

Seed Priming Methods and Integrated Nutrient Sources Influence Growth, Yield, Nutrient Uptake and Profitability of Summer Mungbean (*Vigna radiata* L.) in Punjab

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Abstract
Summer mungbean grown between the wheat harvest and rice transplanting in north-western India establishes in hot, drying soil, and its yield depends on rapid establishment and an adequate nutrient supply. A field experiment was conducted in the spring–summer season of 2025 at DAV University, Jalandhar, Punjab, in a randomized block design with three replications to evaluate hydropriming, biopriming with *Rhizobium* and hormonal priming with GA_3 (50 and 100 ppm), combined with the recommended dose of fertilizer (RDF, 12.50 kg N and 40.00 kg P_2O_5 ha^{-1}) and farmyard manure (FYM, 10 t ha^{-1}), vermicompost (5 t ha^{-1}) or both, against an untreated control. Biopriming + RDF + vermicompost + FYM produced the tallest plants, the highest leaf area index, dry matter, nodulation (39.38 nodules $plant^{-1}$) and seed yield (1365.33 kg ha^{-1}, 42.4% above the control), and the highest N, P and K uptake; its yield was statistically at par with biopriming + RDF + vermicompost, GA_3 50 ppm + RDF + vermicompost and biopriming + RDF + FYM. Biopriming and 50 ppm GA_3 were generally superior to hydropriming and 100 ppm GA_3, respectively, whereas seed protein content was unaffected. Because of the high cost of vermicompost, biopriming + RDF + FYM gave the highest net returns (Rs. 47,946 ha^{-1}). Biopriming with *Rhizobium* combined with RDF and FYM is suggested as a productive and low-cost practice for summer mungbean.

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1. Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] is a short-duration grain legume grown on more than 7 million hectares, mainly in Asia, and its seed contains about 24% easily digestible protein [1]. India is the leading mungbean-growing country; in 2021-22 the country harvested 31.5 lakh tonnes of mungbean from 40.38 lakh hectares, with a mean productivity of only about 780 kg ha^{-1} [2], and production in 2024-25 was estimated at 38.19 lakh tonnes [3]. In the irrigated rice–wheat system of Punjab, summer mungbean can be grown in the window between the wheat harvest and rice transplanting [4]. The crop gives an additional income and, through biological nitrogen fixation, leaves a residual benefit for the following crop, but its yield is often limited by poor and uneven establishment in hot, drying soil and by an inadequate supply of nutrients during the short growing period.

In seed priming, seed is hydrated under controlled conditions before sowing so that the early metabolic events of germination, including DNA repair and antioxidant activity, to proceed without radicle emergence [5]. Primed seed emerges faster and more uniformly, and the technique has been shown to improve stand establishment and yield in many field crops [6]. On-farm hydropriming of mungbean increased grain yield in most trials in Pakistan [7, 8], and biopriming with *Rhizobium* and hormonal priming with gibberellic acid (GA_3) have improved seed vigour, growth and yield of mungbean and related legumes [9, 10, 11]. Gibberellins promote germination and stem elongation, but their effect is strongly concentration-dependent [12], so the optimum dose for seed priming needs to be established.

Integrated nutrient management (INM) pairs mineral fertilizer, which feeds the crop quickly, with organic manures that release nutrients over a longer period and build up soil organic carbon and microbial activity [13]. Vermicompost and FYM applied with fertilizer have increased the growth, yield and nutrient uptake of mungbean and greengram [14, 15, 16, 17], but the cost of vermicompost can offset the yield gain [18]. Seed priming acts on establishment and early growth, whereas INM governs the nutrient supply to the growing crop; combining the two may therefore improve productivity more than either alone. Information on how different priming methods interact with organic nutrient sources, and on the economics of such combinations in summer mungbean, is limited. The present study was therefore undertaken to evaluate the effect of hydropriming, biopriming and hormonal priming in combination with RDF and organic manures on the growth, yield, nutrient uptake, soil fertility and economics of summer mungbean.

2. Materials and Methods

2.1. Experimental Site, Soil and Weather

The field experiment was conducted during the spring–summer season of 2025 at the Research Farm, Department of Agronomy, DAV University, Jalandhar, Punjab (31.42°N, 75.62°E; 228 m above mean sea level). The soil (0-15 cm) was a sandy loam (sand 64.67%, silt 20.23%, clay 15.10%), neutral in reaction (pH 7.42; 1:2.5 soil:water), non-saline (EC 0.34 dS m^{-1}), with 5.20 g kg^{-1} organic carbon [19], 248.64 kg ha^{-1} available N [20], 17.28 kg ha^{-1} available P [21] and 178.67 kg ha^{-1} available K [22]. During the crop season (standard meteorological weeks 13-28) weekly mean maximum temperature increased from 31.2°C to a peak of 41.5°C and stayed at 40°C or higher for five successive weeks in May-June; a total of 231.5 mm of rain was received, about 65% of it in the last four weeks.

2.2. Treatments and Crop Management

The experiment was laid out in a randomized block design with three replications and eight treatments: T_1, control (no priming, fertilizer or manure); T_2, hydropriming + RDF + FYM @ 10 t ha^{-1}; T_3, hydropriming + RDF + vermicompost @ 5 t ha^{-1}; T_4, biopriming (*Rhizobium* @ 200 g $acre^{-1}$) + RDF + FYM @ 10 t ha^{-1}; T_5, biopriming + RDF + vermicompost @ 5 t ha^{-1}; T_6, hormonal priming (GA_3 @ 50 ppm) + RDF + vermicompost @ 5 t ha^{-1}; T_7, hormonal priming (GA_3 @ 100 ppm) + RDF + vermicompost @ 5 t ha^{-1}; and T_8, biopriming + RDF + vermicompost @ 5 t ha^{-1} + FYM @ 10 t ha^{-1}. RDF (12.50 kg N and 40.00 kg P_2O_5 ha^{-1}) was applied as a basal dose through urea and single super phosphate. FYM was incorporated at final land preparation and vermicompost just before sowing. For hydropriming and hormonal priming, seed was soaked in water or GA_3 solution for 10 h, and for biopriming it was treated with *Rhizobium* culture; primed seed was dried in shade before sowing. The gross and net plot sizes were 3.0 m × 2.4 m and 1.8 m × 1.4 m, respectively.

The variety SML 1827 was sown on 28 March 2025 using 30 kg seed ha^{-1}, with 30 cm between rows; plants were thinned to 10 cm apart within rows. Seed was dressed with carbendazim 12% + mancozeb 63% WP @ 2.5 g kg^{-1}. Weeds were controlled with pre-emergence pendimethalin 30% EC @ 1.0 kg a.i. ha^{-1} followed by hand weeding at 20 an0d 40 days after sowing (DAS). Three irrigations were given, at branching, pod formation and seed filling. The crop was harvested on 12 July 2025.

2.3. Observations

Plant height, number of functional leaves and leaf area index (LAI) were recorded on five tagged plants per plot at 15-day intervals from 15 DAS to harvest; leaf area was estimated as leaf length × leaf breadth × number of functional leaves × 0.7435, and LAI as the ratio of leaf area to the ground area occupied by the plants. For dry matter, five plants per plot were sampled at the same intervals, dried at 60 ± 5°C to constant weight and expressed in g $plant^{-1}$. Crop growth rate (CGR, g m^{-2} day^{-1}) was calculated as $(W_2 - W_1)/[A(t_2 - t_1)]$ [23], where W_1 and W_2 are the dry weights per plant at times t_1 and t_2 and A is the land area per plant (0.03 m^2), and relative growth rate (RGR, g g^{-1} day^{-1}) as $(\ln W_2 - \ln W_1)/(t_2 - t_1)$ [24]. Root nodules were counted on five plants per plot at 45 DAS. Branches, pods per plant, seeds per pod, pod length and 100-seed weight were recorded at harvest, and seed and stover yields were determined from the net plot. Harvest index was calculated as the percentage of seed yield in biological yield [25].

Nitrogen in seed and stover was determined by the micro-Kjeldahl method [22], phosphorus by the vanadomolybdophosphoric yellow colour method and potassium by flame photometry in a di-acid digest [26]. Nutrient uptake was calculated as nutrient content × dry yield, and crude protein as seed N (%) × 6.25 [27]. Soil samples taken from each plot after harvest were analysed for pH, EC, organic carbon and available N, P and K by the methods used for the initial sample. The cost of cultivation was worked out from prevailing input and labour rates in 2025; gross returns were calculated at a seed price of Rs. 87.68 kg^{-1}, net returns as gross returns minus the cost of cultivation, and the benefit: cost (B:C) ratio as net returns divided by the cost of cultivation.

2.4. Statistical Analysis

The data were analysed by ANOVA appropriate to a randomized block design, and means were separated by the critical difference (CD) at the 5% level of probability [28].

3. Results

3.1. Growth and Nodulation

All growth characters were significantly influenced by the treatments (Table 1). At harvest, T_8 produced the tallest plants (103.03 cm), statistically at par with T_6 (97.62 cm), and the control the shortest (60.21 cm). Leaf area index reached its maximum at 60 DAS in all treatments; at this stage T_8 recorded the highest LAI (4.10), at par with T_6 (3.77) and T_5 (3.72), against 2.35 in the control. Dry matter accumulation increased up to 90 DAS (Fig. 1), and at harvest it was highest in T_8 (47.49 g $plant^{-1}$), at par with T_5 and T_6. T_8 also produced significantly more branches (10.62 $plant^{-1}$) than every other treatment and the most nodules at 45 DAS (39.38 $plant^{-1}$), 106.8% more than the control. Biopriming produced significantly taller plants and higher LAI than hydropriming with both manures, and GA_3 at 50 ppm was superior to 100 ppm for plant height, LAI, dry matter and branching; T_7 performed no better than the hydroprimed treatments.

Table 1: Growth and nodulation of summer mungbean under different seed priming methods and nutrient sources.

Treatment	Plant height at harvest (cm)	LAI at 60 DAS	Dry matter at harvest (g plant^{-1})	Branches plant^{-1}	Nodules plant^{-1} (45 DAS)
T_1 Control	60.21	2.35	33.12	5.88	19.04
T_2 HP + RDF + FYM	67.49	2.82	36.42	6.81	22.79
T_3 HP + RDF + VC	76.70	2.82	36.14	6.76	25.72
T_4 BP + RDF + FYM	84.77	3.40	40.97	7.66	29.27
T_5 BP + RDF + VC	95.16	3.72	43.73	9.11	32.55
T_6 GA_3 50 + RDF + VC	97.62	3.77	43.58	8.93	34.72
T_7 GA_3 100 + RDF + VC	79.81	2.96	36.99	6.73	27.31
T_8 BP + RDF + VC + FYM	103.03	4.10	47.49	10.62	39.38
SEm (±)	1.96	0.13	1.82	0.44	2.73
CD (P=0.05)	5.93	0.38	5.51	1.33	8.27

Note: HP, hydropriming; BP, biopriming with *Rhizobium*; GA_3 50/100, hormonal priming with GA_3 at 50/100 ppm; RDF, 12.50 kg N + 40.00 kg P_2O_5 ha^{-1}; FYM, farmyard manure @ 10 t ha^{-1}; VC, vermicompost @ 5 t ha^{-1}; NS, non-significant.

Crop growth rate peaked between 30 and 60 DAS and fell afterwards (Table 2). Treatment differences in CGR were significant only during 15-30 and 30-45 DAS; in the latter interval, CGR in T_8 (27.16 g m^{-2} day^{-1}) was at par with T_6 (24.67) and T_5 (24.53) and about twice that of the control (13.22). Biopriming increased CGR during 30-45 DAS over hydropriming by 34.9% with FYM and 48.8% with vermicompost. RGR declined steadily with crop age and was not significantly affected by the treatments in any interval.

Table 2: Crop growth rate (CGR) and relative growth rate (RGR) of summer mungbean as influenced by seed priming and nutrient sources.

Treatment	CGR 15-30 DAS (g m^{-2} day^{-1})	CGR 30-45 DAS	CGR 45-60 DAS	RGR 15-30 DAS (g g^{-1} day^{-1})	RGR 30-45 DAS
T_1 Control	6.80	13.22	18.49	0.064	0.052
T_2 HP + RDF + FYM	7.58	15.93	21.62	0.063	0.056
T_3 HP + RDF + VC	7.51	16.49	21.76	0.063	0.056
T_4 BP + RDF + FYM	9.39	21.49	23.20	0.068	0.060
T_5 BP + RDF + VC	10.49	24.53	24.76	0.069	0.061
T_6 GA_3 50 + RDF + VC	10.38	24.67	25.47	0.069	0.062
T_7 GA_3 100 + RDF + VC	8.07	17.33	21.27	0.065	0.057
T_8 BP + RDF + VC + FYM	11.66	27.16	27.40	0.071	0.062
SEm (±)	0.80	1.60	3.33	0.006	0.005
CD (P=0.05)	2.42	4.85	NS	NS	NS

Note: HP, hydropriming; BP, biopriming with *Rhizobium*; GA_3 50/100, hormonal priming with GA_3 at 50/100 ppm; RDF, 12.50 kg N + 40.00 kg P_2O_5 ha^{-1}; FYM, farmyard manure @ 10 t ha^{-1}; VC, vermicompost @ 5 t ha^{-1}; NS, non-significant.

3.2. Yield Attributes and Yield

Yield attributes and yields differed significantly among treatments (Table 3). T_8 recorded the most pods (31.03 plant^{-1}) and seeds per pod (13.90), both at par with T_5 and T_6, the longest pods (10.20 cm) and a significantly higher seed index (5.00 g) than all other treatments. The highest seed yield (1365.33 kg ha^{-1}) was obtained with T_8, which was statistically at par with T_5 (1356.62 kg ha^{-1}), T_6 (1315.85 kg ha^{-1}) and T_4 (1241.56 kg ha^{-1}); the control yielded 958.89 kg ha^{-1}. Seed yield was 42.4%, 41.5% and 37.2% higher in T_8, T_5 and T_6, respectively, than in the control. With vermicompost, biopriming increased seed yield by 23.6% over hydropriming (significant), and GA_3 at 50 ppm out-yielded 100 ppm by 19.2%. The kind of manure had little effect on seed yield, and adding FYM to vermicompost under biopriming (T_8 vs T_5) increased it by only 0.6%. Stover yield followed the same trend, whereas harvest index varied within a narrow range (33.87-35.94%).

3.3. Nutrient Uptake, Seed Protein and Soil Fertility

Total uptake of N (62.38-90.50 kg ha^{-1}), P (12.68-20.20 kg ha^{-1}) and K (58.70-80.45 kg ha^{-1}) was significantly influenced by the treatments and was highest in T_8, which was at par with T_6 and T_5 (Table 4). Since the treatments did not alter the N, P and K concentrations of seed or stover, the higher uptake simply reflected higher yields. Seed protein content ranged from 20.48 to 22.67% and was not significantly affected. After harvest, organic carbon (7.00 g kg^{-1}) and available N (335.86 kg ha^{-1}), P (27.60 kg ha^{-1}) and K (257.34 kg ha^{-1}) were highest in T_8, at par with T_6, and all treatments maintained available N, P and K above the initial status.

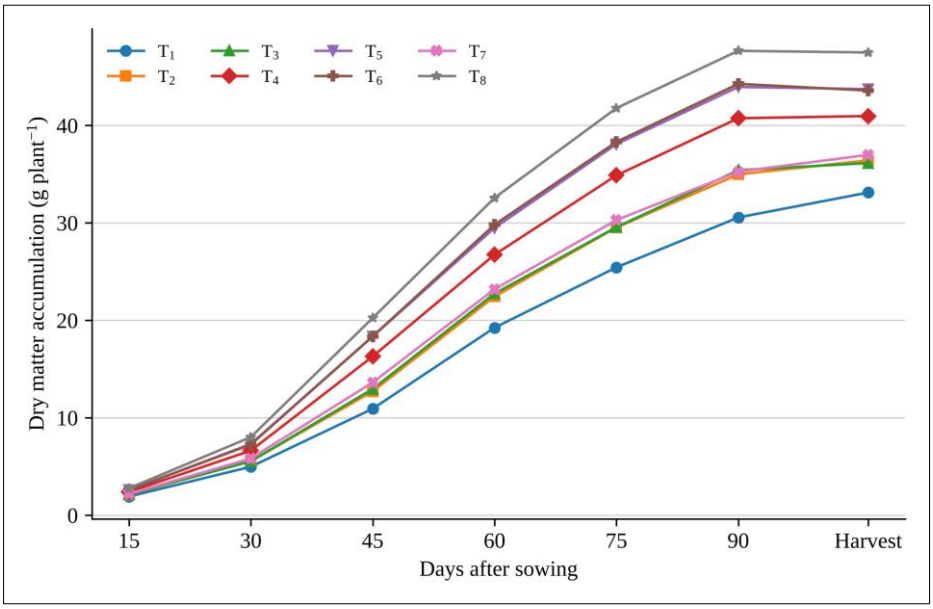

Fig 1: Dry matter accumulation of summer mungbean as influenced by seed priming methods and nutrient sources (treatments as in Table 1).

Table 3: Yield attributes and yield of summer mungbean under different seed priming methods and nutrient sources.

Treatment	Pods plant^{-1}	Seeds pod^{-1}	Pod length (cm)	Seed index (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1 Control	16.00	8.90	7.13	3.83	958.89	1871.52	33.87
T_2 HP + RDF + FYM	19.03	9.67	7.60	4.00	1085.59	2022.09	34.93
T_3 HP + RDF + VC	20.97	10.67	8.13	4.13	1098.01	2013.64	35.29
T_4 BP + RDF + FYM	24.13	11.47	8.67	4.37	1241.56	2258.44	35.48
T_5 BP + RDF + VC	26.60	12.33	9.13	4.53	1356.62	2418.22	35.94
T_6 GA_3 50 + RDF + VC	27.80	12.93	9.57	4.63	1315.85	2431.73	35.11
T_7 GA_3 100 + RDF + VC	19.97	10.33	8.41	4.17	1104.32	2064.98	34.85
T_8 BP + RDF + VC + FYM	31.03	13.90	10.20	5.00	1365.33	2604.83	34.39
SEm (±)	1.89	0.56	0.30	0.10	53.63	98.41	0.06
CD (P=0.05)	5.72	1.70	0.91	0.32	162.65	298.50	0.20

Note: HP, hydropriming; BP, biopriming with *Rhizobium*; GA_3 50/100, hormonal priming with GA_3 at 50/100 ppm; RDF, 12.50 kg N + 40.00 kg P_2O_5 ha^{-1}; FYM, farmyard manure @ 10 t ha^{-1}; VC, vermicompost @ 5 t ha^{-1}; NS, non-significant.

Table 4: Response of total nutrient uptake (kg ha^{-1}), seed protein and soil fertility after harvest (OC, organic carbon; available N, P and K in kg ha^{-1}) of summer mungbean to seed priming methods and nutrient sources.

Treatment	N uptake	P uptake	K uptake	Seed protein (%)	OC (g kg^{-1})	Avail. N	Avail. P	Avail. K
T_1 Control	62.38	12.68	58.70	22.03	5.27	279.30	18.68	199.01
T_2 HP + RDF + FYM	67.14	13.35	63.77	21.13	5.73	286.28	19.77	206.10
T_3 HP + RDF + VC	70.87	14.63	67.92	20.76	6.00	293.26	20.56	212.91
T_4 BP + RDF + FYM	75.92	16.52	71.87	20.84	6.30	306.68	22.72	226.06
T_5 BP + RDF + VC	81.48	17.73	74.01	20.48	6.50	319.17	24.84	239.18
T_6 GA_3 50 + RDF + VC	85.52	18.59	74.88	22.41	6.70	331.69	26.38	251.06
T_7 GA_3 100 + RDF + VC	72.72	15.65	69.18	22.67	6.40	300.45	21.95	220.63
T_8 BP + RDF + VC + FYM	90.50	20.20	80.45	21.94	7.00	335.86	27.60	257.34
SEm (±)	4.29	0.98	3.53	1.97	0.27	9.11	0.76	6.52
CD (P=0.05)	13.01	2.97	10.71	NS	0.81	27.64	2.32	19.78

Note: HP, hydropriming; BP, biopriming with *Rhizobium*; GA_3 50/100, hormonal priming with GA_3 at 50/100 ppm; RDF, 12.50 kg N + 40.00 kg P_2O_5 ha^{-1}; FYM, farmyard manure @ 10 t ha^{-1}; VC, vermicompost @ 5 t ha^{-1}; NS, non-significant.

3.4. Economics

The cost of cultivation ranged from Rs. 40,792 ha^{-1} in the control to Rs. 1,00,914 ha^{-1} in T_8; the organic manures accounted for nearly all of this difference, vermicompost (Rs. 40,000 ha^{-1}) costing much more than FYM (Rs. 15,000 ha^{-1}), while priming cost no more than Rs. 16.50-180 ha^{-1} (Table 5). Gross returns followed seed yield and were highest in T_8. Net returns were highest in T_4 (Rs. 47,946 ha^{-1}), at par with the control and T_2, while the vermicompost-based treatments earned Rs. 10,540-33,035 ha^{-1}. Among the treated plots, T_4 also gave the highest B:C ratio (0.79) (Fig. 2).

Table 5: Economics of summer mungbean under different seed priming methods and nutrient sources.

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 Control	40792.00	84075.48	43283.48	1.06
T_2 HP + RDF + FYM	60733.79	95184.53	34450.74	0.57
T_3 HP + RDF + VC	85733.79	96273.52	10539.73	0.12
T_4 BP + RDF + FYM	60913.79	108859.98	47946.19	0.79
T_5 BP + RDF + VC	85913.79	118948.44	33034.65	0.38
T_6 GA_3 50 + RDF + VC	85750.29	115373.73	29623.44	0.35
T_7 GA_3 100 + RDF + VC	85766.79	96826.78	11059.99	0.13
T_8 BP + RDF + VC + FYM	100913.79	119712.13	18798.34	0.19
SEm (±)	-	4701.85	4701.85	0.08
CD (P=0.05)	-	14261.57	14261.57	0.23

Note: HP, hydropriming; BP, biopriming with *Rhizobium*; GA_3 50/100, hormonal priming with GA_3 at 50/100 ppm; RDF, 12.50 kg N + 40.00 kg P_2O_5 ha^{-1}; FYM, farmyard manure @ 10 t ha^{-1}; VC, vermicompost @ 5 t ha^{-1}; NS, non-significant. B:C ratio = net returns/cost of cultivation. Seed price Rs. 87.68 kg^{-1}. SEm and CD for cost of cultivation not applicable.

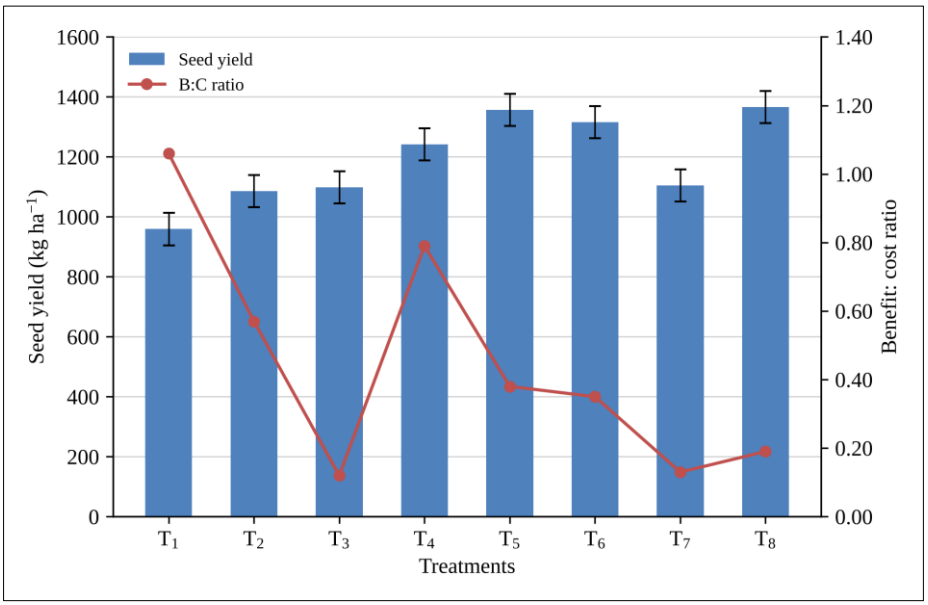

Fig 2: Seed yield (bars; error bars show SEm ±) and benefit: cost ratio (line) of summer mungbean under different seed priming methods and nutrient sources.

4. Discussion

The treatments differed most in the early part of the season: CGR and LAI separated the treatments clearly up to 45-60 DAS, and the advantage gained then was carried through to dry matter, yield attributes and yield. This pattern is consistent with the main mode of action of seed priming, which advances germination and early seedling growth [5, 6], so that primed crops establish their canopy sooner. Under the hot, dry conditions of the present season, when maximum temperatures exceeded 40°C for five weeks, rapid early growth would have been particularly valuable, since high temperature during flowering and pod set reduces pod and seed formation in mungbean [29]. Irrigation at seed filling, together with the onset of rain from late June, ensured adequate moisture during pod filling, which is critical for summer mungbean in Punjab [30].

Biopriming with *Rhizobium* was consistently superior to hydropriming. Coating the seed with an effective *Rhizobium* strain places a large population of bacteria at the site of root emergence, which, in this study, increased nodule number by 26.6-28.5% over hydropriming (within the CD) and significantly improved early growth, LAI and pod characters. Similar effects of *Rhizobium* biopriming on seedling vigour and of *Rhizobium* coating on nodulation, growth and yield have been reported in greengram and blackgram [9, 10], and *Rhizobium* inoculation with organic and inorganic nutrition improved mungbean productivity and soil health [31]. Although nodulation was highest in T_8, the addition of RDF nitrogen did not appear to suppress it, possibly because the starter dose (12.50 kg N ha^{-1}) was small compared with the quantities known to inhibit nodule formation [32].

Priming with 50 ppm GA_3 was significantly better than 100 ppm for nearly all growth and yield characters, and T_7 did not differ from the hydroprimed treatments. Gibberellin responses are strongly concentration-dependent, and supra-optimal doses can cause excessive elongation or fail to improve growth [12]. In mungbean, GA_3 priming at 100 ppm increased seed yield by 39.7% under semi-arid conditions [11], while foliar GA_3 at 45 ppm increased the number of pods per plant by 36.26% under a hot arid climate [33], indicating that the optimum dose varies with the method of application and the environment. Under the hot conditions of the present study, 50 ppm appears to be closer to the optimum for seed priming than 100 ppm.

Vermicompost and FYM supplied nutrients and organic matter in addition to RDF, and post-harvest organic carbon and available N, P and K were higher in all manured plots than in the control, in agreement with earlier reports [13, 14, 34]. However, the kind of manure had a much smaller effect on yield than the priming method, and combining FYM with vermicompost (T_8) gave little additional seed yield over vermicompost alone (T_5). Because nutrient contents of seed

and stover were unaffected, the higher uptake under T_8, T_5 and T_6 reflected higher dry matter production, as also observed by Sasmal *et al.* [17]. Seed protein content was not changed by the treatments, so protein yield per hectare increased in proportion to seed yield.

Higher yield did not translate into higher profit. Vermicompost at 5 t ha^{-1} raised the cost of cultivation by about Rs. 40,000 ha^{-1}, which exceeded the value of the extra seed it produced, so all vermicompost-based treatments had lower net returns than the FYM-based treatments. A similar reduction in profitability when a large share of nutrients was supplied through vermicompost was reported in greengram by Banotra *et al.* [18]. Biopriming with RDF and FYM (T_4) combined a yield statistically at par with the best treatment with the lowest cost among the manured treatments, and therefore gave the highest net returns. The control also had a relatively high B:C ratio because of its very low cost, but its yield was 23% lower than that of T_4, and continuous cropping without nutrient inputs would deplete soil fertility. As the results are from a single season, they should be confirmed over more seasons and locations.

5. Conclusion

Biopriming of summer mungbean seed with *Rhizobium* and hormonal priming with 50 ppm GA_3, combined with RDF and organic manures, improved growth, nodulation, yield attributes, seed yield, nutrient uptake and post-harvest soil fertility compared with hydropriming and with GA_3 at 100 ppm. Biopriming + RDF + vermicompost + FYM recorded the highest seed yield (1365.33 kg ha^{-1}), but because of the high cost of vermicompost, biopriming with *Rhizobium* + RDF (12.50 kg N + 40.00 kg P_2O_5 ha^{-1}) + FYM @ 10 t ha^{-1} gave a statistically similar yield and the highest net returns. This low-cost combination can be suggested for summer mungbean in Punjab, subject to confirmation in multi-season trials.

Conflict of Interest

The authors declare that they have no conflict of interest.

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