

Response of Mothbean to Organic Manure and Bioenhancer Application under Rainfed Conditions

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Abstract— A field experiment was conducted during the kharif season of the year 2021 at Agronomy Instructional Farm, Department of Agronomy, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to study the effect of organic manure and bioenhancer on growth and yield of mothbean under loamy sand soil. The experiment was laid out in a factorial randomized block design with three replications. Total sixteen treatment combinations comprised of four organic manures (castor shell compost @ 0.750 and 1.000 t/ha; FYM @ 4 t/ha and the recommended dose of nitrogen (RDN: 20 kg N ha⁻¹)) and four bioenhancer treatments viz., Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha), panchgavya @ 3% at 50% flowering and 15 days after spray, Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha) + panchgavya @ 3% at 50% flowering and 15 days after spray and water spray. The RDN treatment recorded the highest plant height (40.41 cm), branches plant⁻¹ (13.31), pods plant⁻¹ (41.84), seed yield (743 kg ha⁻¹), gross returns (₹54,490 ha⁻¹), net returns (₹21,554 ha⁻¹) and benefit:cost ratio (1.65), while castor shell compost at 1.0 t ha⁻¹ was generally comparable for several traits. Among bioenhancers, the combined application of Beejamrut + Jeevamrut + Panchgavya produced the highest plant height (40.70 cm), branches plant⁻¹ (13.61), root nodules plant⁻¹ (44.79), pods plant⁻¹ (41.72), seed yield (736 kg ha⁻¹) and stover yield (1244 kg ha⁻¹), while Beejamrut @ 200 ml/kg + soil application of Jeevamrut @ 500 l/ha at 5th week after sowing and panchgavya @ 3% at 50% flowering and 15 days after first spray were generally comparable for several traits. Whereas the interaction between organic manure and bioenhancer was non-significant for the measured growth and yield traits. The findings indicate that mothbean fertilized with 20 kg N/ha OR castor shell compost 1 t/ha along with 40 kg P₂O₅/ha to obtain higher yield and net returns. While in case of bioenhancers seed treatment of Beejamrut @ 200 ml/kg + soil application of Jeevamrut @ 500 l/ha at 5th week after sowing OR panchgavya @ 3% at 50% flowering and 15 days after first spray to obtain higher yield and net returns.

Keywords— Beejamrut, Jeevamrut, Panchgavya, organic manure, mothbean, bioenhancer, seed yield.

I. INTRODUCTION

Mothbean is also known as moth or dew gram. It is an indispensable component of dryland farming system in arid and semi-arid regions because it is the most drought tolerant crop among kharif pulses largely grown predominantly on dryland areas with the least agronomic practices. It contains about 21% easily digestible protein being relatively rich in lysine and tryptophan, the essential amino acids in which cereals are deficient. It offers a variety of edible products such as vegetable and snacks. Mothbean is famous for Bikaneri bhujia and other preparations like dal, kheech, papad and mangori. As a legume, mothbean forms symbiotic associations with *Rhizobium* and contributes to biological nitrogen fixation.

Farmyard manure is a traditional and commonly available organic manure consisting of decomposed cattle dung, urine, bedding material and crop residues. Well-rotted FYM generally contains approximately 0.5-1.5% N, 0.4-0.8% P₂O₅ and 0.5-1.9% K₂O.

Castor shell, a by-product of castor processing can also be composted after proper decomposition and used as an organic nutrient source.

Beejamrut is a seed-treatment preparation made from locally available ingredients including cow dung, cow urine, fresh cow milk and limestone. Jeevamrut is a liquid preparation made from cow dung, cow urine, jaggery, legume flour and a small quantity of living soil; it is used as a microbial bioenhancer. Panchgavya is traditionally prepared from five cow-derived products viz., dung, urine, milk, curd and ghee. Bio-chemical properties of panchgavya reveals that it possesses almost all the nutrients like N, P, K and micronutrients essential for plant nutrition and growth hormones like indole acetic acid and gibberellic acid required for crop growth (Selvaraj et al., 2007).

Although organic manures and bioenhancers are increasingly considered in low-input and sustainable crop production, their relative effects on mothbean growth, yield and economics require location-specific evaluation. Therefore, the present field experiment was conducted to evaluate different organic manure/nutrient treatments and bioenhancer combinations for improving growth, yield attributes, yield and economic returns of mothbean under loamy sand soil.

II. MATERIAL AND METHODS

A field experiment was conducted during *kharif* season of the year 2021 on Plot number C-2 at the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, India. The experimental soil was loamy sand. The experiment comprised 16 treatment combinations arranged in a factorial randomized block design with three replications. The four organic manure/nutrient treatments were castor shell compost @ 0.75 and 1.0 t/ha, FYM @ 4 t/ha and RDN 20 kg N/ha. The four bioenhancer treatments were Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha), panchgavya @ 3% at 50% flowering and 15 days after spray, Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha) + panchgavya @ 3% at 50% flowering and 15 days after spray and water spray. Common application of 40 kg P₂O₅ through SSP in all treatments. Mothbean variety Gujarat Mothbean 2 was used. Growth, root-nodulation, yield and economic parameters were recorded as reported in the experimental dataset. Statistical comparisons were expressed using standard error of mean (S.E.m.±) and critical difference (CD) at P=0.05. The interaction effect of organic manure/nutrient treatment and bioenhancer was assessed within the factorial design.

2.1 Details of the experimental site, treatments, and crop management:

The experimental soil was loamy sand with pH 7.8, electrical conductivity 0.12 dS/m, organic carbon 0.21%, available nitrogen 142 kg/ha, available phosphorus 18.5 kg/ha, and available potassium 168 kg/ha. The experiment was sown on 25 June 2021 with a seed rate of 12 kg/ha at a row spacing of 45 cm and plant-to-plant spacing of 10 cm. Each plot consisted of 6 rows of 3 m length (plot size 2.7 m × 3.0 m). The crop received 325 mm rainfall during the crop season; mean maximum and minimum temperatures were 34.2 °C and 25.6 °C, respectively, and mean relative humidity was 68%.

The organic manure treatments were applied basally at sowing: castor shell compost (0.75 and 1.0 t/ha) and FYM (4 t/ha) were incorporated into the soil two weeks before sowing. The RDN treatment (20 kg N/ha) was applied through urea in two splits (50% basal and 50% at 30 days after sowing). A uniform basal application of 40 kg P₂O₅/ha through single superphosphate (SSP) was made in all plots at sowing.

The bioenhancer treatments were prepared according to standard traditional protocols. Beejamrut was prepared by mixing 5 kg cow dung, 5 L cow urine, 50 g lime, and 1 L water, fermented for 24 hours, and used for seed treatment at 200 ml/kg of seed for 30 minutes before sowing. Jeevamrut was prepared by mixing 10 kg cow dung, 10 L cow urine, 2 kg jaggery, 2 kg legume flour, and 1 kg living soil in 200 L water and fermented for 7 days under shade; it was applied to the soil at 500 l/ha at the 5th week after sowing. Panchgavya was prepared from cow dung (1 kg), cow urine (1 L), cow milk (1 L), curd (1 kg), and ghee (250 g), mixed with 3 L water, fermented for 7 days, and applied as a 3% foliar spray at 50% flowering and 15 days after the first spray using a knapsack sprayer at 500 L spray volume per hectare in the early morning hours (06:00–09:00 h).

Root nodulation was assessed at 45 DAS by carefully uprooting five plants per plot, washing the roots, counting the number of nodules, and recording fresh weight. The nodules were then oven-dried at 65 °C to constant weight for dry weight determination. Growth and yield attributes were recorded at harvest from five randomly selected plants per plot. Seed and stover yields were recorded from the net plot area and converted to kg/ha. Economic analysis was based on prevailing market prices and fixed input costs; hence, economic parameters were computed rather than statistically analyzed.

III. RESULT AND DISCUSSION

3.1 Effect of Organic Manure/Nutrient Treatment

Application of RDN recorded significantly higher plant height at harvest (40.41 cm), number of branches plant⁻¹ (13.31), number of pods plant⁻¹ (41.84) and seed yield (743 kg/ha) which was found at par with castor shell compost @ 1.0 t ha⁻¹. The response may be associated with greater nutrient availability and improved nutrient uptake, supporting photosynthetic activity and translocation of assimilates. This was partially in agreement with Ruheentaj et al. (2020). FYM @ 4 t ha⁻¹ produced the highest number of root nodules plant⁻¹ (45.39) and fresh and dry root-nodule weights (14.63 and 6.05 mg plant⁻¹, respectively) and these values were comparable with castor shell compost @ 1.0 t ha⁻¹. These results were partially in agreement with Joshi et al. (2016) and Desai et al. (2019). The RDN treatment also recorded the highest gross return (₹54,490 ha⁻¹), net return (₹21,554 ha⁻¹) and benefit:cost ratio (1.65).

TABLE 1
EFFECT OF ORGANIC MANURE AND BIOENHANCER ON GROWTH ATTRIBUTES OF MOTHBEAN

Treatment	Plant height (cm)	Number of branches per plant	Number of root nodules per plant at 45 DAS	Fresh weight of root nodules per plant (mg)	Dry weight of root nodules per plant (mg)
Organic manure (O)					
O1: Castor shell compost @ 0.75 t/ha	34.48	11.63	40.33	11.66	5.07
O2: Castor shell compost @ 1.0 t/ha	38.4	12.5	43.5	14.09	5.83
O3: FYM @ 4 t/ha	33.48	10.93	45.39	14.63	6.05
O4: RDN	40.41	13.31	36.82	10.58	4.38
S.Em.±	1.2	0.43	2.2	0.28	0.12
C.D. (P=0.05)	3.47	1.25	6.35	0.82	0.35
Bioenhancer (B)					
B1: Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha at 5th week after sowing)	35.39	11.29	40.69	12.03	5.26
B2: Panchgavya @ 3% at 50% flowering and 15 days after first spray	37.9	12.84	44.08	13.7	5.42
B3: B1 + B2	40.7	13.61	44.79	14.21	5.72
B4: Water spray	32.78	10.64	36.49	11.02	4.94
S.Em.±	1.2	0.43	2.2	0.28	0.12
C.D. (P=0.05)	3.47	1.25	6.35	0.82	0.35
Interaction (O × B)					
S.Em.±	2.4	0.86	4.4	0.57	0.24
C.D. (P=0.05)	NS	NS	NS	NS	NS
C.V.%	11.33	12.39	18.35	7.75	7.94

3.2 Effect of Bioenhancer

The combined application of Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha at 5th week after sowing) + panchgavya @ 3% at 50% flowering and 15 days after first spray recorded significantly higher plant height at harvest (40.70 cm), number of branches plant⁻¹ (13.61), number of root nodules plant⁻¹ (44.79) and fresh and dry weight of root nodules plant⁻¹ (14.21 and 5.72 mg respectively) which was found at par with panchgavya @ 3% at 50% flowering and 15 days after first spray. While application of Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha at 5th week after sowing) + panchgavya @ 3% at 50% flowering and 15 days after first spray recorded significantly higher number of pods per plant (41.72), seed yield (736 kg/ha) and stover yield (1244 kg/ha) which was found at par with application of panchgavya @ 3% at 50% flowering and 15 days after first spray and application of Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha at 5th week after sowing). The increase in plant height might be due to application of panchgavya and Jeevamrut attributed to increase in the availability of cytokinin to shoot which in turn played a role in cell elongation process either through cell division or cell elongation. Foliar spray of panchgavya enhanced the growth rate of plant since it contains the favourable macro and micro-nutrients, growth hormones and microbes in liquid formulation and Jeevamrut is one of the bioenhancer which consists of huge amount of beneficial effective microbes to enhance the availability of nutrients towards rhizosphere. Similar results were reported by Kumar et al. (2011), Desai et al. (2014) and Panchal et al. (2017). Panchgavya @ 3% at 50% flowering and 15 days after first spray gave highest net realization (₹15,776 ha⁻¹). Similar results were reported by Chaudhary et al. (2023).

TABLE 2
EFFECT OF ORGANIC MANURE AND BIOENHANCER ON YIELD AND YIELD ATTRIBUTES OF MOTHBEAN

Treatment	Number of pods per plant	Number of seeds per pod	Pod length (cm)	Seed index (g)
Organic manure (O)				
O1: Castor shell compost @ 0.75 t/ha	36.67	5.34	3.57	4.41
O2: Castor shell compost @ 1.0 t/ha	41.2	5.67	3.58	4.48
O3: FYM @ 4 t/ha	35.64	5.22	3.53	4.37
O4: RDN	41.84	5.79	3.59	4.56
S.Em.±	1.64	0.25	0.07	0.13
C.D. (P=0.05)	4.75	NS	NS	NS
Bioenhancer (B)				
B1: Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha at 5th week after sowing)	37.66	5.14	3.56	4.45
B2: Panchgavya @ 3% at 50% flowering and 15 days after first spray	40.51	5.75	3.59	4.55
B3: B1 + B2	41.72	5.98	3.6	4.57
B4: Water spray	35.48	5.14	3.53	4.25
S.Em.±	1.64	0.25	0.07	0.13
C.D. (P=0.05)	4.75	NS	NS	NS
Interaction (O × B)				
S.Em.±	3.29	0.5	0.14	0.26
C.D. (P=0.05)	NS	NS	NS	NS
C.V.%	14.67	15.74	7.24	10.15

TABLE 3
EFFECT OF ORGANIC MANURE AND BIOENHANCER ON SEED AND STOVER YIELD AND ECONOMICS OF
MOTHBEAN

Treatment	Yield (kg/ha)		Gross returns (₹/ha)	Total cost of cultivation (₹/ha)	Net returns (₹/ha)	BCR
	Seed	Stover				
Organic manure (O)						
O1: Castor shell compost @ 0.75 t/ha	673	1157	49424	35167	14257	1.41
O2: Castor shell compost @ 1.0 t/ha	696	1208	51136	35827	15309	1.43
O3: FYM @ 4 t/ha	653	1048	47806	40237	7569	1.19
O4: RDN	743	1240	54490	32936	21554	1.65
S.E.m.±	23	47	—	—	—	—
C.D. (P=0.05)	65	135	—	—	—	—
Bioenhancer (B)						
B1: Beejamrut (seed treatment @ 200 ml/kg) + Jeevamrut (soil application @ 500 l/ha at 5th week after sowing)	673	1158	49426	35186	14240	1.4
B2: Panchgavya @ 3% at 50% flowering and 15 days after first spray	712	1195	52230	36454	15776	1.43
B3: B1 + B2	736	1244	54008	40124	13884	1.35
B4: Water spray	644	1056	47192	32403	14789	1.46
S.E.m.±	23	47	—	—	—	—
C.D. (P=0.05)	65	135	—	—	—	—
Interaction (O × B)						
S.E.m.±	45	93	—	—	—	—
C.D. (P=0.05)	NS	NS	—	—	—	—
C.V.%	11.32	13.9	—	—	—	—

3.3 Interaction Effect

Interaction effect between organic manure and bioenhancer was non-significant on growth and yield attributes and yield. The non-significant interaction suggests that the effects of organic manure and bioenhancer treatments were largely independent of each other, and that the response to bioenhancers did not vary significantly with the type of organic manure applied. This has a practical implication: growers can select the most suitable organic manure and bioenhancer combinations based on availability and cost, without concern for negative interactions.

Note on the B:C ratio anomaly: Although B4 (water spray) recorded the highest B:C ratio (1.46) among bioenhancer treatments in Table 3, this is attributable to its lower total cost of cultivation rather than to a yield advantage. The absolute net returns were lower for B4 (₹14,789 ha⁻¹) compared to B2 (Panchgavya alone, ₹15,776 ha⁻¹), which recorded the highest net returns among bioenhancer treatments. Therefore, for growers prioritizing higher net returns, B2 (Panchgavya) is recommended; for those prioritizing cost efficiency under resource constraints, B4 (water spray) may have a role. The B:C ratio should be interpreted alongside net returns rather than in isolation.

IV. CONCLUSION

Based on results of the field experiment, it is concluded that mothbean fertilized with 20 kg N/ha OR castor shell compost @ 1 t/ha to obtain higher yield and net returns. While in case of bioenhancers, seed treatment of Beejamrut @ 200 ml/kg + soil application of Jeevamrut @ 500 l/ha at 5th week after sowing OR panchgavya @ 3% at 50% flowering and 15 days after first

spray to obtain higher yield and net returns. Although water spray recorded the highest B:C ratio due to lower input costs, the highest net returns were obtained with Panchgavya alone. The interaction between organic manure and bioenhancer was non-significant, indicating that these treatments can be selected independently.

Limitations of the Study: The experiment was conducted in a single *kharif* season at a single location, so results may vary with rainfall distribution, soil type, and season. The long-term effects of organic manures and bioenhancers on soil health and productivity were not evaluated. Economic analysis was based on prevailing market prices at the time of the study, which may change over time. Future research should include multi-season and multi-location trials, soil health monitoring, and long-term sustainability assessment.

Future Research Directions: Priority research should include: (1) multi-season and multi-location validation of the present findings; (2) evaluation of residual effects on succeeding crops; (3) monitoring of soil biological and chemical properties under continued organic manure and bioenhancer application; (4) standardization and quality control of bioenhancer preparations; and (5) assessment of the compatibility of bioenhancers with integrated nutrient management programmes.

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CONFLICT OF INTEREST

The authors declare that they have no financial or personal relationship with other people or organizations that could inappropriately influence or bias the work submitted in this manuscript. There is no conflict of interest regarding the publication of this research article.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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