. Hence, the availability of these nutrients to plants helps form chlorophyll in the leaves. Vermiwash application has been proved to promote the root formation, nodulation and chlorophyll content, as observed in many field crops (Varghese and Prabha (2014) and Senthilmuruga *et al.*, 2018).

Yield and yield attributes

Foliar application of treatment (T_1) recorded a significantly higher number of pods $plant^{-1}$ (24.67), seeds pod^{-1}(6), test

Table 4: Microbial populations and enzyme activities in vermiwash prepared from different organic wastes.

Treatments symbol	Total bacterial count $\times10^8$	Total fungal count $\times 10^5$	Total actinomycetes count $\times10^5$	Acid phosphatase (µg/ml)	Alkaline phosphatase (µg/ml)	Dehydrogenase (µg/ml)
T_1	3.07	0.79	2.96	7.55	2.54	2.77
T_2	2.77	0.45	2.76	5.63	1.95	1.87
T_3	2.96	0.75	2.86	6.45	2.11	1.96
T_4	2.15	0.40	2.48	3.91	1.78	1.68
T_5	1.27	0.17	0.45	3.55	1.51	1.66
T_6	1.12	0.23	0.25	3.49	1.37	1.64
T_7	1.03	0.12	0.08	3.34	0.77	1.31
T_8	0.54	0.15	0.05	2.93	0.74	1.27
SEm±	0.043	0.032	0.046	0.097	0.037	0.040
CD (P=0.05)	0.131	0.098	0.140	0.295	0.112	0.120

weight (35.88) and seed yield (800 kg ha^{-1}), which was found to be at par with the treatments T_3, T_2 and T_4, respectively (Fig 3 and 4). The higher yield and yield attributes under treatment (T_1) may be attributed because of the positive impact of increased availability of plant nutrients, enzymes and beneficial microbes in a balanced form, which resulted in higher growth rate, chlorophyll synthesis, photosynthetic efficiency and assimilate partitioning from source to sink that increased yield attributes and help to produce healthy seed. The result was in agreement with the findings of Bhardwaj and Sharma (2016).

Table 5: Effect of vermiwash on root length, number of root nodules per plant and total chlorophyll content of organic black gram.

Treatments symbol	Root length (cm) 45 DAS	60 DAS	Number of root nodules per plant at 50% flowering	Total chlorophyll at 45 DAS (mg g^{-1}fresh weight)
T1	17.0	22.0	65.50	2.78
T2	15.7	19.3	61.50	2.65
T3	16.0	19.5	62.07	2.70
T4	15.3	19.2	61.20	2.62
T5	15.0	18.7	61.20	2.60
T6	14.7	18.5	61.17	2.60
T7	14.3	18.5	61.00	2.56
T8	14.0	18.3	60.83	2.56
T9	14.0	17.5	55.33	2.42
S.Em±	0.58	0.42	1.22	0.03
CD (P = 0.05)	1.8	1.27	3.65	0.10

Nutrients and protein content

Application of vermiwash treatment (T_1) recorded the highest nitrogen (3.58%) and (2.55%), phosphorus (0.45%) and (0.223%) and potassium (1.30%) and (2.16%), content in seed and haulm respectively, with a significant increase of 15.48 and 62.42 per cent nitrogen, 40 and 15.47 percent phosphorus and 9.2 and 3.8 percent potassium in seed and haulm, respectively, over the control (Table 6). This might be because of the use of potential vermiwash, which helped in producing higher biomass and also in better recovery of N, P and K in the plant (Table 3 and 4). Similar effects have also been observed by Trivedi and Bhatt (2006). The maximum protein content (22.38%) was recorded with vermiwash treatment T1 and a significant increase of 15.48 per cent over the control (Table 6). It can be due to

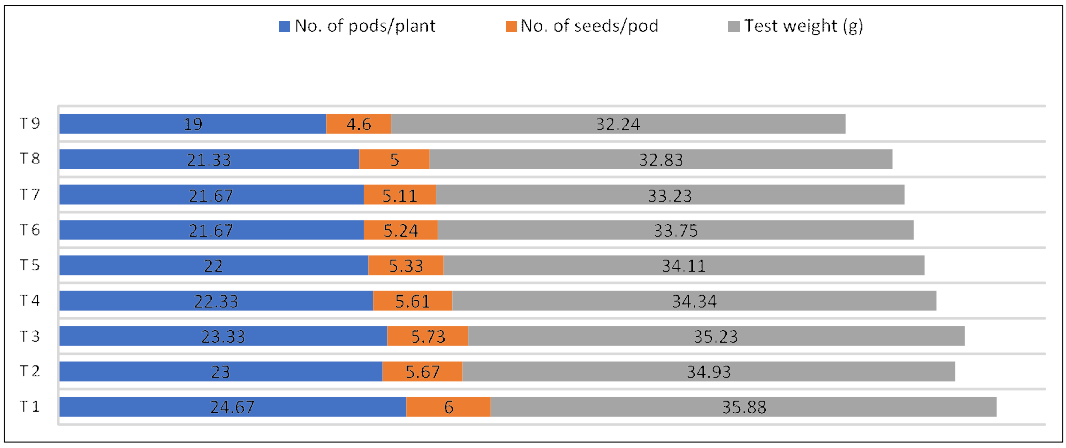

Fig 3: Effect of vermiwash on yield attributes of organic black gram.

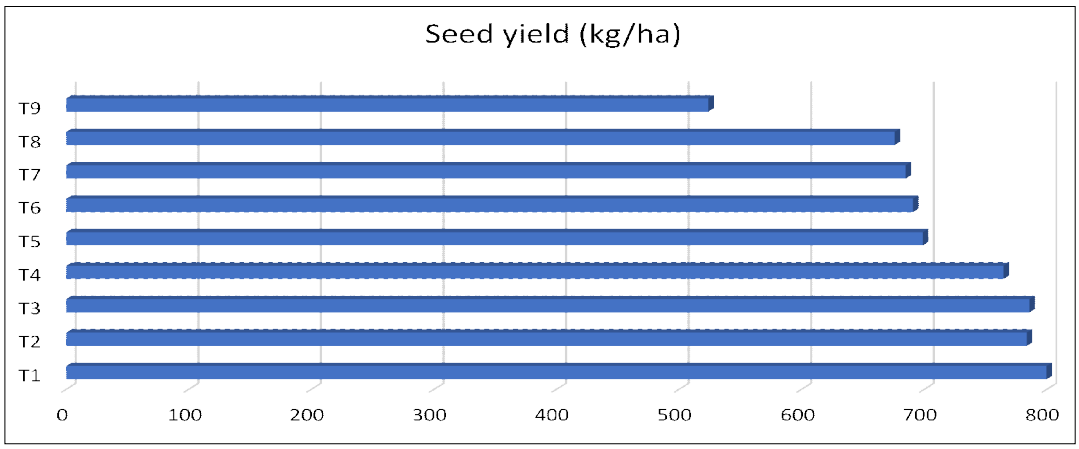

Fig 4: Fffect of vermiwash prepared from different organic wastes on seed yield of organic black gram.

Table 6: Effect of vermiwash on nitrogen, phosphorus, potassium and protein content in seed and haulm of organic black gram.

Treatments symbol	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Protein content in seed (%)
	Seed	Haulm	Seed	Haulm	Seed	Haulm	
T_1	3.58	2.55	0.45	0.223	1.30	2.16	22.38
T_2	3.41	2.44	0.41	0.213	1.28	2.15	21.31
T_3	3.46	2.53	0.43	0.216	1.30	2.15	21.65
T_4	3.39	2.30	0.42	0.211	1.25	2.13	21.17
T_5	3.36	2.26	0.37	0.209	1.26	2.13	20.98
T_6	3.33	2.20	0.35	0.207	1.21	2.08	20.79
T_7	3.34	1.78	0.36	0.208	1.20	2.12	20.88
T_8	3.33	1.86	0.36	0.208	1.25	2.12	20.81
T_9	3.10	1.57	0.32	0.193	1.19	2.08	19.38
S.Em±	0.029	0.115	0.009	0.004	0.009	0.009	0.179
CD (P = 0.05)	0.086	0.348	0.45	0.011	0.029	0.028	0.540

enhanced absorption of nitrogen, which ultimately increases the protein content in seeds. Similarly, Hoffland *et al.* (2000) found that spraying vermiwash considerably changes tissue nitrogen content.

CONCLUSION

Our study indicated that vermiwash is a potential source of plant nutrients, beneficial micro-organisms and enzymes. Vermiwash treatment (T_1) is the best liquid manure showing optimum pH, E.C. and highest nutrient content, microbial count and an increased number of enzymes. Foliar application of vermiwash significantly improved black gram's productivity and quality over the control (water spray). Among the vermiwash treatments, treatment (T_1) showed the highest growth, yield, nutrients and protein content in organic black gram.

conflict of interest: None.

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