Response of fertility levels and biofertilizers on growth and yield attributes quality of chickpea (*Cicer arietinum* L.) crop

Abstract

The experiment was conducted on agricultural research form with split plot design in four main treatments: F1 (control), F2 (100% recommended dose of fertilizer-RDF), F3 (75% RDF), and F4 (50% RDF), and three sub-plot treatments: B1 (Rhizobium + PSB), B2 (Rhizobium + PGPR), and B3 (Rhizobium + PSB + PGPR), each replicated three times. Growth parameters such as plant height and dry matter accumulation were significantly influenced by both fertility levels and biofertilizers. Chickpea plants showed higher growth parameter values and root parameter when treated with 100% RDF (F2). Similarly, biofertilizer treatments, particularly Rhizobium + PSB + PGPR (B3), followed by 75% RDF (F3).Root dry weight per plant was significantly affected by both fertility levels and biofertilizers across all growth stages except at 30 days after sowing (DAS).The number of pods per plant and the number of seeds per pod were significantly influenced by both fertility levels and biofertilizers at all growth stages except at 30 DAS and in the case of 100 seed weight. Chickpea plants treated with 100% RDF (F2) exhibited higher values for both the number of pods per plant and the number of seeds per pod.

Keywords: RDF- recommended dose fertilizer, PSB- Phosphate solubilising bacteria, PGPR- Plant growth promoting rhizobacteria

1.INTRODUCTION

Pulse crops is grown more diverse agro-climatic conditions in India and play a vital role in both intensive and subsistence agriculture. Chickpea is crucial source of dietary protein as millions, provide nutritious feed for livestock, and act as nitrogen-fixing plants and enriching of nitrogen in the soil. The Pulses, dubbed as PULSE- meaning as (P–people, U-umbrella, L-livestock, S- soil, E- energy), are deeply ingrained in the Indian dietary system due to their richness in protein and essential nutrients like Calcium, Iron, and various vitamins. India is globally renowned as the significant play important role of pulse production, contributing 25% to global output (4-6 million tonns) and consumption (26-27 million tonns). Pluse production in 2021-2022 recorded 25.23 million tonns. Among pulses, chickpea (*Cicer arietinum* L.) kept one-third of the area and contributing 40% among total pulse production in India. It should be a cultivation area of 6.3 million hectares and 5.1 million tonns production, chickpea stands as the largest produced and consumed pulse in the nation. Madhya Pradesh leads as the top pulseproducing state, accounting for 23% of total production and covering 32.97% of chickpea cultivation area in the country. Through symbiotic nitrogen fixation, chickpea can fulfill up to 80% of soil nitrogen requirements, reducing the necessary for nitrogen fertilizers compared to non-legume crops. However, despite its significance, chickpea production faces challenges due to farming practices such as indiscriminate chemical fertilizer use, intensive tillage, and lack of biofertilizers, leading to soil fertility reduction and nutrient deficiencies.Chemical fertilizers highly affect soil and the environment, as well as human health, so there is a need to improve soil health without reducing production. Biofertilizers, categorized as organic fertilizers, offer an ecologically safe approach to fertilization. These substances contain living microorganisms that, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or plant interior, promoting growth by enhancing the supply or availability of primary nutrients to the host plant. This presents a sustainable solution to address soil fertility issues and enhance pulse crop production, particularly in low-input agricultural systems worldwide.

Materials and methods

The experiment was conducted during the winter seasons of 2021-22 at the Research Farm School of Agriculture, Eklavya University, Damoh. Sufficient research resources such as irrigation, seeds, fertilizers, equipment, and labor were available at the research farm to facilitate smooth operation. To accommodate the factors under study and agricultural operations conveniently, the experiment consisted of 12 treatment combinations laid out in a split-plot design on the character Plant height (cm), Dry matter accumulation per plant (g), Root dry weight per plant (g), Number of pods per plant, Number of seeds per pod, Test weight (g/ 100-seed weight), Grain yield (q ha^{-1}), Straw yield (q ha^{-1}), Biological yield (kg ha^{-1}), Harvest Index (%) and Protein content in grain (%). Four treatments were assigned to the main plot: F1- Control, F2- RDF 100%, F3- RDF 75%, F4- RDF 50%. In the subplots, three treatments were assigned: B1- Rhizobium+PSB, B2- Rhizobium+PGPR, B3- Rhizobium+PSB+PGPR, each with three replications. The recorded observations throughout the investigation were organized into tables and subjected to statistical analysis to derive meaningful conclusions. The data underwent analysis using the standard "Analysis of Variance" (ANOVA) procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth characters

Typically, during the initial stages, plant growth proceeds at a slow pace primarily because a significant portion of plant nutrients is allocated towards root system expansion and the generation of new leaves, with limited photosynthate availability. Consequently, growth attributes such as plant height, dry matter accumulation per plant, branches per plant, nodules per plant, nodule dry weight per plant, and root dry weight per plant experience a setback in the early stages of crop growth. Furthermore, the synergistic association and additional nutrients obtained from the chickpea crop may contribute to the overall development of the crop, particularly in terms of plant height and dry matter accumulation per plant.

Plant height:

There was no significant difference observed in the plant population due to variations in fertility levels and biofertilizers both at the initial and harvest stages. Fertility levels did have a significant impact on plant height throughout the different stages of crop growth, except at 30 days after sowing (DAS). The highest plant height at 60 DAS was achieved with the 100% recommended dose of fertilizer (RDF), which was statistically similar to 75% RDF but significantly greater than 50% RDF at the control treatment. Similarly, at the harvest stage, maximum plant height was attained with 100% RDF, which was statistically similar to 75% RDF and 50% RDF but significantly higher than the control treatment. Generally, plant height increased as the crop matured, with the highest height observed at maturity. The application of different nutrient levels influenced plant height, with increasing fertility levels leading to higher plant height at successive growth stages and at the harvest stage. This increase in plant height may be attributed to the sufficient availability of nitrogen, phosphorus, and potassium (NPK), which provided a favorable nutritional environment for plant growth during active vegetative stages, promoting cell multiplication, elongation, and expansion, ultimately resulting in increased plant height, similar to the to the finding reported by Fatima*et al.*(2008).

The use of biofertilizers had a noticeable impact on plant height throughout the crop growth stages, except at 30 days after sowing (DAS). Notably, the B3 treatment led to the tallest plants at 60 DAS, surpassing the B2 and B1 treatments significantly. At the harvest stage, plants treated with B3 reached maximum height, statistically comparable to B1 treatment but significantly higher than B2 treatment. This height difference may be attributed to improved nutrient uptake facilitated by microbial inoculants, as noted by Singh*et al.*(2012). The application of biofertilizers resulted in increased plant height, likely due to beneficial enzyme activity and enhanced soil microfloral diversity, a finding consistent with Gupta and Gangwar (2012).

Dry matter accumulation

Different fertility levels significantly affected plant dry matter accumulation at all stages of crop growth except 30 DAS. However, at 60 DAS and 90 DAS, the highest dry matter accumulation per plant was observed with 100% recommended dose of fertilizer (RDF), significantly surpassing the 50% RDF and control treatments. Plant dry matter accumulation reflects the culmination of metabolic processes within the plant, and the application of recommended nutrients led to increased availability of nutrients, thereby enhancing dry matter accumulation, as highlighted by Jat and Ahalawat (2004). Notably, higher fertility levels resulted in greater nutrient availability during the major vegetative growth phase, leading to a sharp increase in dry matter accumulation from 30 DAS to 60 DAS, while maintaining a higher leaf area index, potentially boosting photosynthetic activity.

The application of biofertilizers also had a significant impact on plant dry matter accumulation at all crop growth stages except 30 DAS. However, the maximum accumulation of plant dry matter at 60 DAS and 90 DAS occurred with the B3 treatment, significantly outperforming other treatments. This may be attributed to the secretion of growth-promoting organic acids and biochemical compounds by nitrogen-fixing and phosphorus-solubilizing microorganisms present in biofertilizers. Consequently, biofertilizers influenced soil nutrient availability through enhanced microbial activity, releasing nutrients from the soil and facilitating their absorption and utilization by plants.

Root parameters

All root parameters, including root dry weight per plant, number of nodules per plant, and nodule dry weight per plant, were significantly influenced by varying fertility levels across all crop growth stages except for root dry weight per plant at 30 DAS. However, at 60 DAS and at the harvest stage, the highest root dry weight was observed with the application of the 100% recommended dose of fertilizer (RDF), significantly surpassing other treatments. Similarly, at 30 DAS and 60 DAS, the highest number of nodules per plant occurred with the 100% RDF treatment, significantly exceeding other treatments. At the harvest stage, the maximum number of nodules per plant was also found with the 100% RDF treatment, statistically similar to 50% RDF but significantly higher than the control treatment. Moreover, the maximum nodule dry weight at 30 DAS and 90 DAS was achieved with the 100% RDF treatment, significantly outperforming other treatments. However, at 60 DAS, the maximum nodule dry weight was observed with the 100% RDF treatment, statistically comparable to 75% and 50% RDF but significantly higher than the control treatment. The improved plant growth observed with different nutrient levels compared to the control treatment can be attributed to enhanced nutrient availability and metabolic processes within the plant, influenced by various inherent and environmental factors. This leads to increased root dry weight per plant, number of nodules per plant, and nodule dry weight per plant, as noted by Gray and Bahar (2013) and Egamberdieva*et al.* (2015).

Biofertilizers also had a significant effect on all root parameters throughout the crop growth stages, except for root dry weight per plant at 30 DAS. Notably, the highest root dry weight at 60 DAS and at the harvest stage was observed with the application of the B3 treatment, statistically similar to B1 but significantly higher than other treatments. The maximum number of nodules per plant and nodule dry weight per plant across all growth stages were achieved with the B3 treatment, significantly surpassing all other treatments. This outcome could be attributed to the growth-promoting substances released by microbial inoculants, leading to enhanced root development, improved water transpiration, and increased nutrient uptake, resulting in higher root dry weight per plant, number of nodules per plant, and nodule dry weight per plant. These findings align with the studies of Triphati*et al.* (2015) and Singh and Prasd (2008).

Yield attributing characters

Yield attributes, which directly impact overall yield, are the culmination of the vegetative growth of the crop. Various attributes such as the number of branches per plant, number of pods per plant, and number of seeds per pod were significantly influenced by different fertility levels, except for the number of branches at 30 DAS and 100-seed weight.

However, at 60 DAS, the maximum number of branches per plant was observed with the application of the 100% recommended dose of fertilizer (RDF), significantly surpassing other treatments. Similarly, at the harvest stage, the maximum number of branches per plant was found with the 100% RDF treatment, statistically comparable to 75% RDF but significantly higher than 50% RDF and the control treatment. Additionally, the number of pods per plant and the number of seeds per pod were highest with the application of 100% RDF, significantly exceeding other treatments. The increase in the number of branches per plant may be attributed to heightened activity of the meristematic tissue at higher fertility levels, where NPK nutrients aid in cell differentiation, meristematic division, and translocation of food materials, leading to increased branch production at different growth stages. Specifically, the application of 100% RDF, with its increased nitrogen content, stimulated branch and pod production by enhancing cell differentiation and chlorophyll synthesis, while phosphorus promoted robust root development, enhancing nutrient uptake, and potassium facilitated the translocation of photosynthates within the plant system, as suggested by Fatima *et al.* (2008). The rise in the number of seeds per pod could be due to the optimal fertilization of flowers and increased pollen grain viability resulting from higher fertilizer doses.

Biofertilizer treatment significantly influenced all yield attributes, including the number of branches per plant, number of pods per plant, and number of seeds per pod, except for the number of branches at 30 DAS and 100-seed weight. Notably, the maximum number of branches per plant at 60 DAS and at the harvest stage was observed with the application of the B3 treatment, significantly surpassing other treatments. The number of pods per plant with the B3 treatment was statistically comparable to B1 but significantly higher than the B2 treatment, while the maximum number of seeds per pod was recorded with the B3 treatment, significantly exceeding other treatments. This could be attributed to the enhanced nitrogen-fixing ability of nitrogen-fixing microorganisms in biofertilizers, leading to increased nutrient uptake by plants. These results align with the findings of Singh *et al.* (2006) and Fatima *et al.* (2007). Biofertilizers rapidly mineralize and solubilize nutrients, providing optimal nutrition to plants, thereby stimulating plant growth and increasing the number of branches per plant, the number of pods per plant, and the number of seeds per pod.

Yield

Seed yield, stover yield, and biological yield were significantly influenced by different fertility levels, except for harvest index. Notably, higher seed yield was achieved with the application of the 100% recommended dose of fertilizer (RDF), significantly surpassing other treatments. Similarly, a higher stover yield was obtained with the 100% RDF treatment, statistically comparable to 75% RDF but significantly higher than other treatments. Moreover, maximum biological yield was recorded with the 100% RDF treatment, significantly outperforming other treatments. The increase in seed and stover yield under adequate nutrient supply can be attributed to various factors, such as increased plant height, more branches per plant, a higher number of pods per plant, an increased number of seeds per pod, and a higher 100-seed weight. These factors collectively result in better translocation of photosynthates from source to sink, ultimately leading to increased seed yield, as observed by Pathak et al. (2003) and Tolanur et al. (2008). Similar findings were reported by Kanter et al. (2003), emphasizing the role of adequate nutrient supply in increasing seed yield through enhanced yield attributes.

The increase in biological yield per hectare can be attributed to the increased seed and stover yields under these treatments, along with the pattern of dry matter accumulation at different growth stages. Similar observations were reported by Gupta (2007) and Kushwaha (2007).Biofertilizer treatments significantly influenced seed, stover, and biological yield. Higher yields were observed with the application of the B3 treatment, significantly exceeding other treatments. This increase in yield may be attributed to the proper establishment of Rhizobium strains, resulting in a larger supply of nitrogen to plants. The application of biofertilizers enhanced seed, stover, and biological yield by improving dry matter accumulation, yield attributes, and nutrient content, along with their uptake by chickpea and field pea crops. Treatments inoculated with PGPR also showed higher nitrogen, phosphorus, and potassium content, along with higher nodulation, providing additional evidence for increased yield in biofertilizer-inoculated treatments. This could be due to the secretion of growth-promoting substances by microbial inoculants, leading to improved root development, better water transpiration, and enhanced nutrient uptake and deposition, as noted by Pyare and Dwivedi (2005).

Quality parameters

Protein content in seeds (%)

The impact of different fertility levels was not statistically significant overall, but noteworthy observations were made regarding protein content. The highest protein content was observed in seeds when no additional fertilizer was applied (control treatment), whereas the lowest protein content was recorded with the application of the 100% recommended dose of fertilizer (RDF). This indicates that higher fertility levels, particularly nitrogen, led to decreased protein content in the seeds, aligning with well-established findings in agricultural research. Essentially, as nitrogen levels increase, protein content tends to decrease, as previously confirmed by Jat and Ahalawat (2004). The higher nitrogen content in chickpea grain under the f2 treatment could be attributed to sufficient nitrogen availability, possibly due to enhanced root nodulation and root growth facilitated by the f2 treatment.

Regarding the influence of biofertilizer treatments on seed protein content, notable differences were observed between specific treatments. The highest protein content was associated with the B3 treatment, while the lowest was with the B2 treatment. This observation is consistent with the general understanding that biofertilizers can enhance nutrient uptake by plants. Singh and Prasad (2008) suggest that biofertilizers can improve nutrient uptake and utilization, leading to increased protein content in seeds. This is likely because biofertilizers contain beneficial microorganisms that promote nutrient availability and absorption by plants. Therefore, although the overall effect may not have been statistically significant, specific biofertilizer treatments still had discernible impacts on protein content, likely due to their ability to improve nutrient uptake efficiency.

Protein yield

The information provided suggests that protein yield in chickpea crops is notably affected by various fertility levels. Particularly, applying the 100% recommended dose of fertilizer (RDF) resulted in the highest protein yield. Protein yield was influenced by different levels of RDF, with the 100% RDF treatment showing the highest yield. However, it's worth noting that treatments with 75% RDF and 50% RDF also yielded comparable protein levels, indicating a positive response to fertilization across these levels. Moreover, all RDF treatments resulted in significantly higher protein yields compared to the control treatment, underscoring the importance of fertilizer application in enhancing protein production in chickpea crops. Protein yield is a combination of protein content in seeds and seed yield per hectare, implying that increasing seed yield can directly contribute to higher protein yield. Thus, strategies aimed at improving seed yield, such as optimizing fertility levels, can positively impact protein yield in chickpea crops. These findings are consistent with those of Meena *et al.* (2005).

Regarding the impact of biofertilizers, particularly the B3 treatment (Rhizobium + PSB + PGPR), on protein yield, significant effects were observed. This suggests that the combined use of these biofertilizers enhances the protein production capacity of chickpea plants. Similar to the scenario with fertility levels, protein yield is influenced by both seed yield per hectare and protein content. Therefore, the superior protein yield observed with the B3 treatment may be attributed to its positive effects on seed yield and/or protein content. The results indicate that protein yield was significantly influenced by different biofertilizer treatments, with the maximum yield recorded with the application of the B3 treatment, which was significantly higher than other treatments. Again, these results align with those of Meena *et al.* (2005).

Table 1: Responceof fertility levels and biofertilizers on plant population, plant height, dry matter accumulation and Root dry weight

Treatments	**Plant height (cm)**			**Dry matter accumulation (g/plant)**			**Root dry weight (g/plant)**		
	30DAS	**60 DAS**	**Harvest**	**30DAS**	**60DAS**	**90 DAS**	**30 DAS**	**60DAS**	**Harvest**
Fertility levels									
F1	8.50	47.91	50.92	2.40	14.04	20.22	0.17	0.56	0.63
F2	10.49	58.36	61.99	3.01	17.57	25.31	0.21	0.70	0.78
F3	9.95	55.94	58.92	2.86	16.68	24.02	0.20	0.65	0.73
F4	9.41	52.83	55.93	2.70	15.76	22.71	0.19	0.62	0.69
SEm±	0.19	0.69	1.09	0.07	0.27	0.38	0.01	0.01	0.02
CD (P= 0.05)	0.68	2.39	3.77	0.25	0.96	1.31	NS	0.05	0.06
Biofertilizers									
B1	9.59	53.87	56.99	2.75	16.08	23.16	0.19	0.63	0.71
B2	9.10	50.84	53.96	2.58	15.07	21.71	0.18	0.59	0.66
B3	10.07	56.56	59.86	2.89	16.88	24.32	0.20	0.67	0.75
SEm±	0.18	0.89	0.95	0.07	0.25	0.32	0.008	0.02	0.02
CD (P= 0.05)	0.53	2.69	2.85	0.25	0.75	0.96	NS	0.05	0.06
FXB	NS	NS	NS	NS	NS	NS	NS	NS	NS

Where, F_1-Control, F_2- RDF 100%, F_3- RDF 75%, F_4- RDF 50%,B_1- Rhizobium + PSB,B_2- Rhizobium + PGPR,B_3 – Rhizobium + PSB + PGPR

Table 2: Responce of fertility levels and biofertilizers on yield attributesCharacter and quality of chickpea

Treatments	No. of pods/ plant	No. of seeds/ pod	100 seed weight(g)	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index	Protein (%)	Protein yield (q/ha)
Fertility levels									
F1	37.36	1.190	19.04	12.15	20.92	40.69	34.27	21.22	427.63
F2	45.05	1.43	22.06	18.05	25.62	50.37	36.15	23.11	572.31
F3	42.73	1.36	20.40	16.30	25.40	48.91	35.32	22.10	523.34
F4	40.80	1.29	20.20	15.62	24.42	46.65	34.57	21.87	485.17
SEm ±	0.99	0.02	0.90	0.35	0.40	0.57	0.70	0.051	11.71
CD(P=0.05)	3.42	0.08	NS	1.19	1.39	1.96	NS	0.17	40.42
Biofertilizers									
B1	41.43	1.37	20.66	15.75	24.60	47.26	36.12	21.81	500.68
B2	39.53	1.21	18.24	13.14	22.78	44.03	34.73	21.67	462.74
B3	43.50	1.41	22.50	17.68	24.90	48.67	35.37	22.70	542.91
SEm ±	0.48	0.01	1.13	0.28	0.39	0.48	0.57	0.039	8.98
CD (P=0.05)	1.44	0.05	NS	0.86	1.17	1.45	NS	0.117	26.94
FXB	NS	NS	NS	S	NS	NS	NS	NS	NS

Where, F1-Control, F2- RDF 100% , F3- RDF 75% , F4- RDF 50% ,B1- Rhizobium + PSB, B2- Rhizobium + PGPR,B3 – Rhizobium + PSB + PGPR

CONCLUSION

The findings of this study suggest that the best approach for enhancing growth and yield attributes in late-sown chickpea crops during the rabi season in the central zone of Madhya Pradesh is the combined application of 100% recommended dose of fertilizer (RDF) with Rhizobium, PSB (Phosphate-Solubilizing Bacteria), and PGPR (Plant Growth-Promoting Rhizobacteria) (referred to as treatment F2 B3). This optimized treatment resulted in increased yield, higher protein yield, and ultimately, greater net profit compared to other treatments examined. Therefore, it is recommended that for late-sown chickpea cultivation in this region, the application of 100% RDF along with Rhizobium, PSB, and PGPR be adopted to maximize productivity and profitability.

REFERENCE

Ali, A., M.S. Zia, Rahmatullah, A. Shah and M. Yasin (2006). Nodulation in Sesbania bispinosa as affected by nitrogen application. Pakistan Journal of Soil Science 15: 183-185.

Aslam M, Mahmood I A, Sultan T, Ahmad S and Zahid M A (2000) Growth and yield response of chickpea (*Cicer arietinum*) to various *Rhizobium* strains fertilized with different P levels.*Int J Agri. Biol* 2;89-91.

Dinesh Kumar, Arvadiya LK, Kumawat AK, Desai KL, Patel TU. (2014) Yield, Protein Content, Nutrient (N, P and K) Content and their Uptake in Chickpea (*Cicer arietinum* L.) as Influenced by Graded Levels of Fertilizersand Bio-Fertilizers. Trends in biosciences, 7(24):4229-4233

Egamberdieva, D., Abdiev, A., Khaitov, B., 2015. Synergistic interactions among root-associated bacteria, rhizobia and chickpea under stress conditions. In: Plant Environment Interaction: Responses and Approaches to Mitigate Stress, M.M. Azooz, P. Ahmad (Eds.), John Wiley & Sons, Ltd., pp.250-261.

Fatima, Z., Bano, A., Sial, R., Aslam, M., (2008). Response of chickpea to plant growth regulators on nitrogen fixation and yield. *Pakistan Journal of Botany* 40(5): 2005-2013.

Garg, N., Baher, N., (2013). Role of arbuscular mycorrhizal symbiosis in proline biosynthesis and metabolism of *Cicer arietinum* L. (chickpea) genotypes under salt stress. *Journal of Plant Growth Regulation* 32: 767–778.

Gupta, S.C. (2007). Response of chickpea to micronutrients and bio fertilizers application in vertisol. Abstract International Conference on sustainable Agriculture For food, Bio energy and livelihood security held from Feb. 14- 16 at JNKVV, Jabalpur pp 87.

Gupta, S.C. and Gangwar, S. (2012). Effect of molybdenum, iron and microbial inoculants on symbiotic traits, nutrient uptake and yield of chickpea. Journal of Food legumes. 25(1):45-49.

Kanter, F., Elkoca, E., H .Ogutcu, and Adgur, O.F.,(2003). Chickpea yield in relation to Rhizobium inoculation from wild chickpea at high altitudes. J Agric. Crop Sci. 189 (5): 291-297.

Kushwaha, H. S. (2007). Response of chickpea to bio-fertilizer, nitrogen and phosphorous fertilization under rainfed condition. J. of Food Legumes Res. 20 (2): 179- 181.

Meena KN, Pareek RG, Jat RS (2005). Effect of phosphorus and biofertilizers on yield and quality of chickpea. An. Agric. Res. New Series, 22(3):388-390.

Patil., D.P., Kulkarni., M.V. Maheswari, V.L. and Kothari, R.M. (2001) Improved yield of Bengal gram (*Cicer arietinum* L.) in saline soil ameliorated with soil conditioner, helophiles and plant growth regulators. J. Plant Biol. 28 (2) : 207-211.

Pyare,Ram and Dwivedi D.P. (2005).Yield, economics and quality of chickpea(*Cicer arietinum*) as affected by row spacing and phosphorus doses under limited irrigation. Crop Res. 29 (1): 95-100.

Raghuwanshi R (2012) Opportunities and challenges to sustainable agriculture in India. NEBIO 3(2): 78-86.

Singh R, Prasad K.(2008) Effect of vermicompost, Rhizobium and DAP on growth, yield and nutrient uptake by chickpea. J. Food legumes. 21(2):112-114.

Singh, R. A. and Haider, Ekhlaq (2008). Integrated nutrient management in groundnut-field pea-summer groundnut cropping system. *International Journal of Agricultural Sciences* 4 (2): 613-618.

Singh, R.K., Shukla, D.N. and Nirmal, D.E. (2006). Effect of bio-fertilizers, fertility level and weed management on weed growth and yield of late sown chickpea (Cicer arietinum L.). Indian J. of Agric. Sci. 76 (9):561-563.

Tolanur S.I. (2008). Integrated effect of organic manuring and inorganic fertilizer N on yield and uptake of micronutrients by chickpea in vertisol. Legume Res. 31 (3):184-187.

Tripathi, L.K., Thomas, T., Singh, V.J., Gampala, S., Kumar, R., (2015). Effect of nitrogen and phophorus application on soil nutrient balance in chickpea (*Cicer arietinum* L.) cultivation. 7(24):4229-4233

Vessey J K (2003) Plant growth promoting rhizobacteria as biofertilizers. *Pl soil* 255(2):571-86.