Seed Res. 53 (2): 164-170, December, 2025
doi: https://doi.org/10.56093/SR.v53i2.10

Effect of Seed Treatments on Seed Yield and Quality Parameters in Chickpea Seeds (*Cicer arietinum* L.) Cv. HC-7 and HC-5

MS PUNEETH RAJ, VS MOR AND AXAY BHUKER

Department of Seed Science and Technology,
CCS Haryana Agricultural University, Hisar, Haryana-125004, India
*rajpuneeth@gmail.com

(Received July 2025; Revised August 2025; Accepted September 2025)

ABSTRACT: The present investigation was carried out at the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, to assess the effect of different biological seed treatments on seed yield and quality parameters of chickpea (*Cicer arietinum* L.) cultivars HC-5 and HC-7. The treatments comprised seed inoculation with *Rhizobium*; seed coating on hydro-primed seeds (6 h at 20 °C) with Bio-NPK combined with drought-alleviating bacteria (DAB); seed coating with *Trichoderma harzianum* (2 × 10v CFU g^{-1}) @ 15 ml kg^{-1} seed; and an untreated control. Treated seeds were first evaluated for laboratory seed quality parameters and subsequently sown under field conditions to study growth, yield, and economic performance. The results revealed that *Rhizobium* inoculation significantly improved seed quality and yield attributes in both cultivars, followed by Bio-NPK + DAB seed coating, while the untreated control consistently recorded the lowest values. Germination percentage was highest in *Rhizobium*-treated seeds (99.00% in HC-5) compared to the control (93.33% in HC-5). Vigour Index-I was also significantly higher under *Rhizobium* treatment (2230 in HC-5 and 2600 in HC-7) than in the control (2071 and 2388, respectively). Field evaluation showed significant effects of treatments on plant height, number of seeds per plant, seed yield, and benefit–cost ratio. Maximum seed yield was recorded with *Rhizobium* inoculation (28.11 q ha^{-1} in HC-5 and 29.78 q ha^{-1} in HC-7), whereas the untreated control produced the lowest yields (25.78 and 26.88 q ha^{-1}, respectively). Post-harvest seed quality analysis further confirmed significant improvements in seedling length and Vigour Index-I due to biological seed treatments. The study concludes that *Rhizobium* inoculation is an effective, economical, and environmentally sustainable seed treatment for enhancing seed quality and productivity in chickpea, with additional benefits from bio-based seed coating treatments such as Bio-NPK + DAB and *Trichoderma harzianum*.

Keywords: Chickpea, Seed treatment, Biofertilizers, Seed yield, Seed quality

INTRODUCTION

Pulses play a vital and multifaceted role in global farming systems and human nutrition. Often referred to as food legumes, they are among the earliest crops domesticated by humankind and are popularly known as the "poor man's meat" due to their high nutritional value, providing substantial amounts of calories, proteins, vitamins, and minerals [1]. Pulses are the edible seeds of leguminous plants, many of which are processed into dhal and consumed widely as a staple food.

India occupies a premier position in the global pulse economy, ranking first in production (25% of world output), consumption (27% of global demand), and import (14%) of pulses. Pulses are cultivated over an area of 22.37 million hectares in India, with a total production of 14.66 million tonnes and an average productivity of 655 kg ha^{-1}. Major pulse crops grown in the country include chickpea, pigeon pea, lentil, urd bean, mung bean, pea, lablab bean, moth bean, and horse gram. Among these, chickpea (*Cicer arietinum* L.) is one of the most important and widely cultivated pulse crops across diverse agro-ecological regions of India.

Chickpea, a predominant *Rabi* season pulse crop belonging to the family Fabaceae, originated in south-eastern Turkey [2]. It is primarily grown under cool and dry climatic conditions in semi-arid tropical regions and fits well into crop rotation and intercropping systems with cereals. Chickpea plays a significant role in improving soil health by breaking disease and pest cycles and enhancing soil fertility through biological nitrogen fixation [3,4,5]. The crop has the ability to fix up to 140 kg N ha^{-1} from the atmosphere through symbiotic association with *Rhizobium*, meeting nearly 80% of its nitrogen requirement [6]. In India, chickpea occupies about 10.17

million hectares with a production of 11.35 million tonnes and an average productivity of 1116 kg ha^{-1} [7].

Nutritionally, chickpea grains are rich in protein (18–22%), carbohydrates (61–62%), fats (4.5%), calcium (280 mg 100 g^{-1}), iron (12.3 mg 100 g^{-1}), phosphorus (301 mg 100 g^{-1}), and possess a calorific value of 396 kcal 100 g^{-1} (ICMR). In addition to grain, chickpea straw is an excellent source of fodder, while husk and dhal by-products serve as valuable cattle feed. The leaves contain malic and citric acids, which are traditionally used for medicinal purposes.

Despite the development of high-yielding varieties and improved production technologies, chickpea productivity in India remains constrained by the non-availability of quality seed, improper nutrient management, and inadequate use of biofertilizers. Limited attention has been given to biological inputs such as *Rhizobium*, *Trichoderma*, and phosphate-solubilizing bacteria (PSB), which play a crucial role in sustainable nutrient management. Biofertilizers colonize the rhizosphere and promote plant growth by increasing nutrient availability and providing growth-stimulating substances. Nitrogen-fixing microorganisms, in particular, contribute significantly to reducing dependence on chemical fertilizers and enhancing soil health [8]. Inoculation of legume crops with efficient *Rhizobium* strains has been recognized as an effective approach to improve nitrogen fixation and crop productivity.

Among biofertilizers, *Rhizobium* is well known for its symbiotic nitrogen-fixing ability, forming root nodules in leguminous plants where atmospheric nitrogen is converted into a plant-available form through the action of the nitrogenase enzyme. Similarly, *Trichoderma* spp. serve as effective biocontrol agents and plant growth promoters, producing enzymes such as cellulases and chitinases that suppress soil-borne pathogens like *Rhizoctonia*, *Pythium*, and *Armillaria*. However, research on integrated biological seed treatments aimed at improving seed yield and quality in chickpea remains limited, particularly under Indian conditions.

Seed quality is a critical determinant of crop establishment, productivity, and profitability. Seed treatments using biofertilizers offer a cost-effective, eco-friendly strategy to enhance seed vigour, field performance, and yield sustainability. Therefore, identifying efficient biological seed treatments that improve both seed yield and post-harvest seed quality is of paramount importance to ensure the availability of high-quality seed to farmers at affordable prices.

In view of these considerations, the present investigation entitled was undertaken to evaluate the efficacy of selected biological seed treatments in enhancing seed quality, yield, and overall productivity of chickpea.

MATERIALS AND METHODS

Experimental Material and Location

Seeds of chickpea (*Cicer arietinum* L.) cultivars HC-5 and HC-7 were procured from the Pulse Section, CCS Haryana Agricultural University (CCS HAU), Hisar. The experiment was conducted at the Department of Seed Science and Technology, CCS HAU, Hisar.

Seed Treatments

The experiment comprised the following seed treatment combinations:

1. Rhizobium inoculation as per the recommended package of practices (PoP);
2. Seed coating on hydro-primed seeds (primed for 6 h at 20 °C) with Bio-NPK combined with drought-alleviating bacteria (DAB);
3. Seed coating with *Trichoderma harzianum* (2 × 10v CFU g^{-1}) @ 15 g kg^{-1} seed;
4. Untreated control.

Laboratory Evaluation of Seed Quality

Treated seeds were evaluated for seed quality parameters including seed moisture content, seedling length (cm), seedling dry weight (mg), germination percentage, first count (%), vigour index-I, vigour index-II, and electrical conductivity (µS cm^{-1} g^{-1}).

Seed moisture content was determined as per ISTA procedures. Germination tests were conducted using the between paper (BP) method following ISTA guidelines [9]. Fifty seeds per replication with eight replications were placed on moist germination paper, rolled, and incubated in a germination chamber maintained at 25 ± 1 °C and 90% relative humidity. The first count was recorded on the 5th day, and the final count on the 8th day. Germination percentage was calculated based on normal seedlings.

Seedling length was measured from the root tip to the shoot apex, and seedling dry weight was recorded after oven drying at 80 °C for 24 hours. Vigour index-I was calculated using the formula proposed by Abdul-Baki and Anderson [10]:

SVI-I = Germination (%) × Mean seedling length (cm)

Electrical conductivity was measured using four replications of 25 seeds each. Seeds were weighed accurately to two decimal places, surface sterilized with acetone for five minutes, and thoroughly rinsed with distilled water. The seeds were then soaked in 25 ml distilled water and incubated for 24 hours. Electrical conductivity of the seed leachate was measured using a digital conductivity meter (Model DI-909). After subtracting the conductivity of distilled water, the results were expressed as $\mu S\ cm^{-1}\ g^{-1}$ at 25 ± 1 °C.

Field Evaluation

Treated seeds were sown under field conditions, and observations were recorded on growth, yield, and economic parameters. Final plant stand establishment (%) was recorded at five weeks after sowing by counting plants at four randomly selected locations in each plot over a 5-m row length. Plant height (cm) was measured from five randomly selected plants at four locations per plot.

Yield attributes including number of pods per plant, number of seeds per pod, and seed yield per plant were recorded from five plants at four randomly selected locations in each plot. Thousand-seed weight was determined using four replications of seed samples from each plot. Plot yield (kg) was recorded and converted to yield per hectare. Harvest index (HI) was calculated using the formula:

$$HI\ (\%) = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Post-harvest seed quality of the harvested seed was evaluated following ISTA procedures. Economic analysis was performed by calculating the benefit–cost ratio.

Statistical Analysis

The experimental data were statistically analyzed using OPSTAT software [11]. Significance of treatment effects was tested at the appropriate probability level.

RESULTS AND DISCUSSION

Seed Quality Parameters

Analysis of variance revealed that varietal differences and seed treatments exerted a statistically significant influence on germination percentage, seedling length (cm), seedling dry weight (mg), Vigour Index-I, and Vigour Index-II at the 5% level of significance (Table 1). The treatment- mean differences exceeding the critical difference (CD) values were considered statistically significant, while the standard error (SE) values indicated good precision of the experimental data.

Among the treatments, seeds treated with *Rhizobium* recorded significantly superior seed quality parameters compared to other treatments and the untreated control. Seed coating on hydro-primed seeds (6 h at 20 °C) with Drought Alleviating Bacteria + Biogrow ranked next, whereas the lowest values were consistently recorded in the control.

The highest germination percentage was observed in the recommended Package of Practices (PoP) treated with *Rhizobium* (HC-5: 99.00%), which was significantly higher than the control (HC-5: 93.33%), with the difference exceeding the corresponding CD value. Similar statistically significant trends were observed for Vigour Index-I, where *Rhizobium* treatment recorded the maximum values (HC-5: 2230; HC-7: 2600), while the minimum values were noted in the control (HC-5: 2071; HC-7: 2388). These findings are in conformity with earlier reports [12].

The enhancement in seed quality parameters due to *Rhizobium* inoculation may be attributed to the production of growth-promoting substances such as gibberellic acid (GA), indole-3-acetic acid (IAA), and other auxins. Additionally, improved nodulation and biological nitrogen fixation enhance early seedling growth, which is reflected in higher vigour indices and statistically significant treatment differences supported by low SE values.

Growth and Yield Attributes

Significant differences among treatments (Tables 1 and 2) were also observed for plant height and number of seeds per pod, as evidenced by ANOVA. Seed treatment with *Rhizobium* resulted in a significantly higher number of seeds per pod in both varieties (HC-5: 1.06; HC-7: 1.26), which differed significantly from the untreated control (HC-5: 1.03; HC-7: 1.23), as the treatment means exceeded the corresponding CD values [13, 14]. Similar findings have been reported by [15].

A comparable trend was observed for seed yield and benefit–cost (B:C) ratio. Seed yield differences among treatments were statistically significant at the 5% level. The highest seed yield was recorded in T_2

Table 1. Effect of seed treatment on seed quality parameters in chickpea crop

Treatments (T)	Germination(%)			Seedling length (cm)			Seedling dry weight(mg)			Vigour Index I		
	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean
T_1	93.33	98.00	95.67	22.20	24.37	23.285	28.25	29.33	28.79	2071	2388	2229
T_2	99.00	100.00	99.50	22.53	26.00	24.265	29.55	35.33	32.44	2230	2600	2415
T_3	96.33	100.00	98.17	22.37	25.00	23.685	28.83	34.77	31.80	2156	2500	2328
T_4	95.00	100.00	97.50	22.27	22.67	22.47	28.64	33.33	30.99	2115	2267	2191
Mean	95.92	99.50	97.71	22.34	24.51	23.425	28.82	33.19	31.01	2143	2439	2291
S.Em.±	V=0.47	T= 0.67	VxT=0.95	V=0.21	T=0.29	VxT=0.41	V=0.45	T=0.63	VxT=0.89	V=20.80	T=29.41	VxT=41.60
C.D. (P=0.05)	V=1.44	T=2.03	VxT=NS	V=0.62	T=0.88	VxT=1.25	V=1.35	T=1.91	VxT= NS	V=62.89	T=88.94	VxT= NS

T_1=Control (Untreated), T_2= (seeds treated with *Rhizobium*), T_3=Seed coating (on hydro primed seeds-6hrs at 20ºC) with Drought Alleviating Bacteria + Biogrow, T_4=Seed coating (on dry seeds) with *T. harzianum*

Table 2. Effect of seed treatment on field parameters in chickpea crop

Treatments (T)	Final plant stand establishment (%)			Plant height (cm)			No of pods/plant			Total number of seeds/plant		
	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean
T_1	88.24	91.76	90.00	92.60	71.40	79.70	300.00	265.80	282.90	310.00	326.00	318.00
T_2	94.12	95.29	94.71	98.00	79.00	89.00	312.00	274.60	293.30	330.00	345.00	337.50
T_3	92.94	94.12	93.53	94.60	76.20	86.00	306.00	272.40	289.20	321.40	340.40	330.90
T_4	91.76	94.12	92.94	93.40	74.40	84.10	300.60	269.20	284.90	313.20	332.80	323.00
Mean	91.76	93.83	92.79	94.65	75.25	84.70	304.65	270.50	287.58	318.65	336.05	327.35
S.Em.±	0.94	1.32	1.87	0.50	0.71	1.00	2.32	3.28	4.64	1.76	2.49	3.51
Factors	(V)	(T)	(T×V)	(V)	(T)	(T×V)	(V)	(T)	(T×V)	(V)	(T)	(T×V)
C.D. (P=0.05)	NS	NS	NS	1.46	2.17	NS	6.75	NS	NS	5.12	7.24	NS

T_1=Control (Untreated), T_2= (Recommended PoP-treated with *Rhizobium*), T_3=Seed coating (on hydro primed seeds-6hrs at 20ºC) with Drought Alleviating Bacteria + Biogrow, T_4=Seed coating (on dry seeds) with *T. harzianum*

Table 3. Effect of seed treatment on field parameters in chickpea crop

Treatments (T)	Seeds/pod			Per plant yield (g)			Biologicalyield/plant (g)		
	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean
T_1	1.03	1.23	1.13	46.40	48.40	47.40	118.60	79.00	98.80
T_2	1.06	1.26	1.16	50.60	53.60	52.10	124.40	82.40	103.40
T_3	1.05	1.25	1.15	49.60	51.00	50.30	124.00	78.00	101.00
T_4	1.04	1.24	1.14	49.40	49.80	49.60	117.60	78.80	98.20
Mean	1.05	1.24	1.15	49.00	50.70		121.15	79.55	
S.Em.±	0.011	0.02	0.02	2.49	3.52	4.98	8.56	12.11	17.12
	(V)	(T)	(T×V)	(V)	(T)	(T×V)	(V)	(T)	(T×V)
C.D. (P=0.05)	0.033	NS	NS	NS	NS	NS	24.928	NS	NS

T_1=Control (Untreated), T_2=(Recommended PoP-treated with *Rhizobium*), T_3=Seed coating (on hydro primed seeds-6hrs at 20ºC) with Drought Alleviating Bacteria + Biogrow, T_4=Seed coating (on dry seeds) with *T. harzianum*

Table 4. Effect of seed treatment on field parameters in chickpea crop

Treatments (T)	Seed yield q/ha			Harvest Index			B:C ratio		
	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean
T_1	25.78	26.86	26.32	0.42	0.62	0.52	3.139	3.269	3.204
T_2	28.11	29.78	28.94	0.65	0.69	0.67	3.326	3.525	3.426
T_3	27.56	28.33	27.94	0.60	0.65	0.62	3.259	3.351	3.305
T_4	27.43	27.69	27.56	0.42	0.65	0.54	3.247	3.279	3.263
Mean	27.22	28.16	27.69	0.52	0.65		3.243	3.356	3.299
S.Em.±	0.31	0.43	0.61	0.08	0.10	0.15	0.04	0.05	0.07
	(V)	(T)	(T×V)	(V)	(T)	(T×V)	(V)	(T)	(T×V)
C.D. (P=0.05)	0.89	1.27	NS	NS	NS	NS	0.107	0.151	NS

T_1=Control (Untreated), T_2= (Recommended PoP-treated with *Rhizobium*), T_3=Seed coating (on hydro primed seeds-6hrs at 20ºC) with Drought Alleviating Bacteria + Biogrow, T_4=Seed coating (on dry seeds) with *T. harzianum*

(Recommended PoP-treated with *Rhizobium*) in both varieties (HC-5: 28.11 q ha^{-1}; HC-7: 29.78 q ha^{-1}), which was significantly superior to T_1 (Control) (HC-5: 25.78 q ha^{-1}; HC-7: 26.88 q ha^{-1}). The observed yield differences were greater than the calculated LSD values, confirming the effectiveness of *Rhizobium* inoculation. These results are in agreement with the findings of several researchers [12, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25].

Post-Harvest Seed Quality

Post-harvest seed quality parameters (Tables 5 and 6) also exhibited significant treatment effects, particularly for seedling length and Vigour Index-I. Seedling length was significantly higher under T_2 (Recommended PoP-treated with *Rhizobium*) in both varieties (HC-5: 28.67 cm; HC-7: 29.97 cm) compared to the untreated control (HC-5: 23.67 cm; HC-7: 25.33 cm). The differences among treatments exceeded the respective CD values, indicating true treatment effects rather than experimental variability, in agreement with earlier reports [24].

The improved seedling growth and vigour observed under bioinoculant treatments may be attributed to enhanced enzymatic activity and antioxidant defense mechanisms, including catalase, peroxidase, and superoxide dismutase (SOD). These biochemical processes improve metabolic efficiency during germination and early seedling growth, resulting in statistically significant improvements in seed quality parameters, as reflected by lower SE and higher treatment means.

CONCLUSION

The present investigation clearly demonstrated that seed treatment with *Rhizobium* in combination with the recommended doses of nitrogen, phosphorus, and potassium represents a highly effective and economically viable strategy for enhancing productivity and profitability in chickpea. The recommended Package of Practices (PoP) treated with *Rhizobium* resulted in a statistically significant increase in seed yield over the untreated control, recording yield advantages of 8.29% and 9.73% in varieties HC-5 and HC-7, respectively, and also outperforming all other treatment combinations evaluated in the study. These yield gains reflect the beneficial role of *Rhizobium* in improving nutrient availability, particularly

Table 5. Effect of seed treatment on seed quality parameters in chickpea crop after harvest

Treatments (T)	Germination(%)			Seedling length (cm)			Seedling dry weight(mg)			Vigour Index I		
	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean
T_1	99.33	97.33	98.32	23.67	25.33	24.50	0.403	0.387	0.395	2351	2465	2408
T_2	100.00	99.33	99.67	28.67	29.97	29.32	0.418	0.449	0.434	2867	2977	2922
T_3	100.00	98.67	99.34	27.73	28.10	27.92	0.414	0.441	0.428	2773	2775	2774
T_4	100.00	97.33	98.67	26.83	28.07	27.45	0.412	0.392	0.402	2683	2733	2708
Mean	99.83	98.17	98.99	26.73	27.87	27.30	0.412	0.417	0.415	2669	2737	2703
S.Em.±	V=0.02	T=0.03	VxT=0.04	V=0.73	T=1.03	VxT=1.45	V=1.17	T=1.65	VxT=2.34	V=74.33	T=105.11	VxT=148.65
C.D. (P=0.05)	V=0.06	T=NS	VxT=NS	V=NS	T=3.11	VxT=NS	V=NS	T=NS	VxT=NS	V=NS	T=317.84	VxT=NS

T_1=Control (Untreated), T_2= (Recommended PoP-treated with *Rhizobium*), T_3=Seed coating (on hydro primed seeds-6hrs at 20ºC) with Drought Alleviating Bacteria + Biogrow, T_4=Seed coating (on dry seeds) with *T. harzianum.*

Table 6. Effect of seed treatment on seed quality parameters in chickpea crop after harvest

Treatments (T)	Vigour Index II			1000 seed weight (g)			First count (%)			Radical emergence % (48hr)		
	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean	HC-5	HC-7	Mean
T_1	3999	3783	3891	149.67	138.06	143.87	99.00	97.33	98.17	98.33	96.67	97.50
T_2	4177	4458	4318	153.67	141.12	147.40	99.67	99.00	99.34	99.67	98.67	99.17
T_3	4140	4352	4246	152.00	140.00	146.00	99.33	98.33	98.83	99.33	98.33	98.83
T_4	4120	3818	3969	151.67	138.94	145.31	99.00	97.67	98.34	98.67	97.00	97.83
Mean	4109	4103	4106	151.75	139.53	145.64	99.25	98.08	98.67	99.00	97.67	98.33
S.Em.±	V=124.75	T=176.43	VxT=249.51	V=2.65	T=3.74	VxT=5.29	V=0.45 (0.02)	T=0.64(0.03)	VxT=0.91	V= 0.36	T=0.507	VxT=0.72
C.D. (P=0.05)	V=NS	T=NS	VxT=NS	V=8.00	T=NS	VxT=NS	V=NS	T=NS	VxT=NS	V=1.08	T=NS	VxT=NS

T_1=Control (Untreated), T_2= (Recommended PoP-treated with *Rhizobium*), T_3=Seed coating (on hydro primed seeds-6hrs at 20ºC) with Drought Alleviating Bacteria + Biogrow, T_4=Seed coating (on dry seeds) with *T. harzianum* through enhanced biological nitrogen fixation, which translates into improved crop growth and yield realization under field conditions.

In addition to yield enhancement, *Rhizobium* treatment exerted a pronounced positive influence on seed quality parameters, both before and after harvest. Significant improvements were observed in seedling length and Vigour Index-I, indicating superior physiological quality of seeds produced under this treatment. Seeds obtained from *Rhizobium*-treated plots exhibited significantly higher seedling length values of 28.67 cm in HC-5 and 29.97 cm in HC-7, reflecting improved metabolic activity and early seedling growth potential. The consistent superiority of *Rhizobium* treatment across yield, seed quality, and economic parameters underscores its role as a sustainable bio-input that enhances crop performance while supporting soil health. Overall, the findings suggest that integration of *Rhizobium* seed treatment with recommended fertilization practices can be effectively adopted as a best management practice for achieving higher productivity, improved seed quality and enhanced profitability in chickpea cultivation.

REFERENCES

1. SINGH V AND B SINGH (1990). Tropical grain legumes as important human foods. *Economic Botany*, **46**: 310-321.
2. REDDEN R, W CHEN AND B SHARMA (2007). editors. Chickpea breeding & Management. *CABI, Walling ford*. UK, 355-68.
3. RAIMI A, R ADELEKE AND A ROOPNARAIN (2017). Soil fertility challenges and Biofertiliser as a viable alternative for increasing smallholder farmer crop productivity in sub-Saharan Africa. *Cogent Food & Agriculture,* **3(1)**: 1400933. https://doi.org/10.1080/23311932.2017.1400933.
4. LI J, L HUANG AND J ZHANG (2019). Diversifying crop rotation improves system robustness. *Agronomy for Sustainable Development,* **39(4)**: 1-13. https://doi.org/10.1007/s13593-019- 0584-0.
5. FIKRE A, H DESMAE AND S AHMED (2020). Tapping the economic potential of chickpea in sub-Saharan. *Africa Agronomy,* **10(11)**: 1707. https://doi.org/10.3390/agronomy10111707.
6. SCHILT-VAN, C ETTEKOVEN, KE GILLER, G TON AND DBA GLOVER (2020). Putting nitrogen fixation to work for smallholder farmers in Africa. (No. 58). N2Africa project. N2Africa Podcaster no. 58: Retrieved from https://n2africa.org/sites/default/ files/N2Africa%20Podcaster%2058.pdf.
7. ANONYMOUS (2020). Agricultural statistics at a glance. Directorate of economics & statistics, department of agriculture, cooperation and farmers welfare. New Delhi: Ministry of Agriculture & Farmers Welfare, Govt. of India, 63.
8. TAMBEKAR DH, SR GULHANE, DO SOMKUWAR, KB INGLE AND SP KANCHALWAR (2009). Potential Rhizobium and phosphate solubilizers as a biofertilizers from saline belt of Akola and Buldhana district. *India. Res J. Agric Biol Sci,* **5(4)**: 578-582.
9. ISTA (2011). International rules for seed testing. Ed. (2011). International Seed Testing Association, Zurich. Switzerland.
10. ABDUL BAKI AA AND JD ANDERSON (1973). Vigour determination in Soybean seeds by multiple criteria. *Crop Sci,* **13**: 630-633.
11. SHEORAN OP, DS TONK, LS KAUSHIK, RC HASIJA, RS PANNU, DS HOODA AND RC HASIJA (1998). Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & computer applications by department of mathematics statistics, CCS HAU, Hisar, 139-143.
12. KUMARI N, S MONDAL, P MAHAPATRA, TT MEETEI AND YB BIJILAXMI DEVI (2019). Effect of biofertilizer and micronutrients on yield of chickpea. *Int J Curr Microbiol Appl Sci,* **8(1)**: 2389-97.
13. NAWANGE DD, AS YADAV AND RV SINGH (2011). Effect of phosphorus and sulphur application on growth, yield attributes and yield of chickpea (Cicer arietinum L.). *Legume Research-An Int. Journal,* **34(1)**: 48-50.
14. KARWASRA RS, Y KUMAR AND AS YADAV (2006). Effect of phosphorus and sulphur on greengram (Phaseollus radiatus). *Haryana Journal of Agronomy,* **22(2)**: 164-165.
15. JARANDE NN, PS MANKAR, VS KHAWALE, AA KANSE AND JT MENDHE (2006). Response of chickpea (Cicer arietinum. L) to different levels of phosphorus through inorganic and organic sources. *J. Soils Crops,* **16**: 240-243.
16. SINGH G, HS SEKHON AND P SHARMA (2011). Effect of irrigation and biofertilizer on water use, nodulation, growth and yield of chickpea (Cicer arietinum L.). *Agron. Soil Sci,* **57(7)**: 715-726.
17. SINHA BN, BS MEHTA AND M JOYDIP (2000). Quality and seed yield of garden pea (Pisum sativum) cultivars as influenced by date of planting and phosphorus levels. *Indian J Agric Sci,* **70(4)**: 248-249.
18. VIMALA B AND S NATARAJAN (2000). Effect of nitrogen, phosphorus and biofertilizers on pod characters, yield and quality in pea (*Pisum sativum* L. spp. hortense). *Indian Hortic,* **48(1/6)**: 60-63.
19. TIWARI VN, RM UPADHYAY AND RK PANDEY (2001). Associative effect of diazotrophs and phosphorus on chickpea. *Indian J Pulses Res,* **14(2)**: 129-132.
20. YADAV PS, PR KAMERIA AND S RATHORE (2002). Effect of phosphorus and iron fertilization on yield, protein content and nutrient uptake in gram (*Cicer arietinum* L.) on loamy sand soil. *J Indian Soc Soil Sci,* **50**: 225-6.
21. SINGH A, D SINGH, R KUMAR, S PAL, R SACHAN AND A YADAV (2021). Study the effect of organic, inorganic and biofertilizers on nutrients content and uptake of chickpea (Cicer arietinum L.). *The Pharm Innov J,* **10(10)**: 418-23.
22. SHARMA KC (2001). Fertilizer management in chickpea (Cicer arietinum L.) under rain fed conditions of Jammu region of Kashmir. *Adv Plant Sci*, **14(2)**: 519- 523.
23. PATEL D, MK ARVADIA AND AJ PATEL (2007). Effect of integrated nutrient management on growth, yield and nutrient uptake by chickpea on vertisol of South Gujrath. *J Food Legumes,* **20(1)**: 113-4.
24. PATEL HA AND JD THANKI (2020). Effect of integrated nutrient management on growth, yield, soil nutrient status and economics of chickpea (Cicer arietinum L.) under south Gujarat conditions. *J Pharmacogn Phytochem,* **9(6)**: 623-6.
25. KANTAR F, E ELKOCA, H OGUTCU AND OF ALGUR (2003). Chickpea yields in relation to Rhizobium inoculation from wild chickpea at high altitudes. *J Agron Crop Sci*, **189(5)**: 291-7.