Effect of phosphorus, zinc and *rhizobium* on productivity and profitability of chickpea (*Cicer arietinum* L.)

Abstract

Field experiments were done Effect of phosphorus, zinc and *rhizobium* on yield and profibility of chickpea (*Cicer arietinum* L.) during rabi season of 2020-21 and 2021-22 at students instructional farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. The experiment consist of 18 treatments combinations in factorial randomized block design with three replications consisted of three levels of phosphorous (0, 30 and 60 kg ha^{-1}), three levels of zinc (0, 2.5 and 5.0 kg ha^{-1}) and two levels of *rhizobium* inoculation (with *rhizobium* and without *rhizobium*). Chickpea variety *RVG-202* was grown with the recommended agronomic practices. Results of the experiment reflected that yield of chickpea crop increased with the use of phosphorus, zinc and *rhizobium* inoculation. Maximum grain yield 20.89 kg ha^{-1}, stover yield 25.26 kg ha^{-1}, biological yield 46.15 kg ha^{-1} and harvest index 45.27% were recorded under T_{18} (60 kg P+5 kg Zn ha^{-1} *rhizobium* innoculation) over control during second year. But, significantly increased T_{17} (60 kg P+2.5 kg Zn ha^{-1+} *rhizobium* innoculation) during both years (2020-21 and 2021-22). The maximum cost of cultivation (₹ 36615.23), gross return (₹ 115380), net return (₹ 78764.77) and B:C ratio (2.15) were recorded under T_{18} (60 kg P+5 kg Zn ha^{-1} *rhizobium* innoculation). The present study showed that combined application of phosphorus and zinc with *rhizobium* inoculation along with recommended nitrogen and potassium could be an effective option for enhancing chickpea yield component, yield and economic return.

Key Words: Chickpea, Economics, Phosphorous, *Rhizobium*, Yield and Zinc.

Introduction:

Pulses crop is pre-dominant role in maintain natural resources with high quality. It is grown in large scale in world but highest cultivated area and producer in India. After cereal crop, pulses is the most important grown in every part of India. It is easily available in rural for protein. India is a highly populated country under the category of developing nations. The protein requirement of most of the people is fulfilling through pulses. In India, protein is major source of pulses crop especially vegetarians and provide staple cereals with completely diets likes, protein, essential amino acids, vitamins and **(Pingoliya *et al.,* 2013)** .

In pulses crop, chickpea (*Cicer arietinum* L.) is one of the pre-dominant *rabi* crop in India. It is largest produced food legume in South Asia. Chickpea (*Cicer arietinum* L.) originated in south eastern turkey **(Redden *et al.* 2007).** It is a major legume crop cultivated for its edible seeds and family belong *Fabaceae* (*leguminaceae*), and subfamily *Papilionaceae*. Chickpea is known by various name in different countries like- garbanzo (Spanish), pois chiche (French), kichar or chicher (German), chana (Hindi) and gram or Bengal gram (English). Chickpea is a good source of carbohydrates and important vitamins such as riboflavin, niacin, thiamin, folate and the vitamin A precursor β-carotene. Sulphur containing amino acids, Ca, Mg, Zn. Fe, P and, especially, K are also present in chickpea grains. Chickpea has several potential health benefits, and, in combination with other pulses and cereals, it could have beneficial effects on some of the important human diseases such as CVD, type 2 diabetes, digestive diseases and some cancers. Overall, chickpea is an important pulse crop with a diverse array of potential nutritional and health benefits. Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen **(Balai et al. 2017)**

Phosphorus is an important nutrient epically for pulses crop to increased their productivity and fertility of soil. Legumes are heavy feeder of phosphorus and less responsive to nitrogen because of their capacity to meet their own nitrogen requirement through symbiotic nitrogen fixation **(kumar et al. 2016).** Phosphorus plays an important role in nodulation, nitrogen fixation, growth and yield of chickpea **(Meena *et al.,* 2005)**.It is essential for cell division, seed and fruit development and directly involvement of nucleic acids, that is, phospholipids, chromosomes and the coenzymes nicotinamide adenine dineucleotide (NAD), adenosine triphosphate (ATP) and nicotinamide adenine dineucleotide phosphate (NADP). Phosphorus is used in numerous molecular and biochemical plant processes, particularly in energy acquisition, storage and utilization **(Epstein and Bloom, 2005)**. It also improves the crop quality and resistance against plant diseases. Phosphorus application to legumes not only benefits the current crop but also favourably affects the succeeding non-legume crop. Phosphorus deficiency is a critical nutrient-deficiency problem in the Indian soils and may cause up to 29-45% yield losses in chickpea **(Ahlawat et al., 2007).** Symbiotic nitrogen fixation has a high P demand because the process consumes large amounts of energy **(Schulze et al. 2006)** and energy generating metabolism strongly depends upon the availability of P **(Plaxton, 2004)** .

Similarly, zinc is also an important micro nutrient element which increases resistance to disease in plant. However, **Khan *et al.* (2004)** reported that applying Zn increased yield and quality of chickpea. Zinc deficiency in agricultural soils is also a wide-spread constraint for chickpea production in India. P and Zn facilitate the availability of each other for crop plants **(Ryan *et al.,* 2012).** Similarly zinc is also an important micro nutrient element which increases resistance to disease in plant. **Sharma *et al.* (2000)** reported antagonistic effect of P levels on Zn nutrition by the crops. The information on Zn and P relationship in an important crop like chickpea is not adequate, especially in situations where both the interacting nutrients (P and Zn) are deficient in soil. Most of the soils of Uttar Pradesh have been rated as deficient in available zinc. A favourable balance between phosphorus and zinc should be maintained for optimum growth of plant. It also promotes nodulation and nitrogen fixation in leguminous crops **(Demeterio *et al.,* 1972).**

Biofertilizers may colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients and/or growth stimulus to crop. Nitrogen fixer microorganisms play an important role in supplementing nitrogen to the plant, allowing a sustainable use of nitrogenous fertilizers **(Tambekar *et al.,* 2009).** Nitrogen fixation in agriculture can be improved by inoculation of legume crops with suitable *Rhizobium*. Rhizobium are symbiotic bacteria that facilitate formation of nodules on the roots of legume hosts, within which the bacteria fix atmospheric nitrogen into ammonia. Symbiotic nitrogen fixation is the main route for sustainable input of nitrogen into ecosystems. Adaptability of indigenous *Rhizobium* to their environment results in high levels of saprophytic competence (**Zengeni *et al.,* 2006).** Sometimes indigenous *Rhizobium* may be found in greater numbers than those of the inoculated strains which are also limited in mobility. Using high yielding varieties of chick-pea along with use of effective rhizobial strains can enhance the yield **(Bhuiyan *et al.,* 2008).**

Resources and Methods

Experimental Site:

The experiment was conducted during *rabi* season of 2020-21 and 2021-22 at student's Instructional farm, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The field was well leveled and irrigated by tube well. The farm is situated at main campus of the university, in the west northern part of Kanpur city under sub-tropical zone in vth agro climatic zone (central plain zone).

Edaphic Condition:

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction and low organic carbon in soil. The soil samples were estimated for pH and Electrical conductivity (1:2.5 soil: water suspension method given by **Jackson, 1967**), Organic carbon percentage in soil (Walkley and Black's rapid titration method given by **Walkley and Black, 1934**), with available nitrogen in kg ha^{-1} (Alkaline permanganate method given by **Subbiah and Asija, 1956**), available phosphorus as sodium bicarbonate-extractable P in kg ha^{-1} (Olsen's calorimetrically method**, Olsen *et al.*, 1954**) available potassium in kg ha^{-1} (Flame photometer method given by **Hanwey and Heidel, 1952**) Available sulphur in kg ha^{-1} (Turbidimetric method given by **Chesnin and Yien, 1950**) and Available zinc in mg ha^{-1} was determined by (DTPA extraction **Lindsay and Norvell, 1978**). The nutrient status of initial soil prior to fertilization is presented in table no. 1

Table 1: Analytical data of the experimental soils (pre-sowing)

S. No.	**Soil characters**	**Value**	
		2020-21	**2021-22**
1.	Texture	Sandy loam	Sandy loam
2.	pH (1:2.5 soil water suspension)	8.00	7.98
3.	EC (dsm^{-1}) (1:2.5 soil water suspension)	0.47	0.46
4.	Organic carbon (%)	0.31	0.32
5.	Available N (kg ha^{-1})	201.12	202.59
5.	Available P (kg ha^{-1})	11.78	12.09
6.	Available K (kg ha^{-1})	153.15	154.31
7.	Available S (kg ha^{-1})	0.43	0.45
8.	Available Zinc (mg kg^{-1})	11.84	12.49

Detail of treatments and design

The experiment was consisted of 18 treatments combination of nutrient management having three factors: Factor A: Phosphorus (3 levels); P_0: 0 kg (Control), P_1: 30 kg, and P_2: 60 kg P_2O_5; Factor B: Zinc (3 levels): Zn_0: 0 kg (Control), Zn_1: 2.5 kg and Zn_2: 5 kg Zn ha^{-1} and Factor C: *Rhizobium* (2 level): Rh_0: without *rhizobium* (Control) and Rh_1: with *rhizobium.* The experiment was laid out in Factorial Randomized Complete Block Design (FRBD) with three replications. Full dose (recommended dose) of nitrogen and potash were applied at the time of sowing homogeneously. Phosphorus, zinc and *rhizobium* were applied as per treatments. N, P, K and Zinc were applied through urea, SSP, Murate of potash and zinc sulphate respectively. The crop received two uniform irrigations (pre sowing and pre flowering). The crop was grown by adopting standard agronomic practices. The crop was harvested in the mid fortnight of March in both the years and growth attributes and economics were recorded at harvest.

Table -2: detail of the treatment combinations:

S. N.	**Treatment combination**	**Symbol**
1.	0 kg P+0 kg Zn without *rhizobium*	$\mathbf{P_0\ Zn_0\ Rh_0}$
2.	0 kg P+2.5 kg Zn without *rhizobium*	$\mathbf{P_0\ Zn_{2.5}\ Rh_0}$
3.	0 kg P+5 kg Zn without *rhizobium*	$\mathbf{P_0\ Zn_5\ Rh_0}$
4.	30 kg P+0 kg Zn without *rhizobium*	$\mathbf{P_{30}\ Zn_0\ Rh_0}$
5.	30 kg P+2.5 kg Zn without *rhizobium*	$\mathbf{P_{30}\ Zn_{2.5}\ Rh_0}$
6.	30 kg P+5 kg Zn without *rhizobium*	$\mathbf{P_{30}\ Zn_5\ h_0}$
7.	60 kg P+0 kg Zn without *rhizobium*	$\mathbf{P_{60}\ Zn_0\ Rh_0}$
8.	60 kg P+2.5 kg Zn without *rhizobium*	$\mathbf{P_{60}\ Zn_{2.5}\ Rh_0}$
9.	60 kg P+5 kg Zn without *rhizobium*	$\mathbf{P_{60}\ Zn_5\ Rh_0}$
10.	0 kg P+0 kg Zn with *rhizobium*	$\mathbf{P_0\ Zn_0\ Rh_1}$
11.	0 kg P+2.5 kg Zn with *rhizobium*	$\mathbf{P_0\ Zn_{2.5}\ Rh_1}$
12.	0 kg P+5 kg Zn with *rhizobium*	$\mathbf{P_0\ Zn_5\ Rh_1}$
13.	30 kg P+0 kg Zn with *rhizobium*	$\mathbf{P_{30}\ Zn_0\ Rh_1}$
14.	30 kg P+2.5 kg Zn with *rhizobium*	$\mathbf{P_{30}\ Zn_{2.5}\ Rh_1}$
15.	30 kg P+5 kg Zn with *rhizobium*	$\mathbf{P_{30}\ Zn_5\ Rh_1}$
16.	60 kg P+0 kg Zn with *rhizobium*	$\mathbf{P_{60}\ Zn_0\ Rh_1}$
17.	60 kg P+2.5 kg Zn with *rhizobium*	$\mathbf{P_{60}\ Zn_{2.5}\ Rh_1}$
18.	60 kg P+5 kg Zn with *rhizobium*	$\mathbf{P_{60}\ Zn_5\ Rh_1}$

Harvesting and threshing: the crop was harvested at maturity and was allowed to dry in sun. Separate bundles were made for each plot and weighted. The after drying harvest was threshed manually.

Seed yield (q ha^{-1}): After threshing produce of grain was weighed in kg per plot, which was converted into q ha^{-1} on the basis of net plot area to record the yield in q ha^{-1} under different treatments. Finally grain yield per plot was converted in to q ha^{-1} by conversion factor.

Straw yield (q ha^{-1}): After subtracting the grain yield per plot from the total biological yield. After converting the yields into quintals per hectare, yields were recorded.

Biological yield (q ha^{-1}): Each net plot was harvested and bundles were weighed separately after drying in the sun. Biological yield was recorded in kg plot^{-1} and finally expressed in q ha^{-1}. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

Harvest index (%): The recovery of grains in total dry matter was considered as harvest index, expressed in percentage.

It has been calculated by following formula:

Harvest Index (%) = [Seed Yield (q ha^{-1}) / Biological Yield (q ha^{-1})] x 100

Economics:

The economics of different treatments was worked out on the basis of average yield (seed and stover) of 2020-21 and 2021-22. Treatments was calculated separately. The calculating economics of different treatments and expressed as cost of cultivation, gross return,net returns and benefit : cost ratio (B:C).

(i) Cost of cultivation:

The cost of cultivation was worked out on the basis of input rates at the farm. Treatments cost was calculated separately. The common cost of cultivation (₹ ha^{-1}) was worked out by considering all the expenses incurred in the cultivation and added variable cost due to treatments (including interest of working capital) in order to get total cost of cultivation.

(ii) Gross return (₹ ha^{-1}):

It was calculated by taking the income from the grain and straw produced on the basis of market rates. The yield of chickpea crop was converted into gross return in rupees per hectare on the basis of current price of the produce.

$$\textbf{Gross return}\ (₹\ \textbf{ha}^{-1}) = \textbf{Total income from grain and stover yield}$$

(iii) Net return (₹ ha^{-1}):

Net profit is the outcome received by subtracting the cost of cultivation from gross income (₹ ha^{-1}). The net return was worked out by using following formula-

Net return (₹ ha^{-1}) = Gross return (₹ ha^{-1}) - Cost of cultivation (₹ ha^{-1})

(iv) Benefit Cost ratio (B:C):

Net income of each treatment was divided by cultivation cost of respective treatment and cost benefit ratio was recorded. There was calculated with the help of following formula.

$$\boldsymbol{Benefit\!:cost\ ratio} = \frac{\boldsymbol{Net\ Return}\ (₹\ \boldsymbol{ha^{-1}})}{\boldsymbol{Cost\ of\ cultivation}\ (₹\ \boldsymbol{ha^{-1}})}$$

Statistical analysis:

The growth parameters and yields were recorded and analyzed as per Gomez and Gomez (1984) the tested at 5% level of significance to interpret the significant differences.

Result and Discussion:

Productivity Parameters:

At a glance over the data given in the Table-3 and depicted in Fig.-1 clearly shows that among the productivity parameters viz. grain yield (q ha^{-1}), stover yield (q ha^{-1}) and biological yield (q ha^{-1}) except harvest index (%) significantly increase due to the application of phosphorous, zinc and *rhizobium* inoculation. Grain yield varied from 12.39 to 20.74 q ha^{-1}, stover yield varied from 17.48 to 25.11 q ha^{-1}, biological yield varied from 29.87 to 45.84 q ha^{-1} and harvest index varied from 41.49 to 45.24 % on pooled basis. The application of phosphorus, zinc and rhizobium increased the Grain yield with the result that the 67.39 percent, stover yield 43.64 percent, biological yield 53.47 percent and harvest index 9.04 percent.

The maximum grain yield (20.89 q ha^{-1}), stover yield (25.26 q ha^{-1}), biological yield (46.15 q ha^{-1}) and harvest index (45.27 %) was associated with the treatment T_{18} [60.00 kg P+ 5.00 kg ha^{-1} Zn with *Rhizobium*] during the second year (2021-22) of experimentation. The minimum grain yield (12.26 q ha^{-1}), stover yield (17.16 q ha^{-1}) and biological yield (29.42 q ha^{-1}) associated with the treatment T_1 [0 kg P+ 0kg ha^{-1} Zn without *Rhizobium*] during the first year (2020-21) of experimentation and minimum harvest index (41.31 %) associated with the treatment T_1 [0 kg P+ 0 kg ha^{-1} Zn with *Rhizobium*] during the second year (2021-22) of experimentation.

The enhanced grain yield and stover yield might to be due to adequate amount of nutrients supply of chickpea plants because Symbiotic nitrogen fixation has more phosphorus demand like phosphorus zinc is essential micronutrient and essential for cell wall integrity, cell division, release of enzyme and nitrogen fixation. Rhizobium is symbiotic bacteria which facilitase nodules formation on the root of legume crop. On the whole all three factors increased yield attributes of chickpea. Grain, stover and biological yield of chickpea significantly increased due to phosphorus (60 kg P_2O_5 ha^{-1}) and zinc (2.5 kg Zn kg^{-1}) with *rhizobium* inoculation over their controls. Combine use of phosphorus 60 kg P_2O_5 ha^{-1} and 2.5 kg Zn ha^{-1} alone with *rhizobium* significantly increased grain 20.11 q ha^{-1}, stover 25.26 q ha^{-1} and biological yield 44.7 q ha^{-1} of chickpea recorded under T_{17} [60 kg P+2.5 kg Zn ha^{-1} with *Rhizobium* innoculation] over other treatments during second year. It may due to rhizobium which fix atmospheric nitrogen and increased the supply of other nutrients to plants and ultimately increased grain and stover yield of chickpea. These results also confirms the findings of **Sinha *et al.* (2000), Vimla and Natarajan (2000), Tiwari *et al.* (2001), Yadav *et al.* (2002), Bicer (2014), Badini*et al.* (2015), Pegoraro *et al. (20*18). Mali *et al.* (2003), Yadav *et al.* (2010), Valenciano*et al.* (2011),**). **Singh *et al*. (2012). Krishna *et al.* (2017), Ullah *et al.* (2017), Kumari *et al.* (2019), Raj *et al.* (2019.**

Profitability:

It is visualized from the data given in Table-4 and Table-5 clearly indicate that among the economics parameters viz. cost of cultivation (₹ ha^{-1}), gross return (₹ ha^{-1}), net return (₹ ha^{-1}) and benefit cost ratio significantly increase due to the application of 60 kg phosphorous and 5.00 kg zinc with *rhizobium* inoculation. Cost of cultivation varied from 31524.5 to 36303.5 ₹ ha^{-1}, gross return varied from 67497 to 111596.3 ₹ ha^{-1}, net return varied from 35972.51 to 75292.76 ₹ ha^{-1} and benefit cost ratio varied from 1.14 to 2.08 ₹ ha^{-1} on the pooled basis. The application of phosphorus, zinc and rhizobium increased the cost of cultivation with the magnitude of 15.16 percent, gross return 65.34 percant, net return 109.31 percent and benefit cost ratio 82.46 percent. The maximum cost of cultivation ₹ 36615.23 gross return ₹ 115380, net return ₹ 78764.77 and benefit cost ratio 2.15 was found with T_{18} [60.00 kg P+ 5.00 kg ha^{-1} Zn with *Rhizobium*] over the control during second year. The minimum cost of cultivation ₹ 31212.76, gross return ₹ 64915.5, net return ₹ 33702.74 and benefit cost ratio 1.08 recorded under T_1 [0 kg P+0 kg ha^{-1} Zn with *Rhizobium*] during first year showed the table number 3.

Similar finding of increased the crop yield and profitability with combined application of phosphorus and zinc with *rhizobium* inoculation has been reported by **Singh *et al.* (2005), Kedar *et al.* (2006), Jain *et al.* (2006), Yadav *et al.* (2013), Straw (2014), Pal *et al.* (2021).**

Conclusions:

The current study demonstrate the benefit of phosphorus, zinc and rhizobium alone with recommended N K for achieving higher productibity and profitability by chickpea crop. Application of phosphorus and zinc with *rhizobium* inoculation increased yield attributes, yield and economics of chickpea crop. The burgeoning human population in india needs higher pulses production for fulfilling the dietary protein and minerals requiremnts with maintain soil heath. Finally it can be concluded that the treatment T_{17} (60 kg P+ 2.5 kg Zn with *rhizobium*) is a best option for improving productivity and profitability of chickpea crop.

Table No. 03: Effect of different treatment combinations on productivity parameters of chickpea.

Treatments	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})			Biological yield(q ha^{-1})			Harvest Index (%)		
	2020-21	2021-22	pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	12.26	12.52	12.39	17.16	17.79	17.48	29.42	30.31	29.87	41.67	41.31	41.49
T_2	13.79	14.02	13.91	18.72	18.86	18.79	32.51	32.88	32.70	42.42	42.64	42.53
T_3	14.68	14.86	14.77	19.68	19.94	19.81	34.36	34.8	34.58	42.72	42.7	42.71
T_4	14.51	14.61	14.56	19.16	19.36	19.26	33.67	33.97	33.82	43.09	43.09	43.09
T_5	17.19	17.42	17.31	21.59	21.84	21.72	38.78	39.26	39.02	44.33	44.37	44.35
T_6	18.05	18.47	18.26	22.05	22.37	22.21	40.1	40.84	40.47	45.01	45.23	45.12
T_7	17.36	17.68	17.52	21.87	22.03	21.95	39.23	39.71	39.47	44.25	44.52	44.39
T_8	18.93	19.03	18.98	23.79	23.99	23.89	42.72	43.02	42.87	44.31	44.24	44.28
T_9	19.25	19.51	19.38	24.08	24.27	24.18	43.33	43.78	43.56	44.43	44.56	44.50
T_{10}	13.65	13.87	13.76	18.02	18.28	18.15	31.67	32.15	31.91	43.1	43.14	43.12
T_{11}	14.8	15.1	14.95	20.11	20.61	20.36	34.91	35.71	35.31	42.39	42.29	42.34
T_{12}	16.39	16.82	16.61	20.79	21.07	20.93	37.18	37.89	37.54	44.08	44.39	44.24
T_{13}	16.84	17.04	16.94	21.02	21.58	21.30	37.86	38.62	38.24	44.48	44.12	44.30
T_{14}	18.25	18.63	18.44	22.89	23.1	23.00	41.14	41.73	41.44	44.36	44.64	44.50
T_{15}	19.12	19.38	19.25	23.97	24.13	24.05	43.09	43.51	43.30	44.37	44.54	44.46
T_{16}	18.75	18.86	18.81	23.24	23.68	23.46	41.99	42.54	42.27	44.65	44.33	44.49
T_{17}	19.86	20.11	19.99	24.32	24.59	24.46	44.18	44.7	44.44	44.95	44.99	44.97
T_{18}	20.58	20.89	20.74	24.95	25.26	25.11	45.53	46.15	45.84	45.2	45.27	45.24
Overall mean	16.90	17.16	17.03	21.52	21.82	21.67	38.43	38.98	38.70	43.88	43.91	43.89
SEm±	P 0.34 Zn 0.34 Rh 0.27	P 0.39 Zn0.39 Rh0.32	P 0.26 Zn 0.26 Rh0.21	P0.41 Zn0.41 Rh0.33	P0.45 Zn0.45 Rh0.37	P 0.30 Zn 0.30 Rh 0.25	P0.51 Zn0.51 Rh0.41	P0.57 Zn0.57 Rh0.47	P 0.38 Zn 0.38 Rh 0.31	P0.40 Zn0.40 Rh0.33	P0.45 Zn0.45 Rh0.37	P 0.30 Zn 0.30 Rh 0.25

C.D. at 5%	P 0.96 Zn 0.96 Rh 0.79	P 1.12 Zn1.12 Rh0.91	P 0.72 Zn0.72 Rh0.59	P1.17 Zn1.17 Rh0.95	P1.30 Zn1.31 Rh1.06	P 0.85 Zn 0.85 Rh 0.70	P1.46 Zn1.46 Rh1.19	P1.64 Zn1.64 Rh1.34	P 1.07 Zn 1.07 Rh0.87	P1.14 Zn N.S. Rh N.S.	P1.30 Zn N.S. Rh N.S.	P0.84 Zn N.S. Rh N.S.

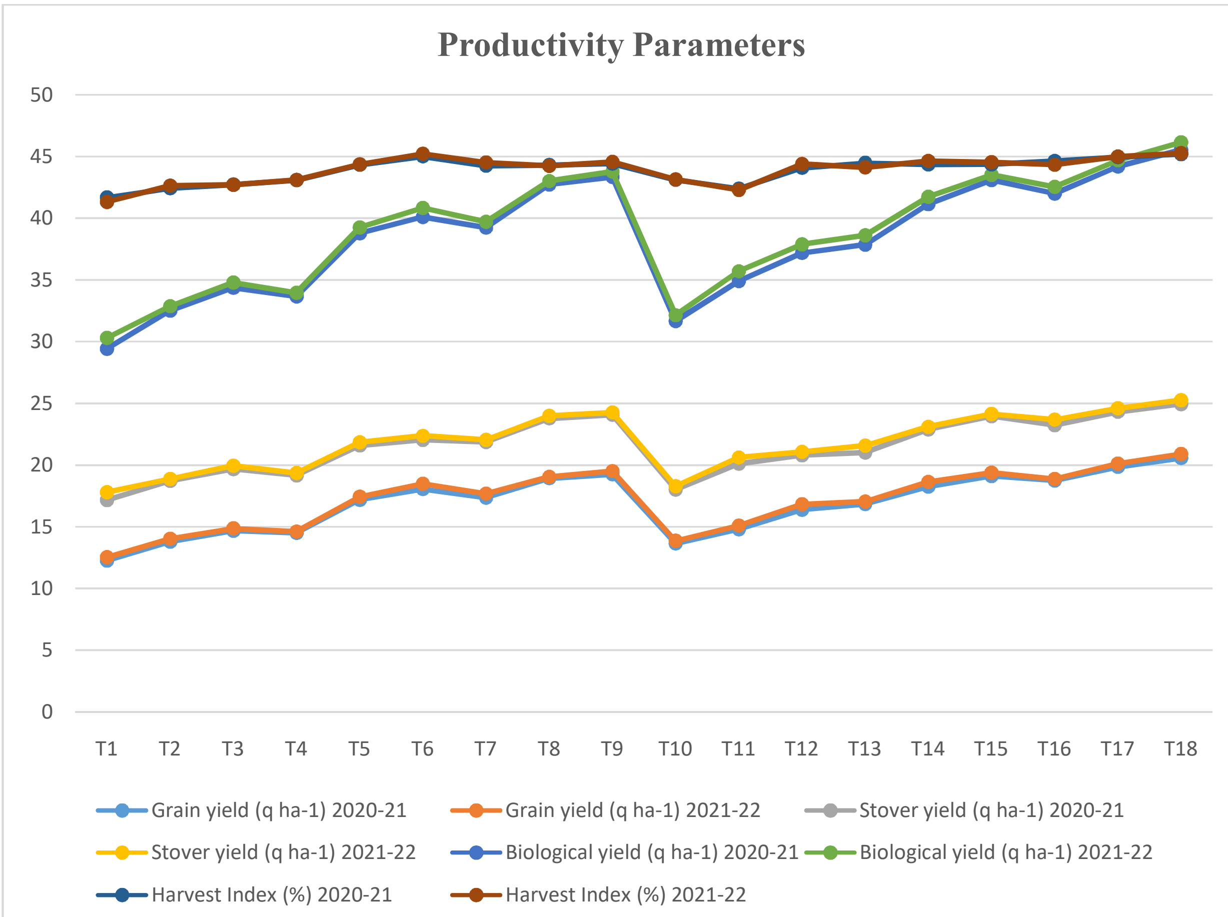

Fig.-1: Effect of different treatments treatments combinations on productivity parameters of chickpea.

Table No.:04 Effect of different treatment combinations on economics of chickpea.

Treatments	Cost of cultivation (₹ ha^{-1})			Gross return (₹ ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	31212.76	31836.23	31524.50	64915.5	70078.5	67497
T_2	32452.76	33076.23	32764.50	72842.25	78103	75472.63
T_3	32831.76	33455.23	33143.50	77469	82765	80117
T_4	33577.76	34201.23	33889.50	76484.25	81287	78885.63
T_5	33956.76	34580.23	34268.50	90278.25	96486	93382.13
T_6	34355.76	34959.23	34657.50	94608.75	102026.5	98317.63

T_7	35073.76	35697.23	35385.50	91191	97878.5	94534.75
T_8	35452.76	36076.23	35764.50	99420.75	105449.5	102435.1
T_9	35831.76	36455.23	36143.50	101067.8	107995.5	104531.7
T_{10}	32233.76	32857.23	32545.50	71949.75	77135	74542.38
T_{11}	32612.76	33236.23	32924.50	78183	84223.5	81203.25
T_{12}	32991.76	33615.23	33303.50	86138.25	93156.5	89647.38
T_{13}	33777.76	34361.23	34069.50	88401	94457	91429
T_{14}	34116.76	34740.23	34428.50	95835.75	103098	99466.88
T_{15}	34495.76	35119.23	34807.50	100401	107283.5	103842.3
T_{16}	35233.76	35857.23	35545.50	98378.25	104474	101426.1
T_{17}	35612.76	36236.23	35924.50	104113.5	111167.5	107640.5
T_{18}	35991.76	36615.23	36303.50	107812.5	115380	111596.3
Overall mean	33989.59	34609.73	34299.66	88860.59	95135.81	91998.2
SEm±	P 55.97 Zn 55.97 Rh 45.70	P 75.29 Zn 75.29 Rh 61.48	P 46.91 Zn 46.91 Rh 38.30	P 276.2 Zn 276.2 Rh 225.5	P 387.9 Zn 387.9 Rh 316.7	P 238.1 Zn 238.1 Rh 194.4
C.D. at 5%	P 161.04 Zn 161.04 Rh 131.49	P 216.65 Zn 216.65 Rh N.S.	P 131.33 Zn 131.33 Rh 107.23	P 794.7 Zn 794.7 Rh 648.9	P 1116.3 Zn 1116.3 Rh 911.4	P 666.6 Zn 666.6 Rh 544.3

Table No.: 05 Effect of different treatment combinations on economics of chickpea.

Treatments	**Net income (₹ ha^{-1})**			**B:C ratio**		
	2020-21	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
T_1	33702.74	38242.27	35972.51	1.08	1.2	1.14
T_2	40389.49	45026.77	42708.13	1.24	1.36	1.30
T_3	44637.24	49309.77	46973.51	1.36	1.47	1.42
T_4	42906.49	47085.77	44996.13	1.28	1.38	1.33
T_5	56321.49	61905.77	59113.63	1.66	1.79	1.73
T_6	60252.99	67067.27	63660.13	1.75	1.92	1.84
T_7	56117.24	62181.27	59149.26	1.6	1.74	1.67
T_8	63967.99	69373.27	66670.63	1.8	1.92	1.86
T_9	65235.99	71540.27	68388.13	1.82	1.96	1.89
T_{10}	39715.99	44277.77	41996.88	1.23	1.35	1.29
T_{11}	45570.24	50987.27	48278.76	1.4	1.53	1.47
T_{12}	53146.49	59541.27	56343.88	1.61	1.77	1.69
T_{13}	54623.24	60095.77	57359.51	1.62	1.75	1.69
T_{14}	61718.99	68357.77	65038.38	1.81	1.97	1.89
T_{15}	65905.24	72164.27	69034.76	1.91	2.05	1.98
T_{16}	63144.49	68616.77	65880.63	1.79	1.91	1.85
T_{17}	68500.74	74931.27	71716.01	1.92	2.07	2.00
T_{18}	71820.74	78764.77	75292.76	2	2.15	2.08
Overall mean	54870.99	60526.08	57698.53	1.60	1.74	167

SEm±	P 689.1 Zn 689.1 Rh 562.6	P 849.6 Zn 849.6 Rh 693.7	P 546.9 Zn 546.9 Rh 446.6	P 0.022 Zn 0.022 Rh 0.018	P 0.033 Zn 0.033 Rh 0.027	P 0.020 Zn 0.020 Rh 0.017
C.D. at 5%	P 1982.8 Zn 1982.8 Rh 1618.9	P 2444.7 Zn 2444.7 Rh 1996.1	P 1531.3 Zn 1531.3 Rh 1250.3	P 0.064 Zn 0.064 Rh 0.053	P 0.096 Zn 0.096 Rh 0.078	P 0.057 Zn 0.057 Rh 0.047

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