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: P₂O₅:K₂O 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.
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., T1: 0%, T2: 100% RDF, T3: Biofertilizer applications (Rhizobium + PSB), T4: Biofertilizer applications + 75% RDN and 75% RDP, T5 : Biofertilizer applications + 50% RDN and 75% RDP, T6 : 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 (Shell-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 T1, and T2.

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°C 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\textsuperscript{1}. Dry matter accumulation in per plant was multiplied with no. of plants per ha and expressed in kg ha\textsuperscript{-1} finally.

2.5 Nutrient Uptake (kg ha\textsuperscript{-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\textsuperscript{-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\textsuperscript{-1}, 225.11 kg ha\textsuperscript{-1} are noted 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\textsuperscript{-1}) noted in (T\textsubscript{2}) 100 % RDF out of sub treatments (264.50 kg ha\textsuperscript{-1}). Moreover, T\textsubscript{2} observed similar with T\textsubscript{4} (253.67 kg ha\textsuperscript{-1}) along with (T\textsubscript{5}) (252.50 kg ha\textsuperscript{-1}). Remarkably, minor dried matter registered concerning to the (T\textsubscript{1}) (195.17 kg ha\textsuperscript{-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\textsuperscript{-1} and 2995.56 kg ha\textsuperscript{-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\textsubscript{2} sixty and ninety days of gram due to 100% RDF (2148.33 kg ha\textsuperscript{-1} and 3140.83 kg ha\textsuperscript{-1}) moreover, it was obtained on par with T\textsubscript{5} (2100 kg ha\textsuperscript{-1}, 3106.67 kg ha\textsuperscript{-1}) and (T\textsubscript{4}) (2045 kg ha\textsuperscript{-1}, 2993.33 kg ha\textsuperscript{-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\textsuperscript{-1} and 1819.31 kg ha\textsuperscript{-1} were registered with and without soybean remnant. The lowest seed yiled recorded at (T\textsubscript{1}) (1011.45 kg ha\textsuperscript{-1}). Moreover, higher seed yield procured with T\textsubscript{5} (2558.33 kg ha\textsuperscript{-1}) on par with T\textsubscript{4} (2537.50 kg ha\textsuperscript{-1}) and T\textsubscript{5} (2517.50 kg ha\textsuperscript{-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 in 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\textsuperscript{-1} and 2544.37 kg ha\textsuperscript{-1} were registered with and without incorporation of soybean residue. The mean lowest stover yiled recorded at (1675.19 kg ha\textsuperscript{-1}). However, higher stover yiled procured with T\textsubscript{2} (3255.33 kg ha\textsuperscript{-1}). But it was found on par with T\textsubscript{4} (3241.50 kg ha\textsuperscript{-1}) and T\textsubscript{5} (3231.29 kg ha\textsuperscript{-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 | 30 DAS          | 60 DAS          | 90 DAS          |
|------------|-----------------|-----------------|-----------------|
|            | M1       | M2       | MEAN     | M1       | M2       | MEAN     | M1       | M2       | MEAN     |
| T1         | 186.33  | 204.00  | 195.17   | 1296.67  | 1420.00  | 2126.67  | 2486.67  | 2306.67  |
| T2         | 251.67  | 277.33  | 264.50   | 2110.00  | 2148.33  | 3008.33  | 3277.33  | 3140.83  |
| T3         | 205.33  | 224.67  | 215.00   | 1506.67  | 1621.67  | 2360.00  | 2780.00  | 2570.00  |
| T4         | 243.00  | 264.33  | 253.67   | 2033.33  | 2100.00  | 2966.67  | 3246.67  | 3106.67  |
| T5         | 241.00  | 264.00  | 252.50   | 1926.67  | 2045.00  | 2793.33  | 3193.33  | 2993.33  |
| T6         | 2232.33 | 244.33  | 233.83   | 1740.00  | 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)

Main
- 2.72       16.56
- 156.80     25.77
- 60.52      213.98
- 178.53     47.71

Sub
- 5.83       17.19
- 156.80     126.80
- 67.47      140.75
- 291.39     47.71

Interactions
- 8.24       NS
- 60.52      178.53
- 67.47      199.05

Factor (B) at same level of A
- 8.00       NS1
- 60.96      213.98
- 78.02      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) for T1: 0.50
SEm± CD (P=0.05) for T2: 0.01
SEm± CD (P=0.05) for T3: 0.02
SEm± CD (P=0.05) for T4: 0.03
SEm± CD (P=0.05) for T5: 0.04
SEm± CD (P=0.05) for T6: 0.05
SEm± CD (P=0.05) for MAIN (A): 27.28
SEm± CD (P=0.05) for SUB (B): 22.59
SEm± CD (P=0.05) for Interactions: 31.94
SEm± CD (P=0.05) for Factor B X A: 39.93
SEm± CD (P=0.05) for Factor A X B: 39.93

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 bioinoculants 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 registered 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 putdown significant influenced 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.

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 (M3) had set down significant influence at any stage of the crop growth as compared to without incorporation (M1). 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 T2 and T4 0.06. However, at sixty, ninety days and at harvest stage by grain and stover mean higher S content noticed with T2 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 (M3) had found significant influence at any stage of the crop growth as compared to without incorporation (M1). 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 T2 (2.25 kg ha⁻¹) followed T4 was 2.07 kg ha⁻¹. Mean lower value was noticed at control (T1) (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 (M3) had recorded significant effect at any stage of the crop growth as compared to without incorporation (M1). 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 bio inoculants 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 T2 (0.195 kg ha⁻¹) followed T4 was 0.180 kg ha⁻¹. Mean lower value was perceived at control (T1) (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 (M3) had registered significant effect at any stage of the crop growth as compared to without incorporation (M1). 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 | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|--------------------|--------------------|
| T1         | M1     | M2     | Mean   | M1     | M2     | Mean   | M1     | M2     | Mean   | M1     | M2     | Mean   |
| T2         | 0.46   | 0.54   | 0.50   | 0.47   | 0.58   | 0.52   | 0.78   | 0.82   | 0.80   | 2.12   | 2.32   | 2.22   | 0.98   | 1.10   | 1.03   |
| T3         | 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   |
| T4         | 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   |
| T5         | 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   |
| T6         | 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   |
| 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) | CD | CD | CD | CD | CD | CD | CD | CD | CD | CD |
| 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) | CD | CD | CD | CD | CD | CD | CD | CD | CD |
| 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 | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|-------------------|-------------------|
|            | M<sub>1</sub> | M<sub>2</sub> | Mean | M<sub>1</sub> | M<sub>2</sub> | Mean | M<sub>1</sub> | M<sub>2</sub> | Mean | M<sub>1</sub> | M<sub>2</sub> | Mean | M<sub>1</sub> | M<sub>2</sub> | 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 | 0.06  | 0.08 | 0.069 | 0.23  | 0.25  | 0.44  | 0.51  |
| SEm ± CD   | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (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 | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD |
| Factor (B) at same level of A | 0.006 | 0.006 | 0.013 | 0.013 | 0.019 | NS | NS | NS | NS |
| Factor (A) at same level of B | 0.005 | 0.006 | 0.012 | 0.012 | 0.021 | NS | NS | NS | 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 | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|-------------------|--------------------|
|            | M₁     | M₂     | Mean   | M₁     | M₂     | Mean   | M₁     | M₂     | Mean   | M₁     | M₂     | 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   | 1.37   | 1.37   | 1.37   | 1.37   | 1.37   |

| SEm ± CD  | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (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 | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD | SEm ± CD |
| Factor (B) at same level of A | 0.015    | 0.022    | 0.023    | 0.023    | 0.019    | 0.027    | 0.028N  | 0.027    | 0.027    | 0.027    |
| Factor (A) at same level of B | 0.045    | 0.021    | 0.023    | 0.023    | 0.018    | NS       | 0.028N  | 0.028N  | 0.028N  | 0.028N  |
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 | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|--------------------|---------------------|
|            | M₁     | M₂     | Mean   | M₁     | M₂     | Mean   | M₁     | M₂     | Mean   | M₁     | M₂     | Mean   | M₁     | M₂     | 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  | 0.05   | 0.059  | 0.063  | 0.06   | 0.07   | 0.09   | 0.252  | 0.305  | 0.215  | 0.241  |
| SEm        | CD     | SEm ±  | CD     | SEm ±  | CD     | SEm ±  | CD     | SEm ±  | CD     | SEm ±  | CD     |
| ±          | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) |
| Main       | 0.002  | 0.011  | 0.001  | 0.003  | 0.001  | 0.003  | 0.008  | 0.005  | 0.005  | 0.032  | 0.03   | 0.016  |
| Sub        | 0.003  | 0.007  | 0.002  | 0.005  | 0.003  | 0.009  | 0.009  | 0.0018 | 0.051  | 0.01   | 0.028  |
| Interactions | SEm    | CD     | SEm ±  | CD     | SEm ±  | CD     | SEm ±  | CD     | SEm ±  | CD     |
| ±          | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (P=0.05) | (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 | 30 DAS Mean | 60 DAS Mean | 90 DAS Mean | At harvest (Grain) Mean | At harvest (Stover) Mean |
|------------|-------------|-------------|-------------|-------------------------|-------------------------|
| T1         | 0.84 ± 0.03 | 1.06 ± 0.02 | 5.94 ± 0.54 | 19.01 ± 1.75           | 28.57 ± 17.57          |
| T2         | 1.93 ± 0.07 | 2.25 ± 0.06 | 19.61 ± 1.23 | 23.97 ± 2.23           | 40.72 ± 34.95          |
| T3         | 1.14 ± 0.08 | 1.40 ± 0.09 | 10.68 ± 0.79 | 10.68 ± 1.13           | 24.14 ± 34.13          |
| T4         | 1.80 ± 0.08 | 2.25 ± 0.10 | 20.50 ± 1.72 | 31.72 ± 4.13           | 37.62 ± 75.66          |
| T5         | 1.68 ± 0.07 | 1.96 ± 0.06 | 18.68 ± 0.87 | 41.13 ± 4.13           | 37.03 ± 80.48          |
| T6         | 1.32 ± 0.07 | 1.80 ± 0.07 | 14.23 ± 1.23 | 25.23 ± 4.13           | 30.54 ± 54.57          |
| Mean       | 1.44 ± 0.08 | 1.85 ± 0.07 | 16.86 ± 1.44 | 26.91 ± 3.44           | 34.44 ± 76.33          |

SEm ± CD (P=0.05) = 0.03 ± 0.02

Main Sub Interactions

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 | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|--------------------|--------------------|
|            | Mi     | Mj     | Mean   | Mi     | Mj     | Mean   | Mi     | Mj     | Mean   |
| T1         | 0.024  | 0.044  | 0.038  | 0.408  | 0.479  | 0.479  | 0.622  | 1.137  | 0.950  |
| T2         | 0.168  | 0.215  | 0.195  | 1.396  | 1.913  | 1.710  | 2.043  | 3.126  | 2.656  |
| T3         | 0.047  | 0.078  | 0.066  | 0.579  | 0.866  | 0.778  | 0.885  | 1.712  | 1.369  |
| T4         | 0.145  | 0.207  | 0.180  | 1.397  | 1.851  | 1.680  | 2.279  | 3.117  | 2.769  |
| T5         | 0.165  | 0.213  | 0.193  | 1.362  | 1.828  | 1.650  | 2.266  | 3.032  | 2.720  |
| T6         | 0.089  | 0.126  | 0.111  | 0.940  | 1.294  | 1.173  | 1.404  | 2.304  | 1.925  |
| Mean       | 0.110  | 0.147  | 1.061  | 1.583  | 2.396  | 1.583  | 1.583  | 2.396  | 1.583  |

SEm ± CD (P=0.05)

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|--------------------|--------------------|
|            | Mi     | Mj     | Mean   | Mi     | Mj     | Mean   | Mi     | Mj     | Mean   |
| 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 | 0.006  | 0.016  | NS     | 0.047  | NS     | 0.091  | NA     | 0.461  |
| 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 | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|--------|--------|--------|-------------------|-------------------|
|            | M1     | M2     | Mean   | M1     | M2     | Mean   | M1     | M2     | Mean   | M1     | M2     | 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  | 23.18  | 34.99  | 32.37  | 26.57  | 34.66  | 30.61  | 31.82  | 38.71  | 35.26  |
| MEAN       | 2.04   | 2.31   | 2.16   | 16.80  | 19.41  | 17.84  | 30.08  | 35.99  | 29.36  | 29.36  | 35.99  | 30.61  | 31.82  | 38.71  | 35.26  |

SEm ± CD (P=0.05)

Main 0.026 0.168 0.461 0.760 0.760 4.978 0.226 1.480 0.511 3.348
Sub 0.061 0.181 0.525 0.730 0.730 2.169 0.488 1.449 0.940 2.794
Interactions 0.063 0.128 1.128 1.862 1.862 0.553 0.553 1.252 NS
Factor (B) at same level of A 0.063 1.128 1.211 NS 0.669 N 1.317 NS
Factor (A) at same level of B 0.083 0.820 0.820 1.211 NS 0.669 N 1.317 NS
Table 10. Treatment effect on nutrient uptake of sulphur in chickpea crop

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest (Grain) | At harvest (Stover) |
|------------|-------|-------|-------|-------------------|-------------------|
|            | Sulphur uptake (kg ha⁻¹) |       |       |                   |                   |
|            | M₁    | M₂    | Mean  | M₁    | M₂    | Mean  | M₁    | M₂    | Mean  | M₁    | M₂    | 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)

Main        | 0.004 | 0.027  |       | 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)
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.

REFERENCES

1. Millan T, Winter P, Jüngling R, Gil J, Rubio J, Cho S, et al. A consensus genetic map of chickpea (Cicer arietinum L.) based on 10 mapping populations. Euphytica. 2010; 175(2):175-189.

2. Rupela OP. Nodulation and nitrogen fixation in chickpea. 1987; 191-206. (in) The Chickpea (Eds. Saxena and K. B. Singh), CAB international ICARDA, Wallingford, UK.

3. Neumann U, Kosier B, Jahnke J, Priefer A, Al-Halbouni D. Soil factors exhibit greater influence than bacterial inoculation on alfalfa growth and nitrogen fixation. Journal of Microbiology Science. 2011; 77:590–599.

4. Ahlawat IPS, Gangaiah B. Effect of land configuration and irrigation on sole and linseed (Linum usitatissimum) intercropped chickpea (Cicer arietinum L.). Indian Journal of Agricultural Science. 2010; 80(3):253.

5. Hussen S, Yirga F, Tibebu F. Effect of phosphorus fertilizer on yield and yield components of chickpea (Cicer arietinum L.) at Kelemeda, South Wollo, Ethiopia. International Journal of Soil Crop Science. 2015;1(1):1-4.

6. Yagoub SO, Salam AK, Hassan MM, Hassan MA. Effects of organic and mineral fertilizers on growth and yield of soybean (Glycine max L.). International Journal of Agronomy and Agricultural Research. 2015;7(1):45-52.

7. Singh D, Raghuvanshi K, Chaurasiya A, Dutta SK. Biofertilizers: Non chemical source for enhancing the performance of pearl millet crop. Environmental Life Science. 2011;6(1):38-42.

8. Bai MH, Khadam D, Khan KR, Hassan GS. Effect of phosphorus, iron and rhizobium on nodulation, growth and yield of chickpea. Annals of Agricultural Research. 2014;11(4):11-17.

9. Kumari MSDN, Kumari KU. Effect of vermicompost enriched with rock phosphate on the yield and uptake of nutrients in chickpea. Journal of Tropical Agriculture. 2015;40:27-30.

10. Chauhan SVS, Bhoopendra Singh Raghav. Effect of phosphorus and phosphate solubilizing bacteria on growth, yield and quality of chickpea (Cicer arietinum L.). Annals of Plant and Soil Research. 2017;19(3):303-306.

11. Gangawar S, Dubey M. Effect on N and P uptake by chickpea (Cicer arietinum L.) as influenced by micronutrients and biofertilizers. Legume Research, An International Journal. 2012; 35(2):56-57.

12. Singh D, Raghuvanshi K, Pandey SK, George PJ. Effect of biofertilizers on growth and yield of pearl millet (Pennisetum glaucum L.). Life Science. 2016;9(3):385-386.

13. Singh D, Raghuvanshi K, Chaurasiya A, Dutta SK, Dubey S. Enhancing the Nutrient Uptake and Quality of Pearl millet through use of Biofertilizers. International Journal of Current Microbiology Applied Science. 2018;7(4):3296-3306.

14. Verma VC, Agrawal S, Kumar A, Jaiswal JP. Starch content and activities of starch biosynthetic enzymes in Chickpea. Journal of Pharmacognosy and Phytochemistry. 2020;9(4):1211-1218.

15. Morshad BH, Forghani A, Norouzi M. Effect of P and Fe application on the yield and nutrient uptake in chickpea. Journal of Indian Journal of Soil Science. 2018; 41:186-187.

16. Asgharali M, Athernadeem Asifanveer, Mumtaz Hussain. Effect of different potash levels on the growth yield and protein contents of chickpea. Pakistan Journal of Botany. 2005;39:523-527.

17. Patel AP, Patel DB, Lakhani SH, Kadu SP. Influence of irrigation scheduling and levels of sulphur on yield and quality of rabi green gram (Vigna radiata L.). Trends in Biosciences. 2013;7(21):3845-3849.

18. Diao CP, Wang ZH, Li Wangs, Huang N. Differences in grain nitrogen contents of high yielding wheat cultivars and relation to NPK uptake and utilization in drylands. Journal of Plant Nutrition and Fertilizers. 2019;24:285-295.

19. Doran J.W., Zeiss M.R. Soil health and sustainability: Managing the biotic
component of soil quality. Applied Soil Ecology. 2000;15:3-11.
20. Mondal I. Effect of potassium and Sulphur on chickpea in relation of growth and productivity under irrigation and non-irrigated condition. Procedure of National Seminar on Frontiers Crop Management. 2001;111-112.
21. Saha I, Gandahi AW, Bhutto GR, Sarki MS, Gandahi R. Growth and Yield Maximization of Chickpea (Cicer arietinum L.) through Integrated Nutrient Management Applied to Rice-Chickpea Cropping System. Sarhad Journal of Agriculture. 2002;31(2).

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