Effect of soybean crop residue incorporation, Biofertilizers on nutrient uptake, yield of chickpea (*Cicer arietinum* L.)

ABSTRACT

The investigation was carried out on clay loam soil at Agricultural Research Station, Adilabad during *rabi*, 2020 with the aim to understand the chickpea crop performance with residue incorporation and use of biofertilizers along with varied NP recommended doses (0,50,75 and 100%). Results revealed that, *i.e.,* application of entire recommended dose of fertilizer *i.e.,* 20:50:20 kg ha^{-1} N: P_2O_5:K_2O recorded significantly higher grain yield (2558 kg ha^{-1}) and stover yield (3255 kg ha^{-1}) among all the treatments. Significantly superior nitrogen content (3.49 %), P content (0.53%), K content (1.62 %) and S content (0.34 %) by grain were observed with full dose of NPK application. Nutrient uptake of N (104.47 kg ha^{-1}), P (15.29 kg ha^{-1}), K (47.95 kg ha^{-1}) and S (10.13 kg ha^{-1}) by grain at harvest.

Keywords: Biofertilizers, Chickpea, Nutrient uptake and Yield.

1. INTRODUCTION

Pulses are one of the major food items to be involved in a vegetarian diet and are the cheapest source of protein and they are regarded as poor man's meat. Pulses contribute 16-18 percent of total protein of Indian diet in general. In addition, their role in maintaining soil fertility and health through natural nitrogen fixation is outstanding and thus they play a crucial role in sustainable agriculture. Chickpea (*Cicer arientinum* L.) is one of the major *rabi* pulse crops and it has digestible dietary protein (17-21 %). Chickpea is also rich in calcium, iron, niacin, vitamin C and vitamin B than other pulses. It's leaves contain malic acid which is very useful for stomach ailments and blood purification. In addition to above it also contains essential amino acids such as cysteine, methionine. The daily use of 14 g chickpea is source of approximately 2.3 per cent (56 kcal) energy and 4.7 per cent (2.7 g day^{-1}) daily protein needs to Indian population besides being a major source of calcium and iron (10-12 %) [1].

Chickpea is an extensive legume crop. It plays an important role in enhancing fertility status of soils due to nitrogen fixation by *Rhizobium* bacteria found in its root nodules. It is also called low input crop as it needs less fertilizer cost due to its nitrogen fixation property [1].

In addition, being a necessary ingredient of human food and animal feed, chickpea also plays a crucial role in sustaining soil productivity by fixing atmospheric nitrogen up to 35 kg ha^{-1} [3]. It has the potential to grow well in poor soils as well as to upgrade them because of its systematic N fixation system [2]. Chickpea economizes nitrogen application for succeeding cereal crop to the tune of 56-68 kg N ha^{-1} [4], which is one of the highest among pulses.

In leguminous crops, symbiosis is an additional factor which effects the internal physiological processes, leading to self-sufficiency in N-supply and in turn enhances the yield. Nitrogen fixing root nodule bacteria (*Rhizobia*) are of special interest because nitrogen is being constantly released in the atmosphere in the form of gas. The return process of N-fixation is a vital link in the nature without which life on earth would ultimately fade away [5].

2. MATERIAL AND METHODS

2.1 Experimental site and soil

A field experiment was carried out during *rabi*, 2020 on clay loam soil at Agricultural Research Station, Adilabad, (Telangana), during *rabi* period of 2020-21. Agricultural Research Station is situated in at 19°39´ N latitude and 78°32´ E longitude and belongs to tenth agro climatic zone of India *i.e.,* Southern plateau and hills and it is known as sub-humid with hot summer and cold winter. Based on the research work carried out and reported results of the experimental field at Adilabad, Agricultural Research Institute was clay loam in texture, neutral in soil reaction (pH 7.29), non saline in EC (0.12 dSm^{-1}), low in organic carbon (0.28 %) content. Primary nutrients *viz*., available N (223 kg ha^{-1}), available P (10.2 kg ha^{-1}) were low and available K (278 kg ha^{-1}) was medium. Secondary nutrient *i.e.*, available sulphur content was also found to be low (13.44 kg ha^{-1}).

2.2 Experimental design and treatments

The experiment was laid out in split plot design with 2 main factors *viz.*, without soybean residue incorporation and with soybean residue incorporation and 6 sub factors *viz.*, T_1: Absolute Control , T_2: 100 % RDF (20: 50: 20 kg ha^{-1} NPK), T_3: *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB Soil application @ 5kg ha^{-1}, T_4: *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +75 % RDN and 75 % RDP, T_5: *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 50 % RDN and 75 % RDP and T_6 : *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 50% RDN and 50% RDP were accommodated in chickpea during the experimentation. The crop was grown at a spacing of 30× 10 cm during first week of Nov, maintaining gross plot area of 3.9 cm × 5.2 cm.

2.3 Application of Biofertilizers and seed treatment

The required quantity of Phosphorus solubilizing Bacteria (Shelf-life period is 3 months) mixed with vermicompost and broadcasted @ 5 kg ha^{-1} to soil uniformly as per the treatments. Seeds of chickpea were treated with *Rhizobium* culture, ordinarily in all treatments except in T_1 (Control) and T_2 (100 % RDF (20: 50: 20 kg ha^{-1} NPK) treatments.

2.4 Dry matter accumulation (kg ha^{-1})

Five plants from each plot were selected randomly and uprooted carefully at 30, 60 and 90 DAS. After removing roots, the samples were kept in an oven at 60^0C for 48 hours till the constant weight was obtained. The samples were weighed on an electronic balance and then averaged to get dry matter accumulation in g $plant^{-1}$. Dry matter per plant was multiplied with no. of plants per ha and expressed in kg ha^{-1} finally.

2.5 Nutrient uptake (kg ha^{-1})

The nutrient uptake is obtained by multiplying the nutrient concentration with dry matter and dividing with 100.

3. RESULTS AND DISCUSSION

3.1 Dry matter production

The data on dry matter (kg ha^{-1}) produced at different stages of crop growth *viz*., 30, 60 and at 90 DAS are presented in Table 1. Chickpea dry matter increased with increase in age of crop from 30 to 90 DAS with application of inorganic and biofertilizers. Perusal of data on dry matter production (kg ha^{-1}) at 30 DAS with incorporation of soybean residue significantly affected when compared to without residue incorporation. The mean higher values 246.44 kg ha^{-1}, 225.11 kg ha^{-1} were registered with and without incorporation. This might be due to better nourishment derived from the soil as a result of balanced fertilization. The residue of soybean has a greater decomposition rate and there by release of nutrients into the soil might be the probable reason for higher dry matter recorded in residue incorporated plots than non incorporated plots. These results are in conformity with the study of [6].

Significantly higher dry matter (kg ha^{-1}) was observed in (T_2) 100 % RDF (20: 50: 20 kg ha^1 NPK) among fertilizers and biofertilizers applied treatments (sub treatments) (264.50 kg ha^{-1}). However, it was found on par with T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75 % RDN and 75 % RDP) (253.67 kg ha^{-1}) and with (T_5) (252.50 kg ha^{-1}). Significantly, lowest dry matter recorded at control (T_1) (195.17 kg ha^{-1}). Increase in dry matter, due to better nourishment derived from the soil as a result of balanced fertilization which improves soil nutrient status. Similar results have also been reported by [6]. Interaction effect at 30 DAS of chickpea on dry matter was found to be non significant.

Dry matter produced at 60 and 90 DAS of chickpea was significantly affected by residue incorporation (1961.11 kg ha^{-1} and 2995.56 kg ha^{-1}) when compared to without residue incorporation (1768.89 kg ha^{-1} and 2638.89 kg ha^{-1}) (Table 1). This might be due to *Rhizobium* inoculation, when applied in combination with PSB, improves the number and dry weight of nodules, branches per plant, root length, shoot length, dry matter production of chickpea was noticed when compared to control as reported by [7].

Significantly, higher dry matter was recorded at T_2 during 60 and 90 DAS due to 100 % RDF (20: 50: 20 kg ha^1 NPK) (2148.33 kg ha^{-1} and 3140.83 kg ha^{-1}) when compared to control (T_1) (1420 kg ha^{-1} and 2306.67 kg ha^{-1}). However, it was found on par with *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75 % RDN and 75 % RDP (2100 kg ha^{-1}, 3106.67 kg ha^{-1}) and with (T_4) (2045 kg ha^{-1}, 2993.33 kg ha^{-1}). A higher amount of dry matter accumulation in *Rhizobium* inoculated plants is attributable to more N availability to plants. *Rhizobium* have a positive effect on biomass production. Effect of biofertilizers inoculation in conjugation with different doses of chemical fertilizers increased the plant dry weight. Similar results are found with Bai *et al.* (2014) [8].

Data pertaining to interaction affect between soybean residue incorporation and graded level of fertilizers along with biofertilizers on dry matter was significant at 60 and 90 DAS of chickpea. Mean highest dry matter at 60 DAS was noticed in soybean residue incorporation and application of inorganic fertilizers and biofertilizers M_2T_2 (2186.67 kg ha^{-1}). However, it was on par with M_2T_4 (2166.67 kg ha^{-1}) and with M_2T_5 (2045 kg ha^{-1}). Significantly, lowest values of dry matter noticed at control M_2T_1 (1543.33 kg ha^{-1}). Similar trend was noticed at 90 DAS. This might be due to incorporation of soybean residue has a greater decomposition rate and there by release of nutrients into the soil and also due to *Rhizobium* inoculation, when applied in combination with PSB, improves the branches per plant, number and dry weight of nodules, and also increase in dry matter production of chickpea. Similar results have also been reported by Yagoub *et al*. (2015) [6].

3.2 Seed yield

The data on seed yield (kg ha^{-1}) (Table 2 and depicted in fig.1) with incorporation of soybean residue significantly enhanced when compared to without soybean residue incorporation. The mean values of 2209.31 kg ha^{-1} and 1819.31 kg ha^{-1} were registered with and without incorporation of soybean residue. The mean lowest chickpea seed yield recorded at control (T_1) (1011.45 kg ha^{-1}). However, higher seed yield procured with T_2 (100% RDF (20: 50: 20 kg ha^1 NPK) (2558.33 kg ha^{-1}) but it was found on par with T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP) (2537.50 kg ha^{-1}) and T_5 (application of *Rhizobium* seed treatment @ 25 g kg^{-1} + PSB soil application @ 5 kg ha^{-1} + 50% RDN and 75 % RDP) (2517.50 kg ha^{-1}). An increase in the yield was observed with application of recommended dose of fertilizers along with biofertilizers.

Application of Nitrogen enhanced nodulation by increasing the supply of nitrogen containing proteins which are essential for multiplication and growth of *Rhizobia* and inoculated phosphobacteria. Similar results are found with Kumari *et al*. (2015) [9].

The interaction between residue incorporation and fertilizer levels along with biofertilizers on seed yield was found to be significant. Among all treatments mean higher seed yield was observed in M_2T_2 (2558.33 kg ha^{-1}) but it was on par with M_2T_4 (2746.43 kg ha^{-1}) and M_2T_5 (2737.76 kg ha^{-1}).

Lowest seed yield recorded at control M_2T_1 (1188.20 kg ha^{-1}). The higher seed yield may be attributed to release of sufficient plant nutrients from inorganic sources required for better crop growth and yield and also due to *Rhizobium* inoculation, when applied alone or in combination with PSB, improves the number and dry weight of nodules, branches per plant, pods per plant and seed yiled of chickpea. The findings are in agreement with the results of Chauhan and Raghav (2017) [10].

Table 1. Effect of treatments on dry matter (kg ha^{-1}) of chickpea crop.

Treatments	Dry matter (kg ha^{-1})								
	30 DAS			60 DAS			90 DAS		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	186.33	204.00	195.17	1296.67	1543.33	1420.00	2126.67	2486.67	2306.67
T_2	251.67	277.33	264.50	2110.00	2186.67	2148.33	3008.33	3273.33	3140.83
T_3	205.33	224.67	215.00	1506.67	1736.67	1621.67	2360.00	2780.00	2570.00
T_4	243.00	264.33	253.67	2033.33	2166.67	2100.00	2966.67	3246.67	3106.67
T_5	241.00	264.00	252.50	1926.67	2163.33	2045.00	2793.33	3193.33	2993.33
T_6	223.33	244.33	233.83	1740.00	1970.00	1855.00	2578.33	2993.33	2785.83
Mean	**225.11**	**246.44**		**1768.89**	**1961.11**		**2638.89**	**2995.56**	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	2.72	16.56		25.77	156.80		47.89	291.39	
Sub	5.83	17.19		156.80	126.24		47.71	140.75	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	8.24	NS		60.52	178.53		67.47	199.05	
Factor (A) at same level of B	8.00	NS		60.96	213.98		78.02	322.30	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.

T_1 = Control (0 % RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50% RDN and 75% RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

3.3 Stover yield

Stover yield (kg ha^{-1}) (Table 2 and depicted in fig.1) with incorporation of soybean residue significantly enhanced when compared to without incorporation. The mean values 2882.25 kg ha^{-1} and 2544.37 kg ha^{-1} were registered with and without incorporation of soybean residue. The mean lowest stover yield recorded at control (T_1) (1675.19 kg $ha^{-1)}$. However, higher stover yield procured with T_2 (100 % RDF (20: 50: 20 kg ha^{1} NPK) (3255.33 kg ha^{-1}). But, it was found on par with T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75 % RDN and 75 % RDP) (3241.50 kg ha^{-1}) and T_5 (application of *Rhizobium* seed treatment @ 25 g kg^{-1} + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 75 % RDP) (3231.29 kg ha^{-1}). The increased availability of nitrogen, phosphorus and their synergistic effect might have increased root growth and nodulation there by increased nitrogen fixation and enhanced yield and yield parameters and higher absorption and utilization of nutrients. Similar results are found with Kumari *et al.* (2015) [9].

Significant effect due to residue incorporation and fertilizers treatments was found on stover yield. Mean higher stover yiled among all treatments was recorded at M_2T_2 (3405.67 kg ha^{-1}). This was on par with M_2T_4 (3405 kg ha^{-1}) and M_2T_5 (3401.33 kg ha^{-1}). Lowest seed yield was recorded at control M_2T_1 (1846.38 kg ha^{-1}). It may be due to higher nutrient uptake by plants increase the growth of plant which ultimately increase stover yield and also due to, application of 100% RDP + PSB affected positively on seed yield, content of N, P, K and S & also their uptake by chickpea seeds as well as stover yield. These findings are in line with the results of Gangawar and Dubey (2012) [11].

Table 2. Effect of treatments on seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) of chickpea crop.

Treatments	**Seed yield (kg ha^{-1})**			**Stover yield (kg ha^{-1})**		
	M_1	M_2	Mean	M_1	M_2	Mean
T_1	834	1188	1011	1504	1846	1675
T_2	2347	2769	2558	3105	3405	3255
T_3	1344	1587	1466	2014	2376	2195
T_4	2328	2746	2537	3078	3405	3241
T_5	2297	2737	2517	3061	3401	3231
T_6	1763	2226	1995	2504	2858	2681
Mean	**1819**	**2209**		**2544**	**2882**	
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
Main	27.28	165.98		50.94	309.97	
Sub	22.59	66.63		47.06	138.82	
Interactions	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
Factor (B) at same level of A	31.94	94.22		66.55	196.32	
Factor (A) at same level of B	39.93	176.21		79.28	336.49	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.

T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +50% RDN and 75 % RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

3.4 Nutrient content and uptake of chickpea at growth stages and at harvest.

It is necessary to determine amount of nutrients removed by crop to improve the production efficiency as well as to know the soil fertility status. Amount of uptake of nutrients by crop increased with increased levels of fertilizer application along with application of biofertilizer.

3.4.1 Nitrogen content

Nutrient content of chickpea crop was enhanced with the age of crop. More nitrogen content was observed at harvest stage. Data pertaining to N content at 30,60,90 DAS and at harvest stage by the crop, grain and stover at harvest are presented in Table 3. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). N content ranged from 0.64 to 2.92 and 0.75 to 3.19 % with the advancement of crop from 30 DAS to harvest stage in major treatments.

Graded levels of N, P fertilizers in combination with biofertilizers had shown significant influence on N content at various stage. The mean N content recorded by grain and stover at harvest, 90 and 60 DAS by crop are 3.49,1.40,1.25 and 1.01 respectively. Mean higher N content at 30 DAS was recorded with T_2 (100% RDF) and T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP) was 0.82. However, at 60,90 DAS and at harvest stage by grain and stover mean higher N content noticed with T_2 treatment (100% RDF) only. Mean lower value was observed at control (T_1) (0.50). Interaction effect was found to be non significant.

3.4.2 Phosphorus content

Nutrient content of chickpea crop was enhanced with the age of crop. More phosphorus content was observed at harvest stage. Data pertaining to P content at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 4. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). P content ranged from 0.05 to 0.23 and 0.06 to 0.25% with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of N P fertilizers in combination with biofertilizers had shown significant influence on P content at various stages of crop growth. The mean P content by grain and stover at harvest stage, 90 and 60 DAS by crop are 0.53, 0.27, 0.09 and 0.08, respectively. Mean higher P content at 30 DAS was recorded with T_2 (100% RDF) and T_5 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 50% RDN and 75% RDP) was 0.07. However, at 60, 90 DAS and at harvest stage by grain and stover mean higher P content noticed with T_2 treatment (100% RDF) only. Mean lower values were observed at control (0.01). Interaction effect was found to be non significant.

3.4.3 Potassium content

Nutrient content of chickpea crop was enhanced with the age of crop. More potassium content was observed at harvest stage. Data pertaining to K content at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 5. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). K content ranged from 0.91 to 1.52 and 0.94 to 1.57 % with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of N P fertilizers in combination with biofertilizers had shown significant influence on K content at various stages of crop growth period. The mean K content by grain and stover at harvest stage, 90 and 60 DAS by crop are 1.62,1.41,1.24 and 1.04 % respectively. Mean higher K content at 30 DAS was recorded with T_2 (100% RDF) and T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 75 % RDN and 75 % RDP) was 0.97. However, at 60,90 DAS and at harvest stage by grain and stover mean higher K content noticed with T_2 treatment (100 % RDF) only. Mean lower value was observed at control (0.85). Interaction effect was found to be non significant.

3.4.4 Sulphur content

Nutrient content of chickpea crop was enhanced with the age of crop. More sulphur content was observed at harvest stage. Data pertaining to S content at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 6. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). S content ranged from 0.04 to 0.25 and 0.05 to 0.30 % with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of N P fertilizers in combination with biofertilizers had shown significant influence on S content at various stages of crop growth. The mean S content recorded by grain and stover at harvest stage, 90 and 60 DAS by crop are 0.34, 0.26, 0.09 and 0.07 respectively. Mean higher S content at 30 DAS was recorded with T_2 (100% RDF) and T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP) was 0.06. However, at 60, 90 DAS and at harvest stage by grain and stover mean higher S content noticed with T_2 treatment (100% RDF) only Mean lower value was observed at control (0.03).

Interaction effect was found to be non significant. Application of combination of fertilizers along with bio fertilizer application was showed superiority in N, P, K and S content in different growth stages along with grain and stover of chickpea crop over control. The increased in N content might be due to enhanced symbiosis fixation [12]. Nitrogen, phosphorus, potassium and sulphur content was found to increased due to proper establishment of *Rhizobium* + PSB which supply nutrients and secreted certain growth promoting substances that results better root development enhances the concentration and deposition of nutrients. Similar results are given by Singh *et al*. (2018) [13]. And also, application of PSB increased the availability of P might be due to the organic acid which were released during microbial decomposition of organic matter which helped in the solubility of native phosphate and resulted in higher P content in grain and stover. The results are similar to the findings of Verma *et al.* (2020) [14] and Morshed *et al.* (2008) [15].

Table 3. Effect of treatments on nutrient content of nitrogen (%) at various growth periods (30, 60,90 DAS and at harvest) of chickpea.

Treatments	**Nitrogen content (%)**														
	30 DAS			**60 DAS**			**90 DAS**			**At harvest (Grain)**			**At harvest (Stover)**		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.46	0.54	0.50	0.47	0.58	0.52	0.78	0.82	0.80	2.12	2.32	2.22	0.96	1.10	1.03
T_2	0.76	0.89	0.82	0.97	1.06	1.01	1.17	1.32	1.25	3.37	3.61	3.49	1.37	1.43	1.40
T_3	0.56	0.64	0.60	0.58	0.71	0.64	0.87	0.99	0.93	2.42	2.86	2.64	1.06	1.21	1.14
T_4	0.75	0.88	0.82	0.92	1.03	0.98	1.15	1.31	1.23	3.34	3.61	3.48	1.30	1.41	1.36
T_5	0.70	0.84	0.77	0.89	0.95	0.92	1.12	1.30	1.21	3.33	3.58	3.45	1.30	1.37	1.34
T_6	0.60	0.74	0.67	0.70	0.82	0.76	1.02	1.16	1.09	2.94	3.17	3.06	1.17	1.30	1.23
Mean	**0.64**	**0.75**		**0.76**	**0.86**		**1.02**	**1.15**		**2.92**	**3.19**		**1.19**	**1.30**	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.019	0.1154		0.014	0.0869		0.016	0.0994		0.035	0.2155		0.017	0.1045	
Sub	0.026	0.076		0.037	0.110		0.041	0.121		0.134	0.395		0.033	0.097	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.037	NS		0.053	NS		0.058	NS		0.189	NS		0.046	NS	
Factor (A) at same level of B	0.038	NS		0.050	NS		0..055	NS		0.176	NS		0.046	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +50% RDN and 75 % RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

Table 4. Effect of treatments on nutrient content of phosphorus (%) at various growth periods (30, 60, 90 DAS and at harvest) of chickpea.

Treatments	Phosphorus content (%)														
	30 DAS			60 DAS			90 DAS			At harvest (Grain)			At harvest (Stover)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.013	0.024	0.019	0.033	0.037	0.035	0.037	0.045	0.041	0.350	0.400	0.375	0.177	0.187	0.182
T_2	0.070	0.083	0.077	0.075	0.091	0.083	0.088	0.096	0.092	0.500	0.563	0.532	0.260	0.280	0.270
T_3	0.024	0.037	0.030	0.040	0.055	0.048	0.045	0.061	0.053	0.390	0.457	0.423	0.207	0.213	0.210
T_4	0.056	0.072	0.064	0.066	0.083	0.075	0.071	0.089	0.080	0.470	0.547	0.508	0.257	0.280	0.268
T_5	0.068	0.082	0.075	0.073	0.089	0.081	0.086	0.093	0.090	0.480	0.553	0.517	0.257	0.280	0.268
T_6	0.041	0.053	0.047	0.055	0.071	0.063	0.061	0.077	0.069	0.423	0.512	0.468	0.230	0.250	0.240
Mean	**0.05**	**0.06**		**0.06**	**0.07**		**0.06**	**0.08**		**0.23**	**0.25**		**0.44**	**0.51**	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.002	0.0098		0.001	0.0062		0.002	0.0098		0.002	0.0145		0.011	0.0661	
Sub	0.004	0.0117		0.004	0.0126		0.004	0.0123		0.009	0.00274		0.014	0.0402	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.006	NS		0.006	NS		0.006	NS		0.013	NS		0.019	NS	
Factor (A) at same level of B	0.005	NS		0.006	NS		0.006	NS		0.012	NS		0.021	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.

T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +50% RDN and 75 % RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

Table 5. Effect of treatments on nutrient content of potassium (%) at various growth periods (30, 60, 90 DAS and at harvest) of chickpea.

Treatments	Potassium content (%)														
	30 DAS			**60 DAS**			**90 DAS**			**At harvest (Grain)**			**At harvest (Stover)**		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.84	0.86	0.85	0.86	0.87	0.87	1.03	1.07	1.05	1.42	1.47	1.44	1.19	1.22	1.21
T_2	0.98	1.01	0.99	1.01	1.06	1.04	1.21	1.27	1.24	1.61	1.63	1.62	1.37	1.45	1.41
T_3	0.86	0.90	0.88	0.89	0.93	0.91	1.08	1.13	1.10	1.46	1.51	1.49	1.22	1.31	1.26
T_4	0.97	0.97	0.97	0.99	1.03	1.01	1.19	1.27	1.23	1.57	1.62	1.60	1.36	1.45	1.40
T_5	0.95	0.95	0.95	0.98	1.03	1.01	1.18	1.25	1.22	1.55	1.59	1.57	1.34	1.44	1.39
T_6	0.89	0.94	0.92	0.94	0.98	0.96	1.13	1.19	1.16	1.51	1.56	1.53	1.27	1.37	1.32
Mean	**0.91**	**0.94**		**0.95**	**0.99**		**1.14**	**1.20**		**1.52**	**1.57**		**1.29**	**1.37**	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.002	0.0115		0.006	0.0385		0.010	0.0588		0.004	0.0215		0.013	0.0799	
Sub	0.011	0.032		0.015	0.045		0.016	0.048		0.013	0.039		0.019	0.057	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.015	NS		0.022	NS		0.023	NS		0.019	NS		0.027	NS	
Factor (A) at same level of B	0.045	NS		0.021	NS		0.023	NS		0.018	NS		0.028	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.

T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +50% RDN and 75 % RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

Table 6. Effect of treatments on nutrient content of sulphur (%) at various growth periods (30, 60, 90 DAS and at harvest stage) of chickpea.

Treatments	Sulphur content (%)														
	30 DAS			60 DAS			90 DAS			At harvest (Grain)			At harvest (Stover)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.031	0.035	0.03	0.042	0.043	0.04	0.056	0.062	0.06	0.147	0.173	0.16	0.157	0.190	0.17
T_2	0.052	0.065	0.06	0.070	0.077	0.07	0.089	0.099	0.09	0.307	0.370	0.34	0.243	0.277	0.26
T_3	0.033	0.048	0.04	0.050	0.050	0.05	0.063	0.075	0.07	0.213	0.240	0.23	0.190	0.210	0.20
T_4	0.052	0.063	0.06	0.068	0.076	0.07	0.084	0.098	0.09	0.307	0.367	0.34	0.243	0.270	0.26
T_5	0.051	0.062	0.06	0.065	0.070	0.07	0.081	0.097	0.09	0.297	0.366	0.33	0.243	0.260	0.25
T_6	0.043	0.054	0.05	0.058	0.063	0.06	0.075	0.083	0.08	0.243	0.315	0.28	0.213	0.240	0.23
Mean	**0.040**	**0.051**		**0.059**	**0.063**		**0.07**	**0.09**		**0.252**	**0.305**		**0.215**	**0.241**	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.002	0.011		0.001	0.003		0.0010	0.0089		0.005	0.032		0.003	0.016	
Sub	0.003	0.007		0.002	0.005		0.003	0.009		0.018	0.051		0.010	0.028	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.004	NS		0.003	NS		0.005	NS		0.073	NS		0.039	NS	
Factor (A) at same level of B	0.004	NS		0.002	NS		0.004	NS		0.072	NS		0.039	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation. T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} +50% RDN and 75% RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

3.4.5 Nitrogen uptake

Nitrogen uptake of chickpea crop was enhanced with the age of crop. More nitrogen uptake was observed at harvest stage. Data pertaining to nitrogen uptake at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 7. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). nitrogen uptake ranged from 1.44 to 26.91 and 1.84 to 34.44 kg ha^{-1} with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of N P fertilizers in combination with biofertilizers had shown significant influence on nitrogen uptake at various stages of crop growth period by grain and stover at harvest stage, 90 and 60 DAS by crop are 104.47, 50.55, 40.72 and 22.31 kg ha^{-1} respectively. Mean higher nitrogen uptake at 30 DAS was recorded with T_2 (100% RDF) (2.25 kg ha^{-1}) followed T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP) was 2.07 kg ha^{-1}. Mean lower value was observed at control (T_1) (0.98 kg ha^{-1}). Interaction effect was found to be non significant.

3.4.6 Phosphorus uptake

Phosphorus uptake of chickpea crop was enhanced with the age of crop. More phosphorus uptake was observed at harvest stage. Data pertaining to phosphorus uptake at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 8. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). Phosphorus uptake ranged from 0.110 to 1.58 and 1.47 to 2.39 kg ha^{-1} with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of N P fertilizers in combination with biofertilizers had shown significant influence on phosphorus uptake at various stages of crop growth. The mean P uptake by grain and stover 90 and 60 DAS by crop are 15.29, 9.98, 2.65 and 1.71 kg ha^{-1} respectively. Mean higher phosphorus uptake at 30 DAS was recorded with T_2 (100% RDF) (0.195 kg ha^{-1}) followed T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP) was 0.180 kg ha^{-1}. Mean lower value was observed at control (T_1) (0.038 kg ha^{-1}). Interaction effect was found to be non significant.

3.4.7 Potassium uptake

Potassium uptake of chickpea crop was enhanced with the age of crop. More potassium uptake was observed at harvest stage. Data pertaining to potassium uptake at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 9. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). Potassium uptake ranged from 2.048 to 30.116 and 2.316 to 35.94 kg ha^{-1} with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of NP fertilizers in combination with biofertilizers had shown significant influence on potassium uptake at various stages of crop growth. The mean K uptake by grain and stover at harvest stage, 90 and 60 DAS by crop. are 47.95, 52.20, 40.46 and 23.04 kg ha^{-1} respectively. Mean higher potassium uptake at 30 DAS was recorded with T_2 (100% RDF) (2.66 kg ha^{-1}) followed T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 75% RDN and 75% RDP) was 2.51 kg ha^{-1}. Mean lower value was observed at control (T_1) (1.65 kg ha^{-1}). Interaction effect was found to be non significant.

3.4.8 Sulphur uptake

Nutrient uptake of chickpea crop was enhanced with the age of crop. More sulphur uptake was observed at harvest stage. Data pertaining to sulphur uptake at 30,60,90 DAS by the crop, grain and stover at harvest are presented in Table 10. Incorporation of soybean residue (M_2) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M_1). Sulphur uptake ranged from 0.090 to 1.847 and 0.125 to 2.696 kg ha^{-1} with the advancement of crop from 30 DAS to 90 DAS in major treatments.

Graded levels of N P fertilizers in combination with biofertilizers had shown significant influence on sulphur uptake at various stages of crop growth. The mean S uptake by grain and stover at harvest stage, 90 and 60 DAS by crop. The mean values are 10.13,9.55, 3.02 and 1.64 kg ha^{-1} respectively. Mean higher potassium uptake at 30 DAS was recorded with T_2 (100% RDF) (0.159 kg ha^{-1}) followed T_4 (*Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 75% RDN and 75% RDP) was 0.148 kg ha^{-1}. Mean lower value was observed at control (T_1) (0.06 kg ha^{-1}). Interaction effect was found to be non significant.

Analysing nutrient content and uptake is the most obvious characteristic for evaluating the effects of PSB [16]. Chickpea crop is heavy feeder of phosphorus and less response of nitrogen because of their capacity to meet their own nitrogen requirement through symbiotic fixation. The increased in N content might be due to *Rhizobium* treatment enhanced symbiosis fixation. Nitrogen and Phosphate fertilization of chickpea promotes growth, nodulation enhance nutrient content and uptake of chickpea crop. Similar findings are found with Singh *et al.* (2016) [12]. Different fertility levels and biofertilizers had significant effect on nutrient uptakes. The maximum uptake enhanced due to more total N uptake at higher fertility levels were revealed to better N nutrition and its accumulation in seed and stover [13]. However, nutrients (total nitrogen, phosphorus, potassium and sulphur) uptake by the crop was recorded with the application of *Rhizobium* + PSB was significantly higher uptake. This might be due to the fact that microorganisms help in nitrogen fixation, solubilization, mobilization of plant nutrients and reduce the need for chemical fertilizers and enhances the nutrients availability and uptake to plants. Similar findings have also corroborated by Patel *et al.* (2013) [17]. In this study, N, P, K and S content and uptake were promoted by the PSB inoculation, demonstrating that PSB elevated the amounts of N, P, K and S content and uptake in the crop and subsequently better nutrition for plant growth. Similar findings are also related with Diao *et al*. (2018) [18].

Table 7. Effect of treatments on nutrient uptake of nitrogen (kg ha^{-1}) at various growth periods (30, 60 ,90 DAS and at harvest stage of chickpea.

Treatments	Nitrogen uptake (kg ha^{-1})														
	30 DAS			60 DAS			90 DAS			At harvest (Grain)			At harvest (Stover)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.84	1.06	0.98	5.94	8.23	7.61	19.01	19.23	20.15	17.57	28.57	23.07	14.45	20.33	17.39
T_2	1.93	2.40	2.25	19.61	23.97	22.31	34.95	44.44	40.72	96.00	112.94	104.47	46.20	54.91	50.55
T_3	1.14	1.40	1.29	8.48	11.83	10.68	19.66	26.56	24.14	35.10	45.16	40.13	21.47	28.94	25.21
T_4	1.80	2.25	2.07	18.01	21.93	20.50	31.72	41.48	37.62	75.66	100.12	87.89	41.99	48.41	45.20
T_5	1.68	2.20	1.96	16.60	19.70	18.68	30.87	41.13	37.03	80.48	99.13	89.81	40.10	46.61	43.35
T_6	1.32	1.80	1.57	12.01	15.50	14.23	25.23	33.80	30.54	54.57	72.09	63.33	29.19	36.75	32.97
Mean	**1.44**	**1.85**		**13.44**	**16.86**		**26.91**	**34.44**		**59.90**	**76.33**		**32.23**	**39.32**	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.03	0.22		0.22	1.45		0.54	3.56		1.10	7.26		0.62	4.08	
Sub	0.07	0.23		0.52	1.55		1.13	3.35		2.64	7.86		1.15	3.43	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.08	NS		0.54	NS		1.33	NS		2.71	NS		1.52	NS	
Factor (A) at same level of B	0.10	NS		0.71	NS		1.55	NS		3.59	NS		1.61	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +50% RDN and 75% RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 50 % RDN and 50 % RDP.

Table 8. Effect of treatments on nutrient uptake of phosphorus (kg ha^{-1}) at various growth periods (30, 60,90 DAS and at harvest stage) of chickpea.

Treatments	Phosphorus uptake (kg ha^{-1})														
	30 DAS			60 DAS			90 DAS			At harvest (Grain)			At harvest (Stover)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.024	0.044	0.038	0.408	0.479	0.499	0.622	1.137	0.950	2.885	4.757	3.821	2.645	3.449	3.047
T_2	0.168	0.215	0.195	1.396	1.913	1.710	2.043	3.126	2.656	13.447	17.137	15.292	9.097	10.874	9.986
T_3	0.047	0.078	0.066	0.579	0.866	0.778	0.885	1.712	1.369	5.243	7.252	6.247	4.135	5.070	4.602
T_4	0.145	0.207	0.180	1.397	1.851	1.680	2.279	3.117	2.769	11.485	15.423	13.454	7.956	9.478	8.717
T_5	0.165	0.213	0.193	1.362	1.828	1.650	2.266	3.032	2.720	11.179	15.198	13.189	7.888	9.534	8.711
T_6	0.089	0.126	0.111	0.940	1.294	1.173	1.404	2.304	1.925	7.479	11.383	9.431	5.790	7.022	6.406
Mean	**0.110**	**0.147**		**1.061**	**1.372**		**1.583**	**2.396**		**8.620**	**11.858**		6.252	7.571	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.002	0.016		0.019	0.126		0.037	0.243		0.188	1.233		0.157	1.031	
Sub	0.012	0.036		0.089	0.264		0.122	0.362		0.192	0.570		0.229	0.680	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.006	NS		0.047	NS		0.091	NS		0.461	NS		0.386	NS	
Factor (A) at same level of B	0.016	NS		0.116	NS		0.162	NS		0.311	NS		0.335N	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.

T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} +50% RDN and 75 % RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 50 % RDN and 50 % RDP.

Table 9. Effect of treatments on nutrient uptake of potassium (kg ha^{-1}) at various growth periods (30, 60,90 DAS and at harvest stage) of chickpea.

Treatments	Potassium uptake (kg ha^{-1})														
	30 DAS			**60 DAS**			**90 DAS**			**At harvest (Grain)**			**At harvest (Stover)**		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	1.52	1.72	1.65	11.30	12.99	12.26	21.86	26.20	24.31	11.83	17.47	14.65	17.86	22.59	20.22
T_2	2.47	2.79	2.66	21.33	24.53	23.04	36.95	43.42	40.46	45.01	50.89	47.95	48.08	56.32	52.20
T_3	1.73	1.99	1.89	13.61	15.82	14.83	25.54	30.79	28.45	19.67	24.03	21.85	24.55	31.07	27.81
T_4	2.32	2.63	2.51	19.27	22.32	20.91	33.62	40.25	37.22	36.98	44.71	40.85	42.06	49.08	45.57
T_5	2.26	2.49	2.40	18.83	21.80	20.43	33.30	40.01	36.94	36.10	43.76	39.93	41.12	48.94	45.03
T_6	1.95	2.26	2.14	16.43	19.02	17.84	29.18	34.99	32.37	26.57	34.66	30.61	31.82	38.71	35.26
Mean	**2.04**	**2.31**		**16.8**	**19.41**		**30.08**	**35.94**		**29.36**	**35.92**		34.25	41.12	
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.026	0.168		0.461	3.017		0.760	4.979		0.226	1.480		0.511	3.348	
Sub	0.061	0.181		0.525	1.561		0.730	2.169		0.488	1.449		0.940	2.793	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.063	NS		1.128	NS		1.862	NS		0.553	NS		1.252	NS	
Factor (A) at same level of B	0.083	NS		0.820	NS		1.211	NS		0.669	NS		1.317	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} +50% RDN and 75% RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 50% RDN and 50% RDP.

Table 10. Effect of treatments on nutrient uptake of sulphur (kg ha^{-1}) at various growth periods (30, 60, 90 DAS and at harvest stage) of chickpea.

Treatments	Sulphur uptake (kg ha^{-1})														
	30 DAS			60 DAS			90 DAS			At harvest (Grain)			At harvest (Stover)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	0.049	0.0041	0.066	0.535	0.608	0.607	1.0342	1.598	1.363	1.234	2.056	1.645	2.420	3.517	2.968
T_2	0.123	0.181	0.159	1.460	1.767	1.649	2.473	3.473	3.020	8.773	11.495	10.134	8.630	10.483	9.557
T_3	0.057	0.105	0.088	0.737	0.814	0.811	1.337	2.136	1.783	2.878	3.823	3.350	3.827	5.003	4.415
T_4	0.114	0.168	0.148	1.312	1.581	1.482	2.315	3.244	2.826	7.050	10.133	8.591	7.447	9.367	8.407
T_5	0.113	0.163	0.145	1.219	1.451	1.370	2.143	3.196	2.716	6.910	10.053	8.481	7.490	8.853	8.172
T_6	0.085	0.129	0.114	0.999	1.193	1.131	1.779	2.530	2.201	4.293	7.018	5.655	5.347	6.767	6.057
Mean	**0.090**	**0.125**		**1.043**	**1.235**		**1.847**	**2.696**		**5.189**	**7.430**		5.860	7.332	
		CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Main	0.004	0.027		0.027	0.174		0.063	0.410		0.141	0.925		0.031	0.202	
Sub	0.007	0.022		0.051	0.151		0.087	0.259		0.325	0.966		0.278	0.826	
Interactions	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
Factor (B) at same level of A	0.010	NS		0.065	NS		0.153	NS		0.346	NS		0.075	NS	
Factor (A) at same level of B	0.011	NS		0.071	NS		0.129	NS		0.443	NS		0.360	NS	

M_1= Without soybean crop residue incorporation, M_2= With soybean crop residue incorporation.

T_1 = Control (0% RDF), T_2 = 100% RDF (20: 50: 20 kg ha^{-1} NPK), T_3 = *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1}, T_4= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5 kg ha^{-1} + 75% RDN and 75% RDP, T_5= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} +50% RDN and 75% RDP, T_6= *Rhizobium* seed treatment @ 25 g kg^{-1} seed + PSB soil application @ 5kg ha^{-1} + 50 % RDN and 50 % RDP.

Although, the use of inorganic fertilizers is the quickest and surest way of boosting crop production but the recent energy crisis and consequent price hike of fertilizers and environmental affairs have again revived and fascinate in organic recycling for sustainable productivity. Continuous use of inorganic fertilizer led to reduction in yield and reported in imbalance of nutrients in soil, which has adverse influence on soil health [19]. Due to the rising population, chemical fertilizers are excessively utilized in order to achieve maximum production which has led to degradation of the agricultural lands [20]. Therefore, to restore the health and quality of the soil, simple practices like judicious utilization of recommended chemical fertilizers can be effectively employed to combat these problems along with organic manures, biofertilizers and fertilizers.

4. CONCLUSION

Hence, the finding of present study indicates that, seed yield, stover yields, nutrient content and uptake of chickpea crop was maximum with 100 % RDF applied treatments over other treatments. However, it was on par with application of 75 % RD of N, P plus biofertilizer application. Incorporation of soybean residue had shown positive impact on economic yield (B:C ratio) of chickpea over non incorporation. Reduction of fertilizer dose to 75 % and use of biofertilizers were also performed equally well with 100 % RDF in yields of both stover and seed that were on par yield. Hence, in soybean – chickpea cropping system incorporation of *Kharif* soybean crop residue and use of biofertilizers can save expenditure incurred on inorganic N P fertilizers upto 25 percent and also enhancing the soil health.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTION

Dr.Anjaiah.T, Dr. Sharma S.H.K and Dr. Sreedhar chauhan: Conceived and designed the field experiment;

D. Swetha : Performed field experiment and laboratory works;

D.Swetha and Dr.Anjaiah.T: Manuscript writing and data analysis.

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