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Impact of Multi-micronutrient Mixture Grades on Yield and Chemical Composition of Soybean (*Glycine max*)

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Authors' contributions

This work was carried out in collaboration among all authors. 'All authors read and approved the final manuscript.

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Abstract

A field experiment was conducted during the *Kharif* seasons of 2022, 2023, and 2024 at the Tribal Research cum Training Center Farm, Anand Agricultural University, Devgadh Baria, Gujarat, to evaluate the effect of multi-micronutrient fertilizer grades on soybean productivity and economics under loamy sand soil conditions. Eight treatments comprising RDF (45:60:00 NPK kg ha^{-1}) alone and in combination with foliar and soil application of different multi-micronutrient grades were tested in a randomized block design with four replications. Results revealed that application of RDF along with foliar spray of 1.0% multi-micronutrient mixture Grade-III or Grade-IV at 30 and 60 DAS significantly improved seed yield, straw yield, and net returns compared to RDF alone. The study highlights the importance of multi-micronutrient fertilization in correcting hidden nutrient deficiencies and enhancing soybean productivity under intensive cropping systems.

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Keywords: Soybean; cropping systems; micronutrient; nutrient deficiencies.

1. Introduction

"Soybean (*Glycine max* L.) is an important oilseed and legume crop globally, valued for its high protein (38–45%) and oil (≈20%) content. Owing to its nutritional richness, diverse food and industrial uses, wide adaptability, stress tolerance, and assured market price, soybean is often referred to as a "wonder crop." It ranks first among oilseed crops in terms of area and production both globally and in India, playing a significant role in improving the socio-economic status of farmers" (Patel et al., 2025).

"In India, soybean cultivation is concentrated mainly in Madhya Pradesh, Maharashtra, Uttar Pradesh, Gujarat, and adjoining states, with Madhya Pradesh accounting for nearly 75% of the national area and production. Despite substantial expansion in area, average productivity in India (≈1.2 t ha^{-1}) remains much lower than the world average (2.53 t ha^{-1}) and its climatic potential (3.5 t ha^{-1}). This yield gap is attributed to several abiotic, biotic, and management-related constraints, particularly nutrient imbalances and moisture stress under rainfed conditions" (Patel et al., 2025).

In view of these limitations, a field experiment was undertaken to study the Impact of Multi-Micronutrient Mixture Grades on Yield and Chemical Composition of Soybean (*Glycine max*) at the Tribal Research cum Training Center, Anand Agricultural University, Devgadh Baria, Gujarat duringthe Kharif seasons of 2022, 2023, and 2024 with the following objectives:

1.1 Objectives

- To find out the Effect of multi-micronutrient mixture grades application on yield and Chemical parameters of Soybean

2. Materials and Methods

A field experiment was conducted at Tribal Research cum Training Center Farm, Anand Agricultural University, Devgadh Baria, Gujarat during *Kharif* season of 2022, 2023 and 2024. The texture of the soil is loamy sand. The soil is very deep and fairly moisture retentive. The soil was low in organic carbon and nitrogen, high in available phosphorus and medium in potassium with pH 7.6. The soil was free from any kind of salinity/sodicity hazards. Eight treatment comprising of RDF and different micronutrient fertilizer grades viz. T_1: RDF (45:60:00 NPK kg/ha), T_2: RDF + Water spray @ 30 and 60 DAS, T_3: RDF + MM Grade I @ 1.0% foliar spray @ 30 and 60 DAS, T_4: RDF + MM Grade II @ 1.0% foliar spray @ 30 and 60 DAS, T_5: RDF + MM Grade III @ 1.0% foliar spray @ 30 and 60 DAS, T_6: RDF + MM Grade IV @ 1.0% foliar spray @ 30 and 60 DAS, T_7: RDF + MM Grade V@ 20 kg/ha (Soil Application) at basal and T_8: RDF +STV (Soil test based application) were tried out in a RBD with four replications.

2.1 Statistical Analysis

The data on yield and chemical parameters were subjected to statistical analysis following the procedures appropriate for a Randomized Block Design as described by Cochran and Cox (1967). Analysis of variance (ANOVA) was performed using a computer system at the Computer Center, Department of Agricultural Statistics, BACA, Anand Agricultural University, Anand. Treatment effects were tested for significance using the F-test at the 5% level of significance. Standard error of mean [S.Em. ±], critical difference (CD) at 5%, and coefficient of variation (CV%) were computed where treatment effects were found significant. Detailed results of the analysis of variance are presented in Tables 1 to 6.

3. Results and Discussion

3.1 Effect of Treatments on Yield Attributes and Yield of Soybean

The pooled analysis indicated a significant effect of different treatments on the number of pods per plant in soybean. The highest number of pods per plant (113.62) was recorded under treatment T5 (RDF + MM Grade-III @ 1.0% foliar spray at 30 and 60 DAS), which remained statistically at par with T6 (RDF + MM Grade-IV @ 1.0% foliar spray at 30 and 60 DAS; 109.58). However, the number of seeds per pod and pod length were not significantly influenced by the application of multi-micronutrient mixture grades during individual years (2022, 2023, and 2024) as well as in pooled analysis.

Seed yield and straw yield of soybean were significantly affected by different treatments during all three years and in pooled analysis. Treatment T5 recorded the highest seed yield

(2183, 2062, 2107, and 2117 kg ha^{-1} during 2022, 2023, 2024, and pooled analysis, respectively), which was statistically at par with T6 (2078, 1982, 2024, and 2028 kg ha^{-1}). The lowest seed yield was observed under T1 (RDF alone), registering 1772, 1601, 1643, and 1672 kg ha^{-1} during respective years and in pooled analysis.

The improvement in yield under multi-micronutrient treatments may be attributed to enhanced growth attributes, increased enzymatic activity, and improved synthesis and translocation of carbohydrates and proteins to the developing seeds. Zinc, in particular, plays a vital role as an enzyme activator in plant metabolic processes, thereby directly or indirectly contributing to improved yield formation. These findings are in agreement with the results reported by (Ravi et al. 2008 and Singh and Singh 2005, FAOSTAT 2013).

The results revealed that the application of multi-micronutrient mixture grades had a significant effect on straw yield of soybean during the years 2022, 2023, 2024, as well as in pooled analysis. Treatment T5 (RDF + MM Grade-III @ 1.0% foliar spray at 30 and 60 DAS) recorded the highest straw yield (2351, 2247, 2304, and 2301 kg ha^{-1} during 2022, 2023, 2024, and pooled analysis, respectively), which remained statistically at par with treatment T6 (RDF + MM Grade-IV @ 1.0% foliar spray at 30 and 60 DAS), producing 2265, 2164, 2218, and 2215 kg ha^{-1}. The lowest straw yield (1887, 1686, 1865, and 1813 kg ha^{-1}) was recorded under treatment T1 (RDF alone) (Paroda 1999).

3.2 Effect of Treatments on Chemical Parameters of Soybean

The pooled analysis revealed a significant influence of different treatments on nitrogen (N), phosphorus (P), and potassium (K) uptake by soybean seed and straw.

Nitrogen uptake by seed varied significantly among treatments, with the highest uptake recorded under T4 (RDF + MM Grade-II @ 1.0% foliar spray at 30 and 60 DAS) at 33.04 kg ha^{-1}, while the lowest uptake (23.86 kg ha^{-1}) was observed under T2 (RDF + water spray at 30 and 60 DAS). In the case of phosphorus uptake by seed, T6 (RDF + MM Grade-IV @ 1.0% foliar spray at 30 and 60 DAS) recorded the maximum uptake (3.29 kg ha^{-1}), whereas the minimum uptake (2.04 kg ha^{-1}) was noted under T1 (RDF alone). Potassium uptake by seed was also significantly influenced, with the highest uptake (7.79 kg ha^{-1}) recorded under T6 and the lowest uptake (5.39 kg ha^{-1}) under T2.

Nitrogen uptake by straw was significantly higher under T7 (RDF + MM Grade-V @ 20 kg ha^{-1} as basal soil application), recording 14.32 kg ha^{-1}, while the lowest uptake (11.00 kg ha^{-1}) was observed in T2. Phosphorus uptake by straw was highest under T6 (2.59 kg ha^{-1}) and lowest under T2 (1.67 kg ha^{-1}). Similarly, potassium uptake by straw was significantly influenced by treatments, with the highest uptake recorded under T6 (8.57 kg ha^{-1}), whereas the lowest uptake (5.59 kg ha^{-1}) was observed under T8 (RDF + soil test–based application).

3.3 Effect of Treatments on Micronutrient Content and Uptake

Data on micronutrient content and uptake by soybean seed as influenced by different treatments during the years 2022, 2023, 2024, and in pooled analysis are presented in Tables 4 and 5, respectively (Seyedeh et al. 2017).

The results presented in Table 4 indicate that the application of multi-micronutrient mixture grades had a significant effect on micronutrient content (Fe, Mn, Zn, and Cu) in soybean seed during individual years as well as in pooled analysis. Treatment T5 (RDF + MM Grade-III @ 1.0% foliar spray at 30 and 60 DAS) recorded the highest seed micronutrient content in pooled analysis, with Fe (89.26 ppm), Mn (53.61 ppm), Zn (46.17 ppm), and Cu (13.95 ppm), which remained statistically at par with T6 (RDF + MM Grade-IV @ 1.0% foliar spray at 30 and 60 DAS), recording 85.19, 52.95, 45.49, and 12.55 ppm, respectively (Bhatia et al. 2008).

Similarly, data presented in Table 5 revealed a significant influence of treatments on micronutrient uptake by soybean seed during all three years and in pooled analysis. The highest uptake of Fe (188.72 ppm), Mn (113.06 ppm), Zn (97.74 ppm), and Cu (36.85 ppm) was recorded under T5, which was statistically at par with T6 (172.16, 106.99, 92.26, and 32.52 ppm, respectively), and significantly superior to the remaining treatments in pooled analysis.

Table 1. No. of pods/plant, No. of seed/pod and pod length of Soybean as influenced by different treatments

Treatments	No. of Pods/plant				No. of Seed/Pod				Pod length (cm)			
	2022	2023	2024	Pooled	2022	2023	2024	Pooled	2022	2023	2024	Pooled
T_1: RDF (45:60:00 NPK kg/ha)	98.60	107.60	98.45	101.55	2.83	3.03	2.89	2.92	2.98	3.38	3.08	3.14
T_2: RDF + Water spray @ 30 and 60 DAS	100.80	109.80	104.80	105.13	2.90	3.10	2.85	2.95	2.93	3.33	3.03	3.10
T_3: RDF + MM Grade I @ 1.0% foliar spray @ 30 and 60 DAS	102.70	111.70	106.70	107.03	2.84	3.04	2.79	2.89	2.96	3.36	3.06	3.12
T_4: RDF + MM Grade II @ 1.0% foliar spray @ 30 and 60 DAS	96.50	105.50	100.50	100.83	2.90	3.10	2.85	2.95	2.84	3.27	2.94	3.02
T_5: RDF+ MM Grade III @ 1.0% foliar spray @ 30 and 60 DAS	109.05	118.40	113.40	113.62	2.93	3.10	2.85	2.96	3.53	3.93	3.11	3.52
T_6: RDF+ MM Grade IV @ 1.0% foliar spray @ 30 and 60 DAS	105.25	114.25	109.25	109.58	3.13	3.20	2.95	3.09	3.03	3.62	3.13	3.26
T_7: RDF + MM Grade V@ 20 kg/ha (Soil Application) at basal	101.55	110.55	105.55	105.88	2.93	3.13	2.88	2.98	3.22	3.49	3.32	3.34
T_8: RDF +STV (Soil test based application)	107.00	114.75	109.75	110.50	3.14	3.29	3.04	3.16	3.09	3.43	3.12	3.21
S.Em.±	2.65	2.62	2.80	1.56	0.10	0.09	0.09	0.10	0.14	0.40	0.13	0.08
C.D @ 5 %	7.81	7.72	8.23	4.40	NS	NS	NS	NS	NS	NS	NS	NS
Year (Y)												
S.Em.±	-	-	-	1.00	-	-	-	0.01	-	-	-	0.01
C.D @ 5 %	-	-	-	NS	-	-	-	NS	-	-	-	0.10
Y x T												
S.Em.±	-	-	-	2.7	-	-	-	0.10	-	-	-	0.10
C.D @ 5 %	-	-	-	NS	-	-	-	NS	-	-	-	NS
C.V. %	5.17	4.71	5.28	5.05	6.66	5.83	6.30	6.26	9.20	7.92	8.24	8.44

Table 2. Test weight, seed yield and straw yield (kg/ha) of Soybean as influenced by different treatments

Treatments	Test weight (g)				Seed yield (Kg/ha)				Straw yield (Kg/ha)			
	2022	**2023**	**2024**	**Pooled**	**2022**	**2023**	**2024**	**Pooled**	**2022**	**2023**	**2024**	**Pooled**
T_1: RDF (45:60:00 NPK kg/ha)	10.18	9.58	9.88	9.88	1772	1601	1643	1672	1887	1686	1865	1813
T_2: RDF + Water spray @ 30 and 60 DAS	10.13	9.53	9.86	9.84	1854	1756	1800	1803	1971	1920	1974	1955
T_3: RDF + MM Grade I @ 1.0% foliar spray @ 30 and 60 DAS	10.16	9.56	9.86	9.86	1876	1780	1822	1826	2045	1944	1998	1995
T_4: RDF + MM Grade II @ 1.0% foliar spray @ 30 and 60 DAS	10.04	9.44	9.74	9.74	1925	1829	1871	1875	2098	1997	2051	2049
T_5: RDF+ MM Grade III @ 1.0% foliar spray @ 30 and 60 DAS	10.65	9.98	10.35	10.33	**2183**	**2062**	**2104**	**2117**	**2351**	**2247**	**2304**	**2301**
T_6: RDF+ MM Grade IV @ 1.0% foliar spray @ 30 and 60 DAS	10.21	9.61	9.91	9.91	**2078**	**1982**	**2024**	**2028**	**2265**	**2164**	**2218**	**2215**
T_7: RDF + MM Grade V@ 20 kg/ha (Soil Application) at basal	10.42	9.82	10.12	10.12	1972	1876	1918	1922	2150	2049	2103	2100
T_8: RDF +STV (Soil test based application)	10.29	9.69	9.99	9.99	1853	1782	1825	1820	2023	1947	1876	1949
S.Em.±	0.30	0.28	0.31	0.17	83.28	86.69	83.73	48.83	94.64	101.71	97.64	56.60
C.D @ 5 %	**NS**	**NS**	**NS**	**NS**	**245**	**255**	**246**	**138**	**278**	**299**	**287**	**160**
Year (Y)												
S.Em.±	**-**	**-**	**-**	**0.10**	**-**	**-**	**-**	29.9	**-**	**-**	**-**	34.7
C.D @ 5 %	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**
Y x T												
S.Em.±	**-**	**-**	**-**	**0.30**	**-**	**-**	**-**	84.6	**-**	**-**	**-**	98.0
C.D @ 5 %	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**
C.V. %	**5.82**	**5.79**	**6.29**	**5.97**	**8.59**	**9.46**	**8.93**	**8.98**	**9.02**	**10.20**	**9.53**	**9.58**

Table 3. Harvest Index, Crude Protein Content and N, P, K Uptake as influenced by different treatments

Treatments	HI (%)	Crude Protein Content (%)	N Uptake (%)		P Uptake (%)		K Uptake (%)	
			Seeds	Straw	Seeds	Straw	Seeds	Straw
T_1: RDF (45:60:00 NPK kg/ha)	46.09	40.41	24.67	12.24	2.04	1.88	7.51	5.64
T_2: RDF + Water spray @ 30 and 60 DAS	46.50	38.76	23.86	11.00	2.13	1.67	5.93	5.74
T_3: RDF + MM Grade I @ 1.0% foliar spray @ 30 and 60 DAS	47.84	39.75	24.94	12.56	2.54	1.74	6.49	6.87
T_4: RDF + MM Grade II @ 1.0% foliar spray @ 30 and 60 DAS	47.00	39.81	33.04	10.87	2.75	2.05	5.94	7.71
T_5: RDF+ MM Grade III @ 1.0% foliar spray @ 30 and 60 DAS	48.13	39.52	26.99	14.21	3.10	2.06	7.20	7.48
T_6: RDF+ MM Grade IV @ 1.0% foliar spray @ 30 and 60 DAS	48.00	38.88	32.35	14.21	3.29	2.59	7.79	8.57
T_7: RDF + MM Grade V@ 20 kg/ha (Soil Application) at basal	47.84	40.16	28.49	14.32	2.89	2.45	6.36	7.35
T_8: RDF +STV (Soil test based application)	48.14	38.47	25.48	12.91	2.01	1.83	7.59	5.59
S.Em.+	0.08	0.56	0.96	0.37	0.07	0.06	0.20	0.19
C.D @ 5 %	0.25	**NS**	**2.71**	**1.13**	**0.21**	**0.16**	**0.61**	**0.54**
Year (Y)								
S.Em.+	**0.22**	**0.30**	**0.60**	**0.20**	**0.01**	**0.01**	**0.10**	**0.10**
C.D @ 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Y x T								
S.Em.+	**0.79**	**0.8**	**1.70**	**0.60**	**0.10**	**0.10**	**0.30**	**0.30**
C.D @ 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C.V. %	**3.05**	**4.96**	**12.10**	**10.07**	**10.00**	**9.47**	**10.22**	**9.65**

Table 4. Micronutrient content of Soybean as influenced by different treatments

Treatments	Fe content (%)				Mn content (%)				Zn content (%)				Cu content (%)			
	2022	**2023**	**2024**	**Pooled**	**2022**	**2023**	**2024**	**Pooled**	**2022**	**2023**	**2024**	**Pooled**	**2022**	**2023**	**2024**	**Pooled**
T_1	57.58	90.58	76.20	74.78	30.24	58.23	45.71	44.72	34.54	40.54	37.58	37.55	10.98	17.50	14.48	10.98
T_2	65.10	98.10	85.10	82.77	29.46	57.46	46.46	44.46	33.71	39.71	37.51	36.98	11.98	18.48	16.08	11.98
T_3	65.35	98.35	85.35	83.02	30.50	58.50	47.50	45.50	34.80	40.80	38.60	38.07	11.48	17.98	15.58	11.48
T_4	65.70	98.70	85.70	83.37	32.56	60.56	49.56	47.56	36.76	42.86	40.66	40.09	12.13	18.63	16.23	12.13
T_5	69.93	105.43	92.43	89.26	38.61	66.61	55.61	53.61	42.91	48.91	46.71	46.17	13.95	20.45	18.05	13.95
T_6	67.53	100.53	87.53	85.19	37.92	65.92	54.92	52.92	42.22	48.22	46.02	45.49	12.55	19.05	16.65	12.55
T_7	62.95	95.95	82.95	80.62	34.06	62.06	51.06	49.06	38.36	44.36	42.16	41.63	11.95	18.45	16.05	11.95
T_8	62.05	95.05	82.05	79.72	31.05	58.97	47.97	46.00	35.35	41.35	39.15	38.62	11.19	17.69	15.05	11.19
S.Em.±	**2.35**	**2.62**	**2.73**	**1.48**	**1.65**	**2.21**	**2.20**	**1.18**	1.73	1.59	1.62	0.95	0.54	0.59	0.57	0.33
C.D @ 5 %	**6.90**	**7.72**	**8.02**	**4.20**	**4.84**	**6.50**	**6.47**	**3.32**	**5.09**	**4.68**	**4.76**	**2.69**	**1.60**	**1.73**	**1.69**	**0.93**
Year (Y)																
S.Em.±	**-**	**-**	**-**	**0.90**	**-**	**-**	**-**	**0.70**	**-**	**-**	**-**	**0.60**	**-**	**-**	**-**	**0.20**
C.D @ 5 %	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**
Y x T																
S.Em.±	**-**	**-**	**-**	**2.60**	**-**	**-**	**-**	**2.0**	**-**	**-**	**-**	**1.60**	**-**	**-**	**-**	**0.60**
C.D @ 5 %	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**	**-**	**-**	**-**	**NS**
C.V. %	**7.27**	**5.37**	**6.44**	**6.24**	**9.96**	**7.24**	**8.83**	**8.49**	**9.27**	**7.34**	**7.88**	**8.12**	**9.06**	**6.33**	**7.18**	**7.33**

Table 5. Micronutrient uptake of Soybean as influenced by different treatments

Treatments	Fe uptake (%)				Mn uptake (%)				Zn uptake (%)				Cu uptake (%)			
	2022	2023	2024	Pooled	2022	2023	2024	Pooled	2022	2023	2024	Pooled	2022	2023	2024	Pooled
T_1	102.54	145.94	125.23	124.57	54.15	93.99	76.52	74.89	61.77	65.53	62.47	63.26	19.45	27.70	23.51	23.55
T_2	121.14	172.71	154.14	149.33	54.83	101.10	84.12	80.01	62.73	69.98	67.98	66.90	22.19	32.41	29.02	27.88
T_3	122.92	175.38	156.34	151.54	57.49	104.40	87.10	82.99	65.56	72.89	70.83	69.76	21.70	32.17	28.65	27.51
T_4	126.38	180.42	160.76	155.86	62.55	110.63	92.89	88.69	71.04	78.37	76.30	75.24	23.32	34.04	30.43	29.26
T_5	153.08	217.72	195.35	188.72	84.39	137.40	117.38	113.06	93.76	100.88	98.59	97.74	30.38	42.12	38.04	36.85
T_6	140.07	198.99	177.43	172.16	78.81	130.66	111.50	106.99	87.75	95.58	93.43	92.26	26.05	37.73	33.77	32.52
T_7	124.07	179.95	159.54	154.52	67.58	116.85	98.66	94.36	76.06	83.64	81.53	80.41	23.63	34.68	30.95	29.75
T_8	115.37	169.62	150.51	145.17	57.41	105.12	87.92	83.48	65.38	73.59	71.60	70.19	20.69	31.48	27.52	26.57
S.Em.±	7.38	9.94	8.32	4.97	5.06	7.66	6.92	3.83	5.63	5.63	5.46	3.22	1.59	1.94	1.64	1.00
C.D @ 5 %	21.71	29.23	24.48	14.06	14.88	22.52	20.35	10.83	16.57	16.55	16.06	9.10	4.69	5.69	4.83	2.82
Year (Y)																
S.Em.±	-	-	-	3.00	-	-	-	2.30	-	-	-	2.00	-	-	-	0.60
C.D @ 5 %	-	-	-	NS	-	-	-	NS	-	-	-	NS	-	-	-	NS
Y x T																
S.Em.±	-	-	-	8.60	-	-	-	6.60	-	-	-	5.60	-	-	-	1.70
C.D @ 5 %	-	-	-	NS	-	-	-	NS	-	-	-	NS	-	-	-	NS
C.V. %	11.74	11.03	10.41	11.09	15.65	13.61	14.64	14.65	15.43	14.05	14.03	14.48	13.61	11.37	10.86	11.84

Table 6. Economics of Soybean as influenced by different treatments

Treatments	Seed Yield (Kg/ha)	Straw Yield (Kg/ha)	Gross Realization (Rs./ha)	Total Cost of cultivation (Rs./ha)	Net Realization (Rs./ha)	BCR
T_1: RDF (45:60:00 NPK kg/ha)	1672	1813	83882	29338	54544	1.86
T_2: RDF + Water spray @ 30 and 60 DAS	1803	1955	90454	29621	60833	2.05
T_3: RDF + MM Grade I @ 1.0% foliar spray @ 30 and 60 DAS	1826	1995	91638	30037	61601	2.05
T_4: RDF + MM Grade II @ 1.0% foliar spray @ 30 and 60 DAS	1875	2049	94098	30156	63942	2.12
T_5: RDF+ MM Grade III @ 1.0% foliar spray @ 30 and 60 DAS	2117	2301	106218	30103	76115	2.53
T_6: RDF+ MM Grade IV @ 1.0% foliar spray @ 30 and 60 DAS	2028	2215	101774	30077	71697	2.38
T_7: RDF + MM Grade V@ 20 kg/ha (Soil Application) at basal	1922	2100	96456	30182	66274	2.20
T_8: RDF +STV (Soil test based application)	1820	1949	91258	29338	61920	2.11

Soybean selling Price: 49.0 Rs/kg, Straw Price: 2.0 Rs/kg

3.4 Economics

Data on gross realization, net realization, and benefit–cost ratio (BCR) as influenced by different treatments are presented in Table 4. Among the treatments, T5 (RDF + MM Grade-III @ 1.0% foliar spray at 30 and 60 DAS) recorded the highest net realization (₹76,115 ha^{-1}), followed by T6 (RDF + MM Grade-IV @ 1.0% foliar spray at 30 and 60 DAS), which registered ₹71,697 ha^{-1}. Similarly, the highest benefit–cost ratio (1:2.53) was obtained under T5, followed by T6 (1:2.38) (Maghsud et al. 2014).

The higher profitability under these treatments was primarily attributed to increased seed and straw yields of soybean. These findings are in agreement with earlier reports by Babhulker et al. (2000), Bameri et al. (2012), Wojtkowiak (2015) and Bhatia et al. (2003).

4. Conclusion

Based on the results of the present investigation, it can be concluded that for achieving higher yield and net economic returns, soybean should be fertilized with the recommended dose of fertilizer (45:60:00 NPK kg ha^{-1}) along with foliar application of 1.0% multi-micronutrient mixture Grade-III or Grade-IV at 30 and 60 days after sowing.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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