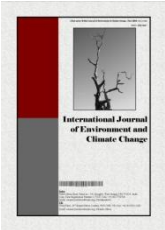

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Effect of Soybean Crop Residue Incorporation, Biofertilizers on Nutrient Uptake, Yield of Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors TA, SHKS and SC conceived and designed the field experiment. Author SD Performed field experiment and laboratory works of the manuscript. Authors SD and TA wrote the manuscript and data analysis. All authors read and approved the final manuscript.

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ABSTRACT

The investigation was laid 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 fertilizers *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.

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1. INTRODUCTION

Pulses which belong to leguminous family are crucial nutrients artefacts are included to the vegan foodstuffs are the affordable provenance of the protease compounds in addition to have life considered as poor man's meat. Pulses come up with 16-18 percent of total protein of Indian diet widely.in addition, their contribution in maintain soil fertility and health through natural nitrogen fixation is out standing and thus they play a pivotal role in sustainable agriculture.

Gram exist solitary as concern to the utmost winter legume fruitage moreover that one possess ingestible salutary nitrogenous matter (17-21%). Chickpea come about also rich in calcium, iron, niacin, vitamin C and vitamin B than other pulses. Its blade contains malic acid which is very functional for stomach aliments and blood purification. In supplement to above it also contains essential amino acids such as cysteine, methionine. The day to day make use of 14g gram is provenance of approximately 2.3 percent (56Kcal) energy and 4.7 percent (2.7g day^{-1}) daily protein needs to Indian people besides being a paramount pedigree of calcium and iron (10-12%) [1].

Gram is a substantial legume crop. It takes part in a cardinal bit part in intensify nutrient condition of soil rightful to nitrogen hang-up hard by *Rhizobium* bacteria elevated in its rhizome nodular. This one crop up additionally ejaculated as inexpensive type in by-product as it required slighter dressing tariff on account of its nitrogen fetish features [1].

In supplement, being a mandatory element of human food and animal feed, chickpea also take part in a pivotal role in sustain soil productiveness up to 35 kg N ha^{-1} [2]. It has the probable to grow well in poor soils as well as to ameliorate them because of its systematic N fixation system [3]. Chickpea economize nitrogen utilization for succeeding cereal crop to the tune of 56-68 kg N ha^{-1} [4], which is one of the elevated among pulses [5].

2. MATERIALS 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), throughout *rabi* period of 2020-21. Agricultural Research Station is located in at 19°39´ N latitude and 78°32´ E longitude and be part of 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. Dependence on the research work accomplished and described outcome of the experimental field at Adilabad, Agricultural Research Station 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 research was compassed 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: 0%, T_2: 100% RDF, T_3: Biofertilizer applications (*Rhizobiu*m + PSB), T_4 : Biofertilizer applications + 75% RDN and 75% RDP, T_5 : Biofertilizer applications + 50% RDN and 75% RDP, T_6 : Biofertilizer applications + 50% RDN and 50% RDP with a spacing of 30 X 10 cm. sown in first week of Nov and gross plot area of 3.9 cm X 5.2 cm.(100% RDF: (20: 50: 20 kg ha^{-1} NPK, *Rhizobium* @ 25 g kg^{-1} seed + PSB @ 5 kg ha^{-1}).

2.3 Application of Biofertilizers and Seed Treatment

The essential quantity amount of Phosphorus solubilizing Bacteria (Shelf-life period is 3 months) assorted with vermicompost and broadcasted @ 5 kg ha^{-1} to soil homogeneously as per the treatments. Seeds of chickpea were treated with *Rhizobium* culture, ordinarily in all treatments except in T_1. and T_2.

2.4 Dry Matter Accumulation (kg ha^{-1})

Five plants from each plot were hand-picked randomly and uprooted considerably at different stages. 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 production in g

plant^{-1}. Dry matter accumulation in 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 acquired by multiplying the nutrient concentration with dry matter and dividing with 100.

3. RESULTS AND DISCUSSION

3.1 Dry - Matter Accumulation

Gram dried matter enhanced along with enlarge inside the duration of crop with apply of inorganic along with biofertilizers. Reviewing of information on dry - matter producing (kg ha^{-1}) high content at thirty days with residue notably pretentious contrasted when differentiated along with without residue. Thus, it elevated values 246.44 kg ha^{-1}, 225.11 kg ha^{-1} are notated with and without residue. It may due to best nutrient obtained via soil a outcome of stabilized dressing. Remnant soybean encounter a prominent decaying outlay moreover liberation of nutritive elements interested inside the soil may also expected logic for utmost dry -matter registered in soybean remnants plots. These results are in conformity with the study of [6].

Outstandingly more dried matter (kg ha^{-1}) noted in (T_2) 100 % RDF out of sub treatments (264.50 kg ha^{-1}). Moreover, T_2 observed similar with T_4 (253.67 kg ha^{-1}) along with (T_5) (252.50 kg ha^{-1}). Remarkably, minor dried matter registered concerning to the (T_1) (195.17 kg ha^{-1}). Raise in dried matter, because of finer nutritive acquired via soil as a consequence of equal dressing in whatever place enhance topsoil fertility values. Alike results also been reported by [6]. Interaction effect at 30 DAS of chickpea noted to be non significant.

Dried matter mass production at sixty and ninety days of gram notably affected by soybean remnant (1961.11 kg ha^{-1} and 2995.56 kg ha^{-1}).It might be due to *Rhizobium* inoculation, when applied in mixed with PSB, stimulate dried weight of nodules as reported by [7].

Exceptionally, more dried matter was registered at T_2 sixty and ninety days of gram due to 100% RDF (2148.33 kg ha^{-1} and 3140.83 kg ha^{-1}) moreover, it was obtained on par with T_5 (2100 kg ha^{-1}, 3106.67 kg ha^{-1}) and (T_4) (2045 kg ha^{-1}, 2993.33 kg ha^{-1}).

An high amount of dried matter lodgement in *Rhizobium* inoculated set is ascribes to high N availability to plants. *Rhizobium* possess a constructive influence continuously biomass proffering. Similar results with Bai et al. [8].

3.2 Seed Yield

The values of 2209.31 kg ha^{-1} and 1819.31 kg ha^{-1} were registered with and without soybean remnant. The lowest seed yiled recorded at (T_1) (1011.45 kg ha^{-1}). Moreover, higher seed yield procured with T_2 (2558.33 kg ha^{-1}) on par with T_4 (2537.50 kg ha^{-1}) and T_5 (2517.50 kg ha^{-1}).An raise yiled noticed with recommended dose of fertilizers and biofertilizers. The interaction between residue incorporation and fertilizer levels along with biofertilizers on seed yiled was registered to be significant. The more grain outcomes because of adequate elements interested with inorganic sources required for better crop growth and yiled and also due to *Rhizobium* inoculation, when applied in combination with PSB, improves the dry weight of nodules, pods per plant and seed yiled of chickpea. The findings agreement with Chauhan and Raghav [9,10,11].

3.3 Stover Yiled

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 yiled recorded at (1675.19 kg ha^{-1}). However, higher stover yiled procured with T_2 (3255.33 kg ha^{-1}). But it was found on par with T_4 (3241.50 kg ha^{-1}) and T_5 (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 yiled and yiled parameters and higher absorption and utilization of nutrients. Similar results are found with Kumari et al. [9].

3.4 Nutrient Content and Uptake of Chickpea at Growth Stages and at Harvest

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

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

Treatments	Dry matter (kg ha^{-1})								
	30 DAS			60 DAS			90 DAS		
	M1	M2	MEAN	M1	M2	MEAN	M1	M2	MEAN
T1	186.33	204.00	195.17	1296.67	1543.33	1420.00	2126.67	2486.67	2306.67
T2	251.67	277.33	264.50	2110.00	2186.67	2148.33	3008.33	3277.33	3140.83
T3	205.33	224.67	215.00	1506.67	1736.67	1621.67	2360.00	2780.00	2570.00
T4	243.00	264.33	253.67	2033.33	2166.67	2100.00	2966.67	3246.67	3106.67
T5	241.00	264.00	252.50	1926.67	2163.33	2045.00	2793.33	3193.33	2993.33
T6	2232.33	244.33	233.83	1740.00	1970.00	1855.00	2578.33	2993.33	2785.83
Mean	**225.11**	**246.44**		**1786.89**	**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	126.80		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	NS1		60.96	213.98		78.02	322.30	

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

Treatments	Yield (kg ha^{-1})					
	M1	**M2**	**MEAN**	**M1**	**M2**	**MEAN**
T1	834	1188	1011	1504	1846	1675
T2	2347	2769	2558	3105	3405	3255
T3	1344	1587	1466	2014	2376	2195
T4	2328	2746	2537	3078	3405	3241
T5	2297	2737	2517	3061	3401	3231
T6	1763	2226	1995	2504	2858	2681
MEAN	**1819**	**2209**		**2544**	**2882**	
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
MAIN (A)	27.28	165.98		50.94	309.97	
SUB (B)	22.59	66.63		47.06	138.82	
Interactions	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
Factor B X A	31.94	94.22		66.55	196.32	
Factor A X B	39.93	176.21		79.28	336.49	

3.4.1 Nitrogen content

Nutrient content of chickpea crop was amplified with the age of crop. More nitrogen content was observed at harvest phase. Incorporation of soybean residue (M_2) had recorded similar influence inside the gram plant period as differentiated to without incorporation (M_1). N content varies 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.

Different contributions of application N, P fertilizers in combination biostimulants had shown outstandingly influence on N content at various stage. The 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 and T_4 was 0.82. However, at sixty and ninety days and at harvest stage by grain and stover mean higher N content noticed with T_2 treatment only. Mean lower value was observed at control (T_1) (0.50). Interaction effect found 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. Incorporation of soybean residue (M_2) had recorded similar influence inside the gram plant period 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.

Different contributions of application of N P fertilizers in combination along bioinoculants 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 in thirty days was registered with T_2 and T_5 was 0.07. However, at sixty and ninety days and at harvest stage by grain and stover mean higher P content noticed with T_2 treatment 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 buildup with the age of crop. More potassium content was declared at harvest stage. Incorporation of soybean residue (M_2) had putdown significant influenced 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.

Different contributions of application of N P fertilizers in combination along bio inoculants had shown similar influence inside the gram plant period. The mean K content by grain and stover at harvest stage, ninety and sixty days by crop are 1.62,1.41,1.24 and 1.04% respectively. Mean higher K content at thirty days recorded with and T_4 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 only. Mean less value was mentioned 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 different phases of crop. More sulphur content was observed at harvest stage. Incorporation of soybean residue (M_2) had set down significant influence at any stage of the crop growth as compared to without incorporation (M_1). S content varies 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.

Different contributions of application of N P fertilizers in combination with bioinoculants had shown similar effect. The mean S content takedown by grain and stover at harvest stage, ninety and sixty days by crop are 0.34, 0.26, 0.09 and 0.07 respectively. Mean higher S content at thirty days noted with T_2 and T_4 0.06. However, at sixty, ninety days and at harvest stage by grain and stover mean higher S content noticed with T_2 treatment only Mean lower value was mentioned at control (0.03).

Interaction effect was noticed to be non significant. Application of combination of fertilizers accompanying 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 enriched in N content might be due to enhanced symbiosis fixation [12]. Nitrogen, phosphorus, potassium and sulphur content was found to elevated due to proper establishment of *Rhizobium* + PSB which supply nutrients and excrete certain growth promoting substances that reveal greater root development enhances the concentration and deposition of nutrients. Similar results are given by Singh et al. [13]. And also, application of PSB increased the accessible of P might be due to the organic acid which were produced during microbial decomposition of organic matter which assist in the solubility of native phosphate and outcomes in higher P content in grain and stover. The results are similar to the findings of Verma et al. [14] and Morshed et al. [15].

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 obtaining 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 found significant influence 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 improvement of crop from 30 DAS to 90 DAS in major treatments.

Application of fertilizers and bio inoculants shown significant influence on nitrogen uptake at various stages of crop growth stages by grain and stover at harvest stage, ninety and sixty days by crop are 104.47, 50.55, 40.72 and 22.31 kg ha^{-1} sequentially. Mean higher nitrogen uptake at thirty days was recorded with T_2 (2.25 kg ha^{-1}) followed T_4 was 2.07 kg ha^{-1}. Mean lower value was noticed 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 concerned to phosphorus uptake at 30,60,90 DAS by the crop, grain and stover at harvest are submitted 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.

Application of fertilizers and bioinoculants shown significant influence on phosphorus uptake at various stages of crop growth. The mean P uptake by grain and stover ninety and sixty days by crop are 15.29, 9.98, 2.65 and 1.71 kg ha^{-1} sequentially. Mean higher phosphorus uptake at thirty days was noted with T_2 (0.195 kg ha^{-1}) followed T_4 was 0.180 kg ha^{-1}. Mean lower value was perceived at control (T_1) (0.038 kg ha^{-1}). Interaction effect non significant.

3.4.7 Potassium uptake

Potassium uptake of chickpea crop was enhanced with the age of crop. More potassium uptake was mentioned at harvest stage. Data pertaining to potassium uptake at 30,60,90 DAS by the crop, grain and stover at harvest are dispensed in Table 9. Incorporation of soybean residue (M_2) had registered 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.

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
T1	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
T2	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
T3	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
T4	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
T5	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
T6	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	0.011		0.014	0.086		0.016	0.099		0.035	0.215		0.017	0.104	
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	

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
T1	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
T2	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
T3	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
T4	0.056	0.072	0.064	0.066	0.083	0.075	0.071	0.089	0.083	0.470	0.547	0.508	0.257	0.280	0.268
T5	0.068	0.082	0.075	0.073	0.089	0.081	0.086	0.093	0.080	0.480	0.553	0.517	0.257	0.280	0.268
T6	0.041	0.053	0.047	0.055	0.071	0.063	0.061	0.077	0.090	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**	0.069	**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	0.009		0.001	0.006		0.002	0.014		0.002	0.0145		0.011	0.066	
Sub	0.004	0.011		0.004	0.0126		0.004	0.002		0.009	0.002		0.014	0.040	
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		0.013	NS		0.013	NS		0.019	NS	
Factor (A) at same level of B	0.005	NS		0.006	NS		0.012	NS		0.012	NS		0.021	NS	

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
T1	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
T2	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
T3	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
T4	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
T5	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
T6	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	0.011		0.006	0.038		0.010	0.058		0.004	0.021		0.013	0.079	
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		0.028N	NS	

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
T1	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
T2	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
T3	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
T4	0.052	0.063	0.06	0.068	0.076	0.07	0.084	0.097	0.09	0.307	0.367	0.34	0.243	0.270	0.26
T5	0.051	0.062	0.06	0.065	0.070	0.07	0.081	0.098	0.09	0.297	0.366	0.33	0.243	0.260	0.25
T6	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**	
	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		0.001	0.008		0.005	0.032		0.03	0.016	
Sub	0.003	0.007		0.002	0.005		0.003	0.009		0.0018	0.051		0.01	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		0.002N	NS		0.004	NS		0.072	NS		0.039	NS	

Table 7. Treatment effect on nutrient uptake of nitrogen in chickpea crop

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
T1	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
T2	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
T3	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
T4	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
T5	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
T6	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	

Table 8. Treatment effect on nutrient uptake of phosphorus in 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
T1	0.024	0.044	0.038	0.408	0.479	0.479	0.622	1.137	0.950	2.885	4.757	3.821	2.645	3.449	3.047
T2	0.168	0.215	0.195	1.396	1.913	1.710	2.043	3.126	2.656	13.44	17.13	15.29	9.097	10.87	9.986
T3	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
T4	0.145	0.207	0.180	1.397	1.851	1.680	2.279	3.117	2.769	11.48	15.423	13.45	7.956	9.478	8.717
T5	0.165	0.213	0.193	1.362	1.828	1.650	2.266	3.032	2.720	11.17	15.19	13.18	7.88	9.534	8.711
T6	0.089	0.126	0.111	0.940	1.294	1.173	1.404	2.304	1.925	7.47	11.38	9.43	5.790	7.022	6.406
Mean	**0.110**	**0.147**		**1.061**			**1.583**	**2.396**		**8.62**	**11.85**		**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	1.230				
SUB	0.012	0.036		0.089	0.264		0.122	0.362		0.192	0.570				
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	NA		0.461	NS				
Factor (A) at same level of B	0.016	NS		0.116	NS		0.162	NS		0.311	NS				

Table 9. Treatment effect on nutrient uptake of potassium in 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
T1	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
T2	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
T3	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
T4	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
T5	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
T6	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**		**16.80**	**19.41**		**30.08**	**35.99**		**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	4.978		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	2.794	
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		0.669N	S		1.317	NS	

Table 10. Treatment effect on nutrient uptake of sulphur in chickpea crop

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
T1	0.049	0.004	0.066	0.535	0.608	0.607	1.03	1.598	1.363	1.234	2.056	1.645	2.42	3.517	2.968
T2	0.123	0.181	0.159	1.460	1.767	1.649	2.47	3.473	3.020	8.774	11.48	10.134	8.63	10.48	9.557
T3	0.057	0.105	0.088	0.737	0.814	0.811	1.33	2.136	1.783	2.878	3.823	3.35	3.82	5.003	4.415
T4	0.114	0.168	0.148	1.312	1.581	1.482	2.31	3.244	2.826	7.050	10.133	8.59	7.44	9.367	8.407
T5	0.113	0.163	0.145	1.219	1.451	1.370	2.14	3.196	2.716	6.910	10.053	8.48	7.49	8.853	8.172
T6	0.085	0.129	0.114	0.999	1.193	1.131	1.77	2.530	2.201	4.293	7.018	5.65	5.34	6.767	6.057
Mean	**0.090**	**0.125**		**1.043**	**1.235**		**1.84**	**2.696**		**5.189**	**7.430**		5.86	7.33	
	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	0.004	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	

Application of fertilizers and bioinoculants shown significant influence on potassium uptake at various stages of crop growth. The mean K uptake by grain and stover at harvest stage, ninety and sixty days 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 (2.66 kg ha^{-1}) followed T_4 is 2.51 kg ha^{-1}. Mean lower value was observed at control (T_1) (1.65 kg ha^{-1}). Interaction effect 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 sulphur uptake by the crop, grain and stover at harvest are presented in Table 10. Incorporation of soybean residue (M_2) had recorded similar influence 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.

Application 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, ninety and sixty by crop. The mean values are 10.13,9.55, 3.02 and 1.64 kg ha^{-1} respectively. Mean higher potassium uptake at thirty days was recorded with T_2 (0.159 kg ha^{-1}) followed T_4 was 0.148 kg ha^{-1}. Mean lower value was observed at (T_1) (0.06 kg ha^{-1}). Interaction effect 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. [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*.* [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. [18].

Thoroughly application of inorganic fertilizer led to depletion in yield and outlined in unappropriated of nutrients in soil, which has uncomfortable effect on soil health [19]. Due to the rising population, chemical fertilizers are extremely utilized in order to pull off topmost production which has led to deterioration of the agricultural lands [20,21]. Therefore, to restore the health and quality of the soil, simple implementation like judicious utilization of recommended chemical fertilizers can be effectively employed to conflict 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. Moreover, it similar with 75% RDN & RDP 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.

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