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Effect of chemical fertilizers and different *Rhizobium* inoculants on nutrient content, uptake, growth and yield of soybean (*Glycine max* (L.) Merrill)

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Abstract
An experiment entitled "Effect of chemical fertilizers and different *Rhizobium* inoculants on nutrient content, uptake, growth and yield of soybean (*Glycine max* (L.) Merrill)" was conducted in *Kharif* season at student research field, College of Agriculture, Indore (M.P.). The soil of the experimental field was medium black in texture, neutral in reaction (pH 7.70) with normal EC (0.38 dS/m) and medium organic carbon contents (0.60%) and analysing low in available N (225 kg/ha), medium in available P (9.60 kg/ha) and high in available K (508 kg/ha) contents. Due to dominance of montmorillonite clay content it has high capacity to swell and shrink and high CEC. A field experiment was consisted of 15 treatments replicated four times in randomized block design (RBD). As per treatment, the seed of soybean cv. JS 335 treated or not treated with fungicides and inoculated with *Rhizobium* culture before 15, 10, 05, 01 days of planting and on the day of sowing. The maximum NPK content and uptake was recorded in T_{10} [Thiram+Carbendazim 50 WP - Premax + Rizo-liq (ODS)], while minimum was found in T_{15} (Absolute control). This increase was due to *Rhizobium* application which fixed the atmospheric nitrogen and enhanced the availability of nutrients to soybean crop. Maximum yield (21.47 q/ha) was recorded under [Thiram + Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] (T_{10}) treatment and the minimum (15.09 q/ha) was recorded in absolute control (T_{15}) treatment. The application of *Rhizobium* with or without fungicides showed a synergic effect in increasing the seed yield of soybean per hectare.

Keywords: Soybean, fungicide, *Bradyrhizobium japonicum* (Premax + Rizo-liq), seed treatment, nodulation, yield and economics

Introduction
Soybean (*Glycine max* (L.) Merrill) is a major legume crop recognized as the efficient producer of the two scarce quality characters i.e. the protein and oil, which are not only the major components in the diet of vegetarians mass but a boon to the developing countries as well. Soybean plays a vital role in the agricultural economy of India.

In Madhya Pradesh, Farmers generally apply unbalanced under dose of fertilizers and less use of FYM and bacterial cultures which lead to low production. Indiscriminate use of chemical fertilizers deteriorates the soil health with environmental pollution. Biofertilizers are the substitute or supplementary materials in addition to the chemical fertilizers. Biofertilizers are economically viable lever for realizing the ultimate goal of increasing productivity. These microbial systems siphon out appreciable amount of nitrogen from the atmospheric reservoir and enrich the soil with these important but scare nutrients.

Culture inoculation of legume seeds at the time of sowing was found helpful in increasing the *Rhizobia* population in the soil which resulted into increased number of root nodules and ultimately gave 20-70% more yield of the legume (Dadson and Acquash, 1984) [6]

The limitation of using the *Rhizobia* are that they cannot apply well in advance and in the other hand there is narrow window of soybean planting in India as it is rainy season crop. Soybean is becoming popular in Madhya Pradesh particularly in 'Malwa region' and hence efforts should be made to boost up the production of soybean by adopting modern techniques of crop production.

Soybean is an important leguminous crop and able to leave residual N effect for succeeding crop equivalent to 35-40 kg N/ha.

The crop produces enormous amount of biomass thereby enhances the soil organic matter status in soil. It provides a good protective cover to intercept rain and wind, therefore, minimizes soil erosion. Among several factors responsible for lower productivity improper nutrient management and no use of bio-fertilizers are the major factors. Hence, review has been selected for proper nutrient management and biofertilizers for inoculation are required to increase the productivity of soybean.

Material and Methods

An experiment entitled "Testing of comparative efficacy of different *Rhizobium* inoculants on growth and yield of soybean" was conducted in *Kharif* season at student research field, College of Agriculture, Indore (M.P.). The soil of the experimental field was medium black in texture, neutral in reaction (pH 7.70) with normal EC (0.23 dS/m) and medium organic carbon contents (0.56%) and analysing low in available N (225 kg/ha), medium in available P (9.60 kg/ha) and high in available K (508 kg/ha) contents. Due to dominance of montmorillonite clay content it has high capacity to swell and shrink and high CEC. A field experiment was consisted of 15 treatments replicated four times in randomized block design (RBD). It is located on latitude of 22.43 ^{o}N and longitude of 75.66 ^{o}E. It has subtropical climate having a temperature range of 23 ^{o}C to 41 ^{o}C and 4 ^{o}C to 29 ^{o}C in summer and winter season, respectively. The rainfall in the region is mostly inadequate and erratic. Late commencement, early withdrawal and two to three dry spells are the main features. The average rain is 964 mm and it was below normal (803 mm). The maximum temperature ranged from 25.7 ^{0}C to 40.8 ^{0}C while minimum temperature accelerated between 14.9 ^{0}C to 28.8 ^{0}C during the season.

Properties of fungicides and Bio-fertilizers

Thiram: Thiram is contact fungicide, most effective seed protectant, least phytotoxic and used for the control of many seed-borne or soil-borne diseases.

Carbendazim 50 WP (Bavistin): Carbendazim is systemic with prophylactic and curative action and also non-phytotoxic. It is used for the control of many internally and externally seed borne diseases. Besides the disease control, beneficial side effects like stimulation of growth, flowering and yield of plants on the treated hosts have been reported.

Premax (Protector): Premax protects Rhizobial population from the adverse effects of fungicides.

Rizo-liq: Rizo-liq (*Bradyrhizobium japonicum* Strain) is a liquid biofertilizer which is used well in advance to inoculate the seed and recommended for soybean crop.

***Rhizobium* cultures (Rh_1, Rh_2, Rh_3):** *Rhizobium* cultures (*Rhizobium japonicum* strain) are solid biofertilizers which are used to inoculate the seed of soybean.

Seed yield (kg per hectare)

The seed yield per net plot was recorded after drying the seed. The plot yield was later on converted into kg per hectare by multiplying it by conversion factor.

Stover yield (kg per hectare)

The stover yield per plot was obtained by subtracting grain yield from bundle weight of each plot. This was later on converted into kg per hectare.

Harvest index (%)

The harvest index is calculated by the following equation:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Estimation of nitrogen

Nitrogen determination in straw and grain sample (separately) was done by micro Kjeldhal method as described by Piper (1950) [16].

Estimation of phosphorus and potassium

For preparation of stock solution 1 g of finely grinded plant sample was digested in di-acid mixture of HNO_3 and $HClO_4$ (2:1) on hot plate till clear solution was obtained. The digested material was filtered in a 100 ml volumetric flask and volume made up to the mark by distilled water.

Determination of phosphorus: Taking the aliquot from the stock solution, P content was estimated by the Vanado molybdo phosphoric acid. Yellow colour method in nitric acid system by Koeing and Johnson (1942) as described by Jackson (1967).

Determination of potassium: The potassium content in stock solution was estimated by flame photometer as described by Black (1965) [4]. The results have been expressed as content of K in percentage.

Results and Discussion

Initial soil fertility status

Initial soil fertility status showed that soil was slightly saline in nature. The nitrogen in soil was medium and phosphorus and organic carbon were medium in soil. The potassium in soil was high.

Table 1: Initial soil fertility status

Characters	Replications				Average
	I	II	III	IV	
pH	7.80	7.70	7.90	7.40	7.70
EC (DSm^{-1})	0.38	0.37	0.36	0.41	0.38
Organic carbon (%)	0.63	0.57	0.60	0.60	0.60
Available nitrogen (kg/ha)	230.00	225.00	200.00	245.00	225.00
Available phosphorus (kg/ha)	9.60	11.20	9.60	8.00	9.60
Available potassium (kg/ha)	518.00	520.00	486.00	508.00	508.00

Soil fertility status at harvest

The data revealed that the pH was reduced by different treatments as compared to T_{15} (Absolute control). The maximum (7.85) was recorded under T_{15} (Absolute control) and minimum (7.70) in T_{13} [Thiram + Carbendazim 50 WP - Rh_3 (ODS)] treatment. The electrical conductivity (EC) of soil (dSm^{-1}) at harvest stage was affected by various treatments and showed decreasing trend as compared to T_{15} (Absolute control). The maximum (0.45 dSm^{-1}) EC was found under the influence of T_{15} (Absolute control) treatment and minimum

(0.38 dSm^{-1}) EC was found in T_{11} [Thiram + Carbendazim 50 WP - Rh_1 (ODS)] treatment.

The organic carbon content of soil (%) at harvest stage was influenced by various treatments. The organic carbon was found maximum (0.62%) underT_{10} [Thiram+Carbendazim 50 WP- Premax+ Rizo-liq (ODS)] and minimum (0.50%) in T_{15} (Absolute control) treatament.

A perusal of data revealed that the available nitrogen (kg/ha) content in soil was increased by various treatments as compared to T_{15} (Absolute control) treatment. The maximum (222.6 kg/ha) available nitrogen was recorded in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] treatment and minimum (208.6 kg/ha) in T_{15} (Absolute control) treatment.

The data of available P_2O_5 (kg/ha) presented in Table 2 showed the available P_2O_5 (kg/ha) content was increased by application of various treatments. The maximum (19.4 kg/ha) available P_2O_5 in soil was found in T_{10} [Thiram+Carbendazim 50 WP- Premax+ Rizo-liq (ODS)] and minimum (12.4 kg/ha) in T_{15} (Absolute control) treatment.

The effect of various treatments changed the available K_2O (kg/ha) content in soil. The K_2O content was found maximum (522 kg/ha) in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] and minimum (466 kg/ha) under T_{15} (Absolute control) treatment**.**

Table 2: Soil Fertility status at harvest as affected by various treatments

Tr. No.	Treatment	pH	EC dSm^{-1}	OC%	N kg/ha	P_2O_5 kg/ha	K_2O kg/ha
T_1	Premax+Rizo-liq (15 DPS)	7.84	0.43	0.51	212.80	13.60	480.00
T_2	Premax+Rizo-liq (10 DPS)	7.79	0.40	0.55	214.20	13.80	480.00
T_3	Premax+Rizo-liq (05 DPS)	7.83	0.44	0.56	219.80	14.20	491.00
T_4	Premax+Rizo-liq (01 DPS)	7.83	0.43	0.58	220.40	14.60	493.00
T_5	Premax+Rizo-liq (ODS)	7.74	0.43	0.59	221.20	17.50	513.00
T_6	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (15 DPS)	7.82	0.44	0.53	214.20	13.80	476.00
T_7	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (10 DPS)	7.81	0.43	0.58	217.00	14.80	480.00
T_8	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (05 DPS)	7.78	0.40	0.59	218.60	15.70	481.00
T_9	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (01 DPS)	7.76	0.43	0.59	220.40	16.50	507.00
T_{10}	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (ODS)	7.72	0.44	0.62	222.60	19.40	522.00
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	7.80	0.38	0.60	219.80	17.50	507.00
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	7.81	0.43	0.59	220.60	17.20	496.00
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	7.70	0.40	0.61	221.20	18.00	520.00
T_{14}	Uninoculated seed (but fungicidal treatment)	7.84	0.40	0.51	212.80	13.60	476.00
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	7.85	0.45	0.50	208.60	12.40	466.00

Nutrient content (%) in plant

(a) Nitrogen content (%)

The data at harvest presented in Table 3 indicated that all the treatments increased the nitrogen content (%) in grain as compared to T_{15} (Absolute control). The maximum (6.23%) nitrogen content in grain was found in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] treatment and minimum (4.72%) in T_{15} (Absolute control) treatment. The data presented in Table 3 indicated that nitrogen content in stover was found maximum (1.23%) under the influence of T_{10} [Thiram + Carbendazim 50 WP - Premax + Rizo-liq (ODS)] treatment and minimum (1.02%) in T_{15} (Absolute control) treatment. The data in Table 3 also indicate that the nitrogen content (%) in grain was higher as compared to stover.

Table 3: Nitrogen content (%) in plant as affected by various treatments

Tr. No.	Treatment	N content in grain (%)	N content in stover (%)
T_1	Premax + Rizo-liq (15 DPS)	5.36	1.07
T_2	Premax + Rizo-liq (10 DPS)	5.42	1.10
T_3	Premax + Rizo-liq (05 DPS)	5.65	1.10
T_4	Premax + Rizo-liq (01 DPS)	5.78	1.12
T_5	Premax + Rizo-liq (ODS)	6.00	1.14
T_6	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (15 DPS)	5.62	1.08
T_7	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (10 DPS)	5.85	1.09
T_8	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (05 DPS)	5.86	1.11
T_9	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (01 DPS)	5.90	1.12
T_{10}	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (ODS)	6.23	1.23
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	6.02	1.15
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	5.99	1.12
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	6.19	1.19
T_{14}	Uninoculated seed (but fungicidal treatment)	5.26	1.05
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	4.72	1.02

(b) Phosphorus content (%)

The data on phosphorus content at harvesting presented in Table 4 revealed that the phosphorus content (%) in grain was higher in all the treatments as compared to T_{15} (Absolute control) treatment. The maximum (0.25%) phosphorus content in grain was recorded in T_{10} [Thiram+Carbendazim 50 WP- Premax+ Rizo-liq (ODS)] and minimum (0.16%) was found in T_{15} (Absolute control) treatment. The data presented in Table 4 revealed that phosphorus content (%) in stover was higher in all the treatments as compared to T_{15} (Absolute control) treatment. The maximum (0.19%) phosphorus content in stover was recorded in T_{10} [Thiram+Carbendazim 50 WP-Premax+ Rizo-liq (ODS)] treatment and minimum (0.10%) was found in T_{15} (Absolute control) treatment. The data also indicate that phosphorus content was higher in grain as compared to stover.

Table 4: Phosphorus content (%) in plant as affected by various treatments

Tr. No.	Treatment	P content in grain (%)	P content in stover (%)
T_1	Premax + Rizo-liq (15 DPS)	0.18	0.11
T_2	Premax + Rizo-liq (10 DPS)	0.20	0.13
T_3	Premax + Rizo-liq (05 DPS)	0.20	0.14
T_4	Premax + Rizo-liq (01 DPS)	0.21	0.14
T_5	Premax + Rizo-liq (ODS)	0.22	0.15
T_6	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (15 DPS)	0.19	0.12
T_7	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (10 DPS)	0.19	0.13
T_8	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (05 DPS)	0.20	0.14
T_9	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (01 DPS)	0.21	0.14
T_{10}	Thiram+Carbendazim50WP-Premax+Rizo-liq (ODS)	0.25	0.19
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	0.21	0.16
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	0.20	0.13
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	0.23	0.18
T_{14}	Uninoculated seed (but fungicidal treatment)	0.18	0.11
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	0.16	0.10

(c) Potassium content (%)

The data presented in Table 5 revealed that the potassium content in grain at harvest increased by application of various treatments as compared to T_{15} (Absolute control). The maximum (2.35%) potassium content in grain was recorded in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] and minimum (1.81%) was recorded in T_{15} (Absolute control) treatment. The data of potassium content (%) in stover showed similar trend as shown in potassium content in grain at harvest. The maximum (1.9%) potassium content was recorded in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] and minimum (1.29%) in T_{15} (Absolute control) treatment.

Table 5: Potassium content (%) in plant as affected by various treatments

Tr. No.	Treatment	K content in grain (%)	K content in stover (%)
T_1	Premax + Rizo-liq (15 DPS)	2.04	1.34
T_2	Premax + Rizo-liq (10 DPS)	2.14	1.44
T_3	Premax + Rizo-liq (05 DPS)	2.14	1.53
T_4	Premax + Rizo-liq (01 DPS)	2.20	1.59
T_5	Premax + Rizo-liq (ODS)	2.26	1.85
T_6	Thiram+Carbendazim 50 WP - Premax+Rizo-liq (15 DPS)	2.06	1.40
T_7	Thiram+Carbendazim 50 WP - Premax+Rizo-liq (10 DPS)	2.14	1.44
T_8	Thiram+Carbendazim 50 WP - Premax+Rizo-liq (05 DPS)	2.17	1.62
T_9	Thiram+Carbendazim 50 WP - Premax+Rizo-liq (01 DPS)	2.21	1.70
T_{10}	Thiram+Carbendazim 50 WP - Premax+Rizo-liq (ODS)	2.35	1.90
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	2.21	1.86
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	2.20	1.79
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	2.33	1.87
T_{14}	Uninoculated seed (but fungicidal treatment)	2.02	1.34
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	1.81	1.29

Nutrient uptake (kg/ha) by plant

(a) Nitrogen uptake (kg/ha)

A perusal of data in Table 6 showed that total nitrogen uptake (kg/ha) was higher in all the treatments as compared to T_{15} (Absolute control) treatments. The maximum (168.73 kg/ha) nitrogen uptake was recorded in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] whereas minimum (91.90 kg/ha) was recorded in T_{15} (Absolute control) treatment. Similar trend in nitrogen uptake was shown in grain and stover individually. The data also indicated that the accumulation of nitrogen is higher in grain as compared to stover.

Table 6: Nitrogen uptake (kg/ha) by plants as influenced by various treatments

Tr. No.	Treatment	N uptake (kg/ha)		
		Grain	Stover	Total
T_1	Premax + Rizo-liq (15 DPS)	99.07	25.56	124.63
T_2	Premax + Rizo-liq (10 DPS)	99.82	26.55	126.36
T_3	Premax + Rizo-liq (05 DPS)	107.03	27.87	134.90
T_4	Premax + Rizo-liq (01 DPS)	114.93	29.08	144.01
T_5	Premax + Rizo-liq (ODS)	124.09	31.08	155.17
T_6	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (15 DPS)	107.01	27.22	134.24
T_7	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (10 DPS)	113.09	28.90	141.99
T_8	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (05 DPS)	116.29	29.38	145.68
T_9	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (01 DPS)	119.04	30.08	149.13
T_{10}	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (ODS)	133.82	34.91	168.73
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	121.84	30.13	151.96
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	115.36	30.60	145.95
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	130.91	33.10	164.00

T_{14}	Uninoculated seed (but fungicidal treatment)	85.59	22.66	108.25
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	70.56	21.35	91.90

(b) Phosphorus uptake (kg/ha)

A critical examination of data in Table 7 showed that total phosphorus uptake (kg/ha) was higher in all the treatment as compared to T_{15} (Absolute control) treatment. T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] treatment was recorded highest (10.90 kg/ha) phosphorus uptake whereas lowest (4.51 kg/ha) was recorded in T_{15} (Absolute control) treatment. Similar trend was observed in phosphorus uptake (kg/ha) in grain and stover individually. The study of data indicated that phosphorus accumulation was higher in grain as compared to stover.

Table 7: Phosphorus uptake (kg/ha) by plants as influenced by various treatments

Tr. No.	Treatment	P uptake (kg/ha)		
		Grain	Stover	Total
T_1	Premax + Rizo-liq (15 DPS)	3.38	2.61	5.99
T_2	Premax + Rizo-liq (10 DPS)	3.65	3.25	6.90
T_3	Premax + Rizo-liq (05 DPS)	3.75	3.57	7.32
T_4	Premax + Rizo-liq (01 DPS)	4.10	3.66	7.76
T_5	Premax + Rizo-liq (ODS)	4.59	4.14	8.73
T_6	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (15 DPS)	3.57	3.06	6.63
T_7	Thiram+Carbendazim 50 WP-Premax+ Rizo-liq (10 DPS)	3.75	3.44	7.19
T_8	Thiram+Carbendazim 50 WP -Premax+Rizo-liq (05 DPS)	4.04	3.78	7.82
T_9	Thiram +Carbendazim 50 WP-Premax+Rizo-liq (01 DPS)	4.30	3.70	8.00
T_{10}	Thiram +Carbendazim 50 WP - Premax + Rizo-liq (ODS)	5.44	5.42	10.86
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	4.30	4.16	8.47
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	3.91	3.63	7.54
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	4.80	5.05	9.85
T_{14}	Uninoculated seed (but fungicidal treatment)	2.96	2.42	5.39
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	2.41	2.10	4.51

(c) Potassium uptake (kg/ha)

Data presented in Table indicated that total potassium uptake (kg/ha) was higher in all the treatments as compared to T_{15} (Absolute control) treatment. The maximum (105 kg/ha) Potassium uptake was recorded in T_{10} [Thiram+Carbendazim 50 WP - Premax+ Rizo-liq (ODS)] whereas minimum (54.3 kg/ha) was found in T_{15} (Absolute control) similar trend was found in potassium uptake (kg/ha) in grain and stover, individually.

Table 8: Potassium uptake (kg/ha) by plants as influenced by various treatments

Tr. No.	Treatment	K uptake (kg/ha)		
		Grain	Stover	Total
T_1	Premax + Rizo-liq (15 DPS)	37.69	32.06	69.75
T_2	Premax + Rizo-liq (10 DPS)	39.50	34.85	74.35
T_3	Premax + Rizo-liq (05 DPS)	40.62	39.26	79.88
T_4	Premax + Rizo-liq (01 DPS)	43.72	41.07	84.79
T_5	Premax + Rizo-liq (ODS)	46.64	49.64	96.29
T_6	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (15 DPS)	39.21	35.35	74.55
T_7	Thiram+Carbendazim 50 WP-Premax+ Rizo-liq (10 DPS)	41.27	38.09	79.35
T_8	Thiram+Carbendazim 50 WP -Premax+Rizo-liq (05 DPS)	43.09	43.05	86.15
T_9	Thiram +Carbendazim 50 WP-Premax+Rizo-liq (01 DPS)	44.54	45.08	89.62
T_{10}	Thiram +Carbendazim 50 WP - Premax + Rizo-liq (ODS)	50.72	54.39	105.11
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	44.97	48.95	93.91
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	42.06	48.75	90.81
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	49.38	51.57	100.96
T_{14}	Uninoculated seed (but fungicidal treatment)	33.04	28.96	62.00
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	27.47	26.86	54.33

Number of branches per plant

Maximum number of branches per plant (4.02) was recorded in T_{10} [Thiram + Carbendazim 50 WP- Premax+Rizo-liq (ODS)] treatment and minimum (2.95) was recorded under T_{15} (Absolute control) treatment. The data revealed that *Rhizobium* inoculation with or without fungicide on the day of sowing increased the number of branches per plant as compared to control and uninoculated seed treatment at all the growth stages. However rest of the treatments produced more number of branches per plant than absolute control.

Table 9: Number of branches per plant as affected by various treatments at successive stages of plant growth

Treatment No.	Treatments	Number of branches per plant		
		45 DAS	60 DAS	At Harvest
T_1	Premax + Rizo-liq (15 DPS)	1.65	3.10	3.10
T_2	Premax + Rizo-liq (10 DPS)	1.80	3.20	3.20
T_3	Premax + Rizo-liq (05 DPS)	1.85	3.20	3.20
T_4	Premax + Rizo-liq (01 DPS)	1.90	3.80	3.80
T_5	Premax + Rizo-liq (ODS)	2.15	3.95	3.95
T_6	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (15 DPS)	1.85	3.15	3.15
T_7	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (10 DPS)	1.90	3.25	3.25
T_8	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (05 DPS)	1.95	3.30	3.30
T_9	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (01 DPS)	2.10	3.80	3.80
T_{10}	Thiram + Carbendazim 50 WP - Premax + Rizo-liq (ODS)	2.60	4.02	4.02
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	2.20	3.85	3.85
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	2.25	3.80	3.80
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	2.55	3.95	3.95
T_{14}	Uninoculated seed (but fungicidal treatment)	1.60	3.05	3.05
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	1.55	2.95	2.95
SEm ±		0.23	0.31	0.31
CD at 5%		NS	NS	NS

DPS: Days prior sowing, ODS: On days of sowing, DAS: Days after sowing

Seed yield per hectare

Yield of the crop is the result of the various biotic and environmental factors, which are responsible for changes brought about in the productivity. Effectiveness of any treatment could be judged by the magnitude of changes in the productivity brought about by that particular treatment. The seed yield was recorded per net plot and then it was converted into q/ha. Perusal of data in Table 10 revealed that the maximum (21.47 q/ha) seed yield of soybean in entire experiment was recorded in T_{10} [Thiram+carbendazim 50 WP - Premax+ Rizo-liq (ODS)] treatment which was appreciably higher than all other treatments, immediately followed by T_{13} [Thiram + Carbendazim 50 WP - Rh_3 (ODS)] (2115 kg/ha) treatment. Minimum (15.09 q/ha) seed yield was recorded in T_{15} (Absolute control) treatment.

Stover yield per hectare

The stover yield obtained was statistically analysed in order to find out the effect of different treatments. The stover yield was calculated by subtracting the seed yield from the biological yield. The maximum (28.46 q/ha) stover yield in entire experiment was recorded in T_{10} [Thiram+Carbendazim 50 WP- Premax+ Rizo-liq (ODS)] treatment. T_{10} [Thiram+Carbendazim 50 WP- Premax+ Rizo-liq (ODS)] was found to be at par with all the treatments except T_1, T_2, T_{14}, and T_{15} (Absolute control). The lowest stover yield (20.80 q/ha) was noted in T_{15} (Absolute control) treatment.

Harvest index (%)

Data revealed that all the treatments increased the harvest index of soybean as compared to T_{15} (Absolute control) treatment. The differences in harvest index among the treatments were non significant. The maximum harvest index up to 43.62% equally found in T_{11} [Thiram + Carbendazim 50 WP - Rh_1 (ODS)] and T_1 [Premax+Rizo-liq (15 DPS)] treatments whereas the minimum harvest index (39.56%) was recorded in T_{15} (Absolute control).

Table 10: Seed yield, Stover yield (q/ha) and harvest index (%) as affected by different treatments

Tr. No.	Treatments	Seed Yield (q/ha)	Stover Yield (q/ha)	Harvest Index (%)
T_1	Premax + Rizo-liq (15 DPS)	18.45	23.88	43.61
T_2	Premax + Rizo-liq (10 DPS)	18.45	24.17	43.33
T_3	Premax + Rizo-liq (05 DPS)	18.98	25.39	42.84
T_4	Premax + Rizo-liq (01 DPS)	19.95	26.06	43.43
T_5	Premax + Rizo-liq (ODS)	20.65	27.28	43.32
T_6	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (15 DPS)	19.04	25.28	43.00
T_7	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (10 DPS)	19.35	26.46	42.15
T_8	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (05 DPS)	19.79	26.52	42.69
T_9	Thiram+Carbendazim 50 WP-Premax+Rizo-liq (01 DPS)	20.22	26.72	43.37
T_{10}	Thiram+Carbendazim50 WP-Premax + Rizo-liq (ODS)	21.47	28.46	43.20
T_{11}	Thiram + Carbendazim 50 WP - Rh_1 (ODS)	20.25	26.22	43.62
T_{12}	Thiram + Carbendazim 50 WP - Rh_2 (ODS)	19.25	27.22	41.42
T_{13}	Thiram + Carbendazim 50 WP - Rh_3 (ODS)	21.15	27.63	43.36
T_{14}	Uninoculated seed (but fungicidal treatment)	16.35	21.74	43.03
T_{15}	Absolute control (No fungicidal treatment and no inoculation)	15.09	20.80	39.56
SEm ±		0.72	1.27	1.67
CD at 5%		2.05	3.63	NS

DPS: Days prior sowing, ODS: On days of sowing, DAS: Days after sowing

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