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Effect of Liquid Biofertilizers (*Bradyrhizobium* and PSB) on Availability of Nutrients and Soil Chemical Properties of Soybean (*Glycine max* L.)

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ABSTRACT

A field experiment was carried out on "Response of liquid biofertilizers (Bradyrhizobium and PSB) on availability of nutrients and soil chemical properties of soybean (Glycine max)". It was conducted in Kharif season during the year 2013-14 at the research farm of Oil Seed Research Station, Latur, Maharashtra, in factorial randomized block design with three replications and variety MAUS-81 as a test crop. Availability of nitrogen in soil was increased by seed inoculation with liquid 10ml of Bradyrhizobium (A_2). Phosphorus availability in soil was improved by seed inoculation with liquid 10ml of PSB (B_2). However in later stages N uptake in soybean was increased significantly due to seed inoculation with 10ml of PSB (B_2). Organic carbon content in experimental soil was improved due to residual effect of soybean crop grown under liquid biofertilizers treatment.

Key words: *Liquid Bio-fertilizers, Bradyrhizobium, PSB, Soybean, Nutrients availability*

INTRODUCTION

Soybean (*Glycine max*) a leguminous crop originated in China. It is basically a pulse crop and gained the importance as an oil seed crop as it contains 20% cholesterol free oil. It posses a very high nutritional value, and contains 40 per cent high quality protein due to this reason, soybean is known as `poor man's meat'. India stands next only to China in the Asia pacific region, with respect to production (12.9m.t). Maharashtra is the second largest producer in India, with 4.86 m.t of production[2]. Soybean played a key role in the yellow revolution. It is newly introduced and commercially exploited crop in India .Soybean has been playing an important role in national economy by earning an average of Rs. 32,000 million per annum through export of soy meal and contributing about 18% to the edible oil production[1].Biofertilizers are commonly called as microbial inoculants *Rhizobium* and PSB inoculants helps to increase yield of legume crop by fixing atmospheric nitrogen in root nodules of legume crop and by converting the insoluble phosphate in to soluble form respectively.

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Rhizobium inoculant is recommended to ensure adequate nodulation and N_2 fixation for maximum growth and yield of pulse crop. Biological nitrogen fixation offers an economically attractive and ecologically sound means of reducing external inputs and improving the quality and quantity of internal resource of nitrogen. In soybean nitrogen fixation is through a symbiotic association between the bacteria of the genus *Bradyrhizobium* and soybean crop. It is the estimated that the nitrogen fixed by soybean crop ranges between 49-450 kg nitrogen ha^{-1}. Though the biofertilizers helps to provide nutrient elements to crop plants, these cannot replace the mineral fertilizers.Sujata and Nibha[22] studied the microbial bioinoculant and their role in plant growth and development and observed microorganisms are significantly useful for biomineralization of bound soil and make nutrients available to their host and/or it surroundings. Gupta[8] studied the effect of biofertilizer and phosphorus levels on yield attributes, yield and quality of urdbean (*Vigna mungo*) and reported that the NO_3-N in the soil profile decreased with advancement of crop growth.

MATERIAL AND MATHEDS

The field experiment was conducted in *Kharif* season during the year 2013-14 at the research farm of Oil Seed Research Station, Latur, Maharashtra, geographically situated between 18^0 05' to 18^0 ·75' N latitude and between 76^0 25' to $77^0$36' E longitude on the Deccan plateau with height mean sea level (MSL) about 633.85 meters and average rainfall is 750-800mm. The experimental soil was deep black in color with good drainage, moderate calcareous in nature and moderate alkaline in reaction with pH (1:2.5) 8.30, EC (1:2.5) 0.36 dSm^{-1} $CaCO_3$ (5.03%) and organic C (5.4 g kg^{-1}) The available soil N, P, K and S were 131.20, 19.68, 597.9, 15.35 $kgha^{-1}$ respectively. Soybean was grown in factorial randomized block design with three replications and variety MAUS-81 as a test crop along with 16 treatment combination containing four levels of liquid *Bradyrhizobium* (0ml, 5ml, 10ml, and 15ml) and four levels of liquid PSB (0ml, 5ml, 10ml, and 15ml). Soybean seed after inoculation with required quantity of liquid biofertilizers *viz. Bradyrhizobium* and PSB was sown at spacing 45 × 5cm @ 75 kg ha^{-1} in 4th July, 2013. A uniform dose of fertilizers (30:60:30:30 kg ha^{-1} of N, P_2O_5, K_2O, S) were supplied through urea, SSP, MOP and bensulph before sowing. Hand weeding was carried out at 26 DAS first spray of Chloropyriphos 25 ml/10lit water, bavistin 20 gm/10lit water at time of incidence of insect pests (30DAS) and second of proclaim (benzoet) 15gm/10lit of water at in 30 days interval of first spray. The crop was harvested on 15 Oct. 2013.

RESULTS AND DISCUSSION

Availability of nutrients at various growth stages

Available nutrients *viz.* N, P, K and S were also analyzed from respective soil samples collected from different plots at various growth stages of soybean crop and result are presented here.

Available nitrogen

The N content in soil was not influenced significantly by liquid *Bradyrhizobium* levels at branching and flowering stages but it was significantly influenced the N status in soil at pod formation, maturity and at harvest stages (Table 1). The higher available nitrogen in soil was recorded under the treatment A_2 (10ml of *Bradyrhizobium japonicum* kg^{-1} seed) at branching (223.14 kg ha^{-1}) and flowering (205.41 kg ha^{-1}) stages. The treatment A_2 (10ml of *Bradyrhizobium japonicum* kg^{-1} seed) recorded significantly higher available N at pod formation (192.88 kg ha^{-1}) maturity (184.09 kg ha^{-1}) and at harvest (171.29 kg ha^{-1}) stages of soybean over A_0 and A_1 treatments. The treatments A_0 (control) and A_1 (5ml *Bradyrhizobium japonicum* kg^{-1} seed) as well as A_2 (10ml *Bradyrhizobium japonicum* kg^{-1} seed) and A_3 (15ml *Bradyrhizobium japonicum* kg^{-1} seed) were at par with each other. This might be due to microbial activity involved in the mineralization and immobilization process. Meshram *et al.,* (2005)[17] a field experiment conducted on efficacy of biofertilizers integrated with chemical fertilizers *in-vivo* in soybean and observed the treatment with *Rhizobium* RS-1 was significantly increased the N and K availability by 19.57 and 5.47 per cent over control due to increased nitrogen fixation with the *Rhizobium* inoculation. Similar findings were reported by Dubey[6]. At branching stage available N in soil was higher followed by flowering, pod formation and maturity stages and it was lower at harvest stage of soybean. The reason might be due to increase in uptake of available nitrogen by growing plants as compared to early stage of crop growth. Gupta *et al.,*[10] reported that the NO_3-N in the soil profile decreased with advancement of crop growth.

The data indicated that the difference in N availability in soil due to different liquid PSB levels was failed to reach the levels of significance at all the growth stages of soybean crop. The levels of liquid PSB was significantly not affected but the treatment B_2 (10ml of PSB kg^{-1} seed) recorded higher N content in soil at flowering (204.52 kg ha^{-1}), maturity (183.07 kg ha^{-1}) and at harvest (170.27 kg ha^{-1}). Treatment B_3- 15ml of PSB kg^{-1} seed recorded higher N content in soil at branching (216.96 kg ha^{-1}) and pod formation (192.70 kg ha^{-1}). Lower N content in soil was recorded with treatment B_0 (control). Similar results were observed by Dhage and Kachhave[4], Dhage *et al.,*[5] and Kumar and Majumdar[15].

Table 1: Influence of liquid bio-fertilizers on available nitrogen in soil at various growth stages of soybean

Treatments	Available nitrogen (kg ha^{-1})				
	Branching	Flowering	Pod formation	Maturity	Harvest
***Rhizobium* levels (A)**					
A_0 (0ml)	218.48	203.64	181.22	178.27	165.47
A_1 (5ml)	221.55	203.82	188.29	179.67	166.87
A_2 (10ml)	223.14	205.41	192.88	184.09	171.29
A_3 (15ml)	212.25	204.52	191.99	181.61	168.81
S.Em±	0.72	0.85	1.76	1.13	1.12
CD at 5%	NS	NS	3.82	3.25	3.24
PSB levels (B)					
B_0 (0ml)	211.20	203.23	190.94	178.87	166.07
B_1 (5ml)	212.87	203.78	191.61	179.91	167.11
B_2 (10ml)	219.40	204.52	192.14	183.07	170.27
B_3 (15ml)	216.96	204.11	192.70	181.82	169.02
S.Em±	0.72	0.85	0.76	1.13	1.12
CD at 5%	NS	NS	NS	NS	NS
Interaction (A×B)					
S.Em±	1.44	1.70	1.52	2.26	2.24
CD at 5%	NS	NS	NS	NS	NS

The interaction effect of liquid *Bradyrhizobium* and PSB (A×B) on nitrogen availability in soil was failed to reach the levels of significance. The combined treatment A_2B_2 was not significant but it gave highest N content in soil. The maximum N availability in soil with *Bradyrhizobium* + PSB might be due to increased N fixation with dual inoculation. Dubey[6] observed that co-inoculation of *Bradyrhizobium* + PSB gave maximum response in nitrogen fixation. However dual as well as multi inoculation of biofertilizers with or without FYM statistically increased the uptake of N and P. This might be attributed to enhanced activity of nitrogenase and nitrate-reductase enzyme in the soil[3], leading to greater biological nitrogen fixation by *Rhizobium*. Increased availability of P in the soil was due to greater solubilization of phosphate compound by phosphate solubilizing bacteria.

Available phosphorus

The data on P status in soil as influenced by different levels of liquid *Bradyrhizobium* and PSB are presented in table 2. Phosphorus availability in soil was not influenced significantly due to different liquid *Bradyrhizobium* levels but the higher P content in soil was recorded under the treatment A_2 (10ml of *Bradyrhizobium* kg^{-1} seed) at all the growth stages of soybean crop. At branching stage available P in soil was higher followed by flowering, pod formation and maturity stages and it was lower at harvest stage of soybean. Singh *et al*.,[21] observed that the inoculation of *Rhizobium* alone or any combination with nutrients slightly increased the Phosphorus availability in soil. Increased activity of micro-organisms in the rhizosphere was due to *Rhizobium* inoculation and their favorable effect on solubilizing and mineralizing compounds might be the reason for more available P in soil. The P content in soil was not influenced significantly by different liquid PSB levels at branching and flowering stages but it was significantly influenced at pod formation, maturity and at harvest stages (Table 2). The treatment B_2 (10ml of PSB kg^{-1} seed) recorded significantly higher available P at pod formation (30.15 kg ha^{-1}) maturity (24.11 kg ha^{-1}) and at harvest (21.65 kg ha^{-1}) stages of soybean over B_0 and B_1 treatments. The treatments B_0 (control) and B_1 (5ml PSB kg^{-1} seed) as well as B_2 (10ml PSB kg^{-1} seed) and B_3 (15ml PSB kg^{-1} seed) were on par with each other. This might be due to phosphate solubilizing micro-organisms which played a major role in solubilization of native and applied soil phosphorus and increased availability of P in soil[14]. Santosh *et al*., (2010)[19] reported that the PSB are known to have ability to solubilize P from insoluble source. The PSB secretes the different organic acids which act on insoluble phosphate to convert them in to soluble phosphate near the root of the plant and hence availability of P is increased.

Table 2: Effect of liquid bio-fertilizers on available phosphorus in soil at various growth stages of soybean

Treatments	Available Phosphorus (kg ha^{-1})				
	Branching	Flowering	Pod formation	Maturity	Harvest
***Rhizobium* levels (A)**					
A_0 (0ml)	54.96	42.10	28.63	18.31	15.85
A_1 (5ml)	54.95	42.16	28.62	19.85	17.39
A_2 (10ml)	56.08	43.22	29.75	22.45	19.99
A_3 (15ml)	55.89	43.03	29.56	21.83	19.37
S.Em±	0.77	0.76	0.82	1.12	1.13
CD at 5%	NS	NS	NS	NS	NS
PSB levels (B)					
B_0 (0ml)	54.66	41.80	25.33	18.23	15.77
B_1 (5ml)	55.00	42.14	25.67	19.13	16.67
B_2 (10ml)	56.48	43.62	30.15	24.11	21.65
B_3 (15ml)	55.76	42.90	29.43	23.03	18.54
S.Em±	0.77	0.76	0.82	1.12	1.13
CD at 5%	NS	NS	3.16	3.24	3.26
Interaction (A×B)					
S.Em±	1.54	1.52	1.64	2.24	2.26
CD at 5%	NS	NS	NS	NS	NS

At branching stage available P in soil was higher followed by flowering, pod formation and maturity stages and it was lower at harvest stage of soybean. The reason might be due to increase uptake of available phosphorus by growing plants as compared to early stage of crop growth. Deshmukh *et al*.,[3] reported that the P in the soil profile decreased with advancement of crop growth.

The interaction effect of liquid *Bradyrhizobium* and PSB (A×B) on phosphorus availability in soil was failed to reach the levels of significance.

Available potassium

Data indicating potassium availability in soil recorded at branching, flowering, pod formation, maturity and at harvest was presented in table 3. It was evident from the results that the availability of potassium was significantly not affected due to individual seed treatment with *Bradyrhizobium* and PSB levels. Potassium content in soil was not influenced significantly due to levels of liquid *Bradyrhizobium* but the higher K availability was recorded under the treatment A_2 (10ml of *Bradyrhizobium* kg^{-1} seed) at branching (538.67 kg ha^{-1}), flowering (458.76 kg ha^{-1}), pod formation (394.26 kg ha^{-1}), maturity (342.67 kg ha^{-1}) and at harvest (310.99 kg ha^{-1}). The highest K availability in soil may due to readily available potassium pool of the soil and lesser demand by crop.

Similarly liquid PSB levels also not influenced significantly but the higher potassium content in soil was recorded under the treatment B_2 (10ml of PSB kg^{-1} seed) at all the five growth stages of soybean *i.e.* at branching (544.46 kg ha^{-1}), flowering (464.65 kg ha^{-1}), pod formation (400.52 kg ha^{-1}), maturity (348.46 kg ha^{-1}) and at harvest (316.78 kg ha^{-1}). Normally lower potassium content was observed with A_0 (control) treatment at all the growth stages of soybean.

Table 3: Effect of liquid bio-fertilizers on available potassium in soil at various growth stages of soybean

Treatments	Available Potassium (kg ha^{-1})				
	Branching	Flowering	Pod formation	Maturity	Harvest
***Rhizobium* levels (A)**					
A_0 (0ml)	521.77	441.76	377.52	326.01	294.09
A_1 (5ml)	522.03	442.01	379.34	327.06	294.32
A_2 (10ml)	538.67	458.76	394.26	342.67	310.99
A_3 (15ml)	535.81	455.80	391.68	339.81	308.12
S.Em±	11.57	12.01	10.92	11.09	13.06
CD at 5%	NS	NS	NS	NS	NS
PSB levels (B)					
B_0 (0ml)	517.38	437.38	373.38	321.38	289.70
B_1 (5ml)	522.56	442.56	378.56	326.56	294.88
B_2 (10ml)	544.46	464.65	400.52	348.46	316.78
B_3 (15ml)	533.86	453.92	389.79	337.86	306.18
S.Em±	11.57	12.01	10.92	11.09	13.06
CD at 5%	NS	NS	NS	NS	NS
Interaction (A×B)					
S.Em±	23.15	24.02	21.84	22.18	26.12
CD at 5%	NS	NS	NS	NS	NS

The interaction effect of liquid *Bradyrhizobium* and PSB (A×B) on potassium availability in soil was failed to reach the levels of significance. Initially the availability of potassium was higher and then it declined with advancing crop age. The dual inoculation of *Rhizobium* + PSB on the available K is also due to the reduction in K fixation and release of K due to action of organic acids with clay resulting in the addition of K in the availability K pool in soil. Disintegration of K minerals due to release of organic acids by bio inoculants used for seed inoculation purpose. It was also noticed that dual inoculation of *Rhizobium* + PSB showed its superiority over single inoculation of PSB and *Rhizobium*. These results are in line with the finding of Sharma and Namdeo[20] ,Namdeo and Guptha[18].At branching stage available K in soil was higher followed by flowering, pod formation and maturity stages and it was lower at harvest stage of soybean. The reason might be due to increase uptake of available K by growing plants as compared to early stage of crop growth. Deshmukh *et al.*,[3] reported that K content in the soil profile decreased with advancement of crop growth.

Available sulphur

Data indicating availability of sulphur in soil recorded at branching, flowering, pod formation, maturity and at harvest was presented in table 4. It was evident from the results that the availability of sulphur was significantly not affected due to individual seed treatment with *Bradyrhizobium* and PSB levels. Sulphur content in soil was not influenced significantly due to levels of liquid *Bradyrhizobium* but the higher S availability was recorded under the treatment A_2 (10ml of *Bradyrhizobium* kg^{-1} seed) at branching (39.09 kg ha^{-1}), flowering (29.68 kg ha^{-1}), pod formation (19.72 kg ha^{-1}), maturity (16.60 kg ha^{-1}) and at harvest (14.58 kg ha^{-1}). The reason for more availability of S might be due to application of initial dose of S and microbial activity improved the availability of sulphur in soil.

Table 4: Effect of liquid bio-fertilizers on available sulphur in soil at various growth stages of soybean

	Available Sulphur (kg ha^{-1})				
	Branching	Flowering	Pod formation	Maturity	Harvest
***Rhizobium* levels (A)**					
A_0 (0ml)	36.97	28.55	18.09	15.47	13.31
A_1 (5ml)	37.08	28.92	18.60	15.48	13.47
A_2 (10ml)	39.09	29.68	19.72	16.60	14.58
A_3 (15ml)	38.90	29.49	19.53	16.41	14.39
S.Em±	0.77	0.75	0.82	0.91	0.77
CD at 5%	NS	NS	NS	NS	NS
PSB levels (B)					
B_0 (0ml)	36.67	28.26	18.30	15.18	13.18
B_1 (5ml)	37.01	28.60	18.64	15.52	13.52
B_2 (10ml)	38.49	30.08	20.12	17.00	15.00
B_3 (15ml)	37.77	29.36	19.40	16.28	14.28
S.Em±	0.77	0.75	0.82	0.91	0.77
CD at 5%	NS	NS	NS	NS	NS
Interaction (A×B)					
S.Em±	1.55	1.50	1.64	1.82	1.55
CD at 5%	NS	NS	NS	NS	NS

Similarly liquid PSB levels also not influenced significantly but the higher S content in soil was recorded under the treatment B_2- 10ml of PSB kg^{-1} seed at all the five growth stages of soybean *i.e.* at branching (38.49 kg ha^{-1}), flowering (30.08 kg ha^{-1}), pod formation (20.12 kg ha^{-1}), maturity (17.00 kg ha^{-1}) and at harvest (15.00 kg ha^{-1}) it might be due to application of initial dose of S and microbial activity improved the availability of sulphur. Normally lower S content was observed with A_0 and B_0 (control) treatment at all the five growth stages of soybean. The interaction effect of liquid *Bradyrhizobium* and PSB

(A×B) on sulphur availability in soil was failed to reach the levels of significance. At branching stage available S in soil was higher followed by flowering, pod formation and maturity stages and it was lower at harvest stage of soybean. The reason might be due to increase uptake of available S by growing plants as compared to early stage of crop growth. Jaipaul *et al*.,[13] reported that the S in the soil profile decreased with advancement of crop growth.

Soil chemical properties

Representative soil samples were collected from each plot after harvest of soybean crop to study the residual effect of liquid biofertilizers (*Bradyrhizobium* and PSB) on soil chemical properties. The result regarding pH, EC, organic carbon and $CaCO_3$ are presented in table 5.

Soil pH

The result regarding residual effect of liquid biofertilizers (*Bradyrhizobium* and PSB) on soil pH was presented in table 5. The result regarding pH of soil was not affected significantly due to individual seed treatment with *Bradyrhizobium* and PSB levels but the lower soil pH was recorded under the treatment A_3 (15ml of *Bradyrhizobium* kg^{-1} seed) (7.98) and B_2- 10ml PSB/kg seed (7.99), similarly higher soil pH was observed with A_0-control (8.23) and B_1-5ml PSB kg^{-1} seed (8.19) treatments.Harpal Singh *et al*.,[11] revealed that the effect of various treatments on soil pH with addition of organic and inorganic fertilizer is not consistent. The slight decrease in soil pH with bio-inoculants treatments may be ascribed to the secretion of organic acids by PSB, *Rhizobium and Azotobacter*.

Soil EC

The data indicated that the difference in soil EC values were not reach to the levels of significance due to individual and combined seed treatment with *Bradyrhizobium* and PSB levels. Minimum EC values was recorded under the treatments of A_3- 15ml of *Bradyrhizobium* kg^{-1} seed (0.21 dSm^{-1}) and B_3-15ml PSB kg^{-1} seed (0.21 dSm^{-1}), similarly minimum EC of soil was observed with A_1-5ml *Bradyrhizobium* (0.207 dSm^{-1}) and B_1-5ml PSB kg^{-1} seed (0.20 dSm^{-1}) treatments. This decrease in EC of post harvest soil sample might be due to leaching of salts due to rains and utilization of nutrients by crop. Similar results were also observed by Mann *et al*., (2006)[16].The interaction effect of liquid *Bradyrhizobium* and PSB (A×B) on soil EC was significant. Singh *et al.*[21] reported that a change in EC values were very close margin due to combined application of bio-inoculants with chemical fertilizers. Further, Govindan and Thirumurugan[7] did not found any change in EC with the treatment of bio-inoculants.

Organic carbon

The result regarding residual effect of liquid biofertilizers (*Bradyrhizobium* and PSB) on organic carbon was presented in table 5. It is evident from the results that the organic carbon content in soil was influenced significantly due to individual seed treatment with *Bradyrhizobium* and PSB levels. The treatment A_2 (10ml *Bradyrhizobium*) recorded significantly higher (10.7 g kg^{-1}) content of organic carbon over the A_0 and A_1 treatment. The treatments A_0 (control) and A_1 (5ml *Bradyrhizobium japonicum* kg^{-1} seed) as well as A_2 (10ml *Bradyrhizobium japonicum* kg^{-1} seed) and A_3 (15ml *Bradyrhizobium japonicum* kg^{-1} seed) were on par with each other. The lower organic carbon content (9.6 g kg^{-1}) was observed with treatment A_0 (control). The increase in organic carbon might be due to seed treatment with *Rhizobium* increased the activity of microbes and due to better root penetration and soybean shedder leaves. Gupta and Thomas[9] reported significant increase in organic carbon content with *Rhizobium* as compared with control. Organic carbon content in soil was significantly influenced due to different PSB levels. Among the PSB levels, significantly higher organic carbon (10.6 g kg^{-1}) content was recorded with treatment B_2- 10 ml of PSB kg^{-1} seed (Table 5) over the B_0 and B_1 inoculations. The treatment B_0 (control) and B_1 (5 ml of PSB kg^{-1} seed) as well as B_2 (10 ml of PSB kg^{-1} seed) and B_3 (15 ml of PSB kg^{-1} seed) were at par with each other. Significantly lower organic carbon (9.7 g kg^{-1}) content was observed with treatment B_0

(control). Further, it was observed from the data that the organic carbon in was increased in soil samples collected after harvest of soybean crop as compared to initial soil samples (5.4 g kg^{-1}). The increase in organic carbon might be due to seed treatment with *Rhizobium* and PSB increased the activity of microbes and due to better root penetration.

Table 5: Residual effect of liquid bio-fertilizers on soil chemical properties

Treatments	Soil pH (1: 2.5)	EC (dSm^{-1}) (1: 2.5)	OC (g kg^{-1})	$CaCO_3$ (%)
***Rhizobium* levels (A)**				
A_0 (0ml)	8.23	0.207	9.6	4.27
A_1 (5ml)	8.07	0.205	9.9	4.18
A_2 (10ml)	8.03	0.206	10.7	4.23
A_3 (15ml)	7.98	0.211	10.2	4.43
S.Em±	0.17	0.004	0.2	0.17
CD at 5%	NS	NS	0.6	NS
PSB levels (B)				
B_0 (0ml)	8.13	0.21	9.7	4.19
B_1 (5ml)	8.19	0.20	9.9	4.20
B_2 (10ml)	7.99	0.22	10.6	4.39
B_3 (15ml)	8.02	0.21	10.4	4.33
S.Em±	0.17	0.004	2.3	0.17
CD at 5%	NS	NS	0.6	NS
Interaction (A×B)				
S.Em±	0.34	0.009	0.4	0.34
CD at 5%	NS	NS	0.6	NS

Iraj *et al*.,[12] reported significant increase in organic carbon content with *Rhizobium* or PSB as compared with control.The interaction effect of liquid *Bradyrhizobium* and PSB (A×B) on organic carbon content failed to reach the levels of significance.

Calcium carbonate

The data regarding residual effect of liquid biofertilizers (*Bradyrhizobium* and PSB) on calcium carbonate after harvest of soybean crop was presented in table 5. The result revealed that there was not significant effect on $CaCO_3$ content in soil due to individual and combined seed treatment with *Bradyrhizobium* and PSB levels. However higher $CaCO_3$ was recorded due to individual treatment with A_3 - 15ml *Bradyrhizobium* (4.43 %) and B_2 -10ml PSB kg^{-1} seed (4.39 %). Lower $CaCO_3$ was recorded due to individual treatment with A_1 - 5ml *Bradyrhizobium* kg^{-1} seed (4.18 %) and B_0 -control (4.19 %). Further data revealed that there was decrease in $CaCO_3$ content in the post harvest soil samples than the initial (5.03 %) soil samples. The interaction effect of liquid *Bradyrhizobium* and PSB (A×B) on calcium carbonate content failed to reach the levels of significance. Uday and Jitender (2011)[23] a field experiment conducted on influence of integrated use of inorganic and organic sources of nutrients on growth and production of pea and reported that the calcium carbonate significantly not affected by the seed treatment with *Rhizobium*, PSB and combined inoculations.

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