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Production and Economic Feasibility of Chickpea (*Cicer arietinum L.*) by the Diverse Bioinputs and Soil Nutrients Amendments

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out the Student's instructional farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Ayodhya (U.P.) during the Rabi season in 2020-2021. The soil of the experimental area was sandy loam in texture. The experiment was laid out in randomized block design with 11 treatments replicated thrice. The experimental results revealed that significantly maximum growth parameter like plant height (18.01 cm 30 DAS, 27.97 cm 60 DAS & 40.38 cm at harvest) and yield attributes like Pods/Plant (44.0), Seeds/pod (1.6), Test Weight (20.12 g), total grain yield (14.65 qha^{-1}) were noticed under T_{11} (Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)] as compared to rest of the treatments and lowest under T_1 (Control), Maximum gross return (Rs. 88795), net return (Rs. 56312) and B:C ratio (1:1.73) was also recorded with the treatment T_{11} (Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-IV [Organic Inputs-I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)].

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1. INTRODUCTION

Pulses constitute an important part of staple human diet providing balanced nutritional benefits because of being a rich source of protein, carbohydrates, dietary fiber and essential amino acids. Consumption of Pulses provide various health benefits in addition to its anti-microbial, anti-cancer, anti-ulcerative and anti-inflammatory effects by virtue of its different constituent phytochemicals such as saponins, phytates, oxalates, flavonoids, lectins, phenolics, tannins, phytosterols, enzyme inhibitors and antimicrobial peptides. It also reduces risk of cardiovascular diseases because of its low fat content [1].

The Chickpea is important in Middle Eastern, Mediterranean & Indian cuisine. The important grains growing countries are India, Turkey, Ethopia, Burma & Pakistan. Pulses occupy about twenty six million ha area in India, contributing to total production of Chickpea which is about 124 Lakh tonnes with about 651.2 kg/ha of annual productivity (IIPR, 2019-20). More than 90 per cent of total pulse production has been the contributed from 10 states namely Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, Gujarat, Andhra Pradesh, Jharkhand, Telangana and Tamil Nadu. Rajasthan has the highest area (24.21%) under chickpea, followed by Maharashtra (22.82%), Madhya Pradesh (18.94%), Karnataka (10.27%), Uttar Pradesh (6.10%) and Andhra Pradesh (4.56%) [2].

Gram occupies an important position among the leguminous crops, as it is consumed by a large vegetarian population of India because of its nutritive values [3]. Chick pea is considered to have medicinal effect and it can also be used as a detoxifier in purifying human blood. Chickpea seeds contain Niacin. Roasted Gram provides essential amino acids like isoleucine, leucine, lysine, valine, and phenylalanine. Chickpea contain 21.1% Protein, 61.5% Carbohydrate, and 4.5% Fat. It is also rich in Calcium, Fe, and Fe, Ca, Phosphate, Mg, Zn, Mn & other important Vitamins to the body. 100gm of Horse gram supplies 321 cal, 22 gm of Protein, and 287 mg of Ca to the body. Therefore, they have rightly described it as "Unique Jewels of Indian crop Husbandry" & Lifeblood of sustainable Agriculture [4].

Production of chickpea are limited by lack of plant nutrients available in Soil. The correct consumption of fertilizers leads to optimum uses of soil and environmental factors to produce high yield of crops [5]. Recommendation for use of fertilizers in Rabi crops for chickpea production is almost negligible.

The use of more agrochemicals in pursuit of higher agricultural production is not only deteriorating the quality of products but also reducing the per capita income of farmers besides polluting our Soils and reducing Soil fertility, soil biological activity and water use efficiency proving to be hazardous for present and future human population [6,7]. But the least attention to Ecological Agricultural principles results in declaration of growth & stagnation in crop yield which causes serious concern and has been a main reason for several environmental problems confronted during the recent decades [8].

Widespread utilization of Rhizobium biofertilizers along with other nutrient mobilizers such as phosphate solubilizing bacteria (PSB), for legume crops, can reduce the use of chemical fertilizers and decrease adverse environmental effects. Biofertilization has great importance in eliminating environmental pollution [9,10]. Organic system relies on management of Organic matter to enhance the Soil fertility & its productivity [11]. Combined application of FYM, Vermicompost produce higher yield apart from improving Soil health [12]. Vermicompost besides being a rich source of micronutrient also act as chelating agent and regulate the availability of Metallic micronutrient to the plants and increase the plant growth & yield by providing nutrients in the available from & based on crop demand. Application of organic viz, FYM, Ca, S & Fe over RDF alone [13]. Studies have shown that the Legume crop productivity can be enhanced and sustained under organic production system.

2. METHODS AND MATERIALS

The experiment was conducted at the Student's instructional farm of ANDUA&T, Narendra Nagar (Kumarganj) Ayodhya (U.P.), during the Rabi season of 2021-2021. Geographically, the experimental site falls under sub-tropical climate zone in the Indo-gangetic plains having alluvial soil and is located at 260 47′ N latitude, 82012′ E longitude and an altitude of 113 meters above mean sea level. The district Ayodhya falls under sub humid climate receiving a mean annual rainfall of about 1200 mm. About 85% of the total rainfall is concentrated from mid-june to the end of September. However, occasional showers are also common during winter. The winter months are cold and occasional frost occurs during this period. The summer season is hot and dry. The soil was sandy loam having initial soil pH of 8.36 and organic carbon (1.3 g/ha) and available N, P and K of 183.4, 12.79 and 220.2 kg ha^{-1} and Zn, Fe, and Mn of 1.32, 1.23, 1.05 mg/kg respectively. The experiment was laid out in randomized complete block design with 3 replications. There were ten treatments consisting of T_1 (Control), T_2 (Soil nutrient amendment as chemical fertilizers @ (20N: 40P:0K), T_3 (Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20P: 0K), T_4 (Organic Inputs -I [FYM + Natural liquid manure (Jeevamrit), T_5 (Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]), T_6 (Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]), T_7 (Organic Inputs-IV [Organic Inputs I (FYM +Jeevamrit) + Organic Inputs III (Rhizobium + PSB)]), T_7 (Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs III (Rhizobium + PSB)]), T_8 (Soil Nutrient Amendment as Chemical Fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs –I [FYM + Natural liquid manure (Jeevamrit)), T_9 (Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]), T_{10} (Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]), T_{11} (Soil nutrient amendment as chemical fertilizers @ half potency (10N : 20P : 0K) +Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)]). A row spacing of 30 cm was adapted to the crops with plant to plant spacing of 10 cm. The cultivar used was KPG -59 (Uday) chickpea with seed rate of 80-100 kg ha-1 (chickpea) .The crops was shown on 20 November 2020 and harvested on 3rd March 2021. Crop was raised under protective irrigation. Chickpea was protected with chlorantrainiprole against pod borer (Helicoverpa armigera) during flowering and pod formation stage and for recording of biometrical observations randomly five plants were taken from net plots excluding border rows. These samples were dried at 70 °C to attain constant dry weight. The dry matter production per plant was expressed as gram per plant. Laboratory analysis- the bulk and particle density of soil was determined by graduate measuring cylinder and pH and EC by Glass electrode pH meter and Digital Conductivity meter [14]. Organic carbon was determined by rapid titration method given by Walkley and Black, [15]. Available N was determined by alkaline permanganate method [16], available P by Olsen et al*.,* [19], available K by Flame photometric method [20] and available Zn, Fe and Mn were determined by the DTPA extracted micronutrients with use of inductively coupled plasma emission spectroscopy (ICP-OES) for the estimation of available micronutrients (mg/Kg) [19]. Treatment-wise the input and output cost was calculated with the help of different economic parameters like, Net profit and B: C ratio etc. The data recorded on various parameters subjected to Fisher's method of analysis of variance and interpretation of the data as given by Gomez and Gomez [20]. The level of significance used in 'F' and't' test was P = 0.05. Critical difference (CD) values were calculated where the 'F' test was found significant.

3. RESULTS AND DISCUSSION

The current investigation entitled "Studies on the Effect of Bio-inputs and Soil Nutrient amendments on Soil Health parameters under Chickpea (*Cicer arietinum L.)* Crop." had been conducted on chickpea crop during *Rabi* season of 2020-2021 at the Student's instructional farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Ayodhya (U.P.). The data obtained during the course of this investigation have been presented in this chapter to observe and analyze the relative impact of different treatments on some of the plant growth parameters, yield attributes and economics of inputs and returns.

3.1 Growth Attributes

Growth parameters, viz. plant height, Number of Nodules $plant^{-1,}$ were significantly influenced by different treatments. Plant heights increased significantly by organic bio-inputs with and without chemical fertilizers are presented in Table-1. The tallest plants were recorded in the treatment T_{10} [Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20 P_2O_5:0 K_2O) + Organic Inputs-III [Biofertilizer Rhizobium + PSB)], while the shortest plants were in treatment T_1 (Control). Soil treated with biofertilizers and the inoculated seed resulted in similar plant height but plants recorded in these treatments were significantly taller than under Control treatment and shorter than other treatments consisting of nitrogen and

Table 1. Effects of different treatments on Plant height and nodules per plant

`S. No.	Treatment details	Days after sowing						
		Plant height				Nodules plant^{-1}		
		30	60	90	At Harvest	45	60	75
$T_{1.}$	Control	15.80	21.57	29.27	31.20	7.99	12.10	10.01
$T_{2.}$	Soil nutrient amendment as chemical fertilizers @ (20N: 40P:0K)	17.02	26.85	37.16	39.09	8.63	13.25	11.16
$T_{3.}$	Soil nutrient amendment as chemical Fertilizers@ half potency (10N: 20 P_2O_5:0 K_2O)(10N : 20P : 0K)	15.86	24.75	32.73	33.10	8.13	12.95	10.72
$T_{4.}$	Organic Inputs -I [FYM + Natural liquid manure (Jeevamrit)	16.32	25.01	34.11	35.39	8.16	12.94	10.83
$T_{5.}$	Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]	16.78	25.18	35.65	37.01	8.43	13.28	13.13
$T_{6.}$	Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]	16.64	25.24	34.49	36.56	8.55	14.10	13.72
$T_{7.}$	Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs III (Rhizobium + PSB)]	16.76	25.42	34.57	36.91	9.06	13.92	12.81
$T_{8.}$	Soil Nutrient Amendment as Chemical Fertilizers@ half potency (10N : 20P : 0K)+ Organic Inputs -I [FYM + Natural liquid manure (Jeevamrit)	16.37	25.79	35.88	37.42	8.31	12.95	11.35
$T_{9.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K)+ Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]	16.54	27.25	36.69	38.53	8.37	14.32	13.93
$T_{10.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20 P_2O_5:0 K_2O) + Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]	17.46	27.39	37.00	38.74	8.76	14.22	13.16
$T_{11.}$	Soil nutrient amendment as chemical fertilizers@ half (10N : 20P : 0K) + Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)]	18.01	27.97	37.81	40.38	9.14	15.10	14.17
SEm ±		**0.42**	**0.33**	**0.32**	**0.54**	**0.43**	**0.50**	**0.41**
CD (@ P≤ 0.05)		**NS**	**1.00**	**0.97**	**1.63**	**NS**	**1.53**	**1.25**

Table 2. Yield and yield attributes of chickpea affected by various treatments combinations

S. No.	Treatment details	Yield (q ha^{-1})		Yield Attributes		
		Seed	Straw	Pods/ Plant	Seeds / pod	Test Weight (g)
$T_{1.}$	Control	08.11	21.51	32.67	1.22	17.54
$T_{2.}$	Soil nutrient amendment as chemical fertilizers @ (20N: 40P:0K)	14.03	27.25	39.33	1.56	19.42
$T_{3.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K)	08.16	16.95	34.00	1.32	17.85
$T_{4.}$	Organic Inputs-1[FYM+ Jeevamrit]	09.01	21.26	34.33	1.44	18.01
$T_{5.}$	Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]	09.25	21.54	34.67	1.39	18.21
$T_{6.}$	Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]	10.54	23.86	35.80	1.37	18.44
$T_{7.}$	Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs III (Rhizobium + PSB)]	11.25	24.51	34.67	1.62	18.26
$T_{8.}$	Soil Nutrient Amendment as Chemical Fertilizers@ half potency (10N : 20P : 0K) + Organic Inputs -I [FYM + Natural liquid manure (Jeevamrit)	11.62	24.01	36.67	1.48	18.29
$T_{9.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-II [Agro residue Mulch+ FYM+ Natural liquid manure (Jeevamrit)]	12.59	26.75	35.67	1.64	18.69
$T_{10.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]	12.83	27.13	42.00	1.43	19.03
$T_{11.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K) +Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)]	14.65	28.16	44.00	1.69	20.12
SEm ±		**0.48**	**1.25**	**0.86**	**0.02**	**0.64**
CD (@ P≤0.05)		**1.43**	**3.67**	**2.62**	**0.06**	**NS**

Table 3. Effect of various treatments combination on economics of chickpea

S. No.	Treatment details	Cost of Cultivation (≠ ha^{-1})	Gross Return (≠ ha^{-1})	Net Return (≠ ha^{-1})	Benefit : Cost ratio
$T_{1.}$	Control	27112	52116	25004	0.92
$T_{2.}$	Soil nutrient amendment as chemical fertilizers @ (20N: 40P:0K)	29404	85328	55924	1.90
$T_{3.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K)	28258	49938	21680	0.76
$T_{4.}$	Organic Inputs -I [FYM + Natural liquid manure (Jeevamrit)	29012	56581	27569	0.95
$T_{5.}$	Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]	29012	57945	28933	0.99
$T_{6.}$	Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]	29437	65684	46247	1.57
$T_{7.}$	Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs III (Rhizobium + PSB)]	31337	69630	38293	1.22
$T_{8.}$	Soil Nutrient Amendment as Chemical Fertilizers@ half potency (10N: 20 P: 0 K)+ Organic Inputs -I [FYM + Natural liquid manure (Jeevamrit)	30158	71267	41109	1.36
$T_{9.}$	Soil nutrient amendment as chemical fertilizers@ half potency (10N : 20P : 0K)+ Organic Inputs-II [Agro residue Mulch + FYM + Natural liquid manure (Jeevamrit)]	30158	77984	47826	1.58
T_{10}.	Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20 P:0 K)+ Organic Inputs-III [Biofertilizer (Rhizobium + PSB)]	29437	77998	48561	1.64
T_{11}.	Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20 P:0 K)+ Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)]	32483	88795	56312	1.73

biofertilizers. Similar results for plant height were reported by Kumar et al. [21].

Number of nodules plant^{-1} was also significantly with application of organic bio-input and biofertilizers. The highest nodules plant^{-1} was recorded under T_{11} at 45 days followed by T_7, T_{10} and after 60 DAS $T_{11} > T_{10} > T_9$ are found highest nodules plant^{-1} and after 75 DAS $T_{11} > T_{10} > T_9$ are also found. Soil treated with organic bio-inputs and the inoculated seeds produced significantly higher nodules plant^{-1} than the control and lower than rest of the treatments. The lowest nodules plant^{-1} production was recorded under treatment control treatment. Number of nodules plant^{-1} was significantly increased owing to combined application of chemical fertilizers@ half potency, organic input and biofertilizer. Similar results were observed by Khan et al. [22] under chickpea crop.

The higher value of growth attributes, viz, plant height, number of nodules plant^{-1} were recorded with combined application of chemical fertilizers, Rhizobium and phosphate solubilizing bacteria, might be owing to supply of all essential nutrient in balanced amount resulted in better growth and development [23]. Integrated use of chemical fertilizer and biofertilizer also improves physical, chemical and biological properties of the soil which favor better nutrition to crops resulting in better growth of the crops. Inoculation of seeds with biofertilizer enhances nutrient supply to plants. Nitrogen plays an important role in increasing vegetative growth, while phosphorus improves root growth and grain quality respectively. Dida et al. [24] and Kumar et al. [25] also reported significant effect of biofertilizers on growth and yield of the crop.

3.2 Yield Attributing Characters

Yield attributes namely number of pod plant^{-1}; number of seeds pod^{-1}, test weight, seed and straw yield of the chickpea were affected by different treatment. Number of pod plant^{-1} significantly increased with combined application of chemical fertilizers and biofertilizers over the control treatment. The highest number of pod plant^{-1} were recorded under T_{11} [Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20P: 0K) +Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)] followed by $T_{10.}$ The lowest numbers of pod plant^{-1} were observed in the control treatment Khosro Mohammadi et al. [24] and Aher et al. [25].

Like number of pod plant^{-1}, seeds/pod also increased significantly with integrated use of chemical fertilizer, organic input and biofertilizers. Pooled data indicated that application of 50% RDF + FYM + Jeevamrit and Rhizobium + PSB (T11), recorded maximum number of grains pod-1, which was found to be at par with T9 (50% RDF + Agro residue mulch along with FYM + Jeevamrit) and T_7 (FYM + Jeevamrit and Rhizobium + PSB) which were further observed to be significantly better than 100% RDF (T_2) and other treatments. Data on number of seeds pod-1 indicated that all the organic bio-inputs recorded significantly higher number of seeds pod-1 over control (T_1) which had lowest number of seeds pod-1. Pooled data indicated that amongst the organic bio-inputs, 50% RDF + Rhizobium + PSB + FYM and Jeevamrit (T_{11}) recorded maximum number of seeds pod-1 which was statistically at par with 50% RDF + Agro residue mulch along with FYM + Jeevamrit. These treatments (T_{11}, T_9, and T_7 respectively) were found significantly superior to others and control, Saiful Islam et al. [27] and Paneliya et al. [28].

Seed weight or test is an important yield contributing character which increased with the increase in diverse fertilizers dose, organic input with or without biofertilizer. The highest test weight was recorded in Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20P: 0K) +Organic Inputs-IV [Organic Inputs I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB)] followed by $T_{2,}$ and $T_{10.}$ Seed weight was statistically similar in T_4 to $T_{9,}$ but higher than the control and lower than the T_{11} and $T_{2.}$ The lowest test weight was noted in the control. The higher value of these yield contributing characters may be attributed to increased nutritional availability, improved nodulation, nitrogen fixing and phosphate solublizing bacteria. Insufficient availability of nutrients in the control treatment resulted in poor yield attributes, Kumari et al. [29].

3.3 Yield

Yields were also significantly influenced by different treatments. Significantly higher seed yield was recorded with integrated use of chemical fertilizer, organic and biofertilizers over the control as well as T_{11}. Maximum seed yield was obtained from Treatment T_{11} amended with Half RDF + FYM + Jeevamrit + Rhizobium + PSB; followed by T_2 (Full RDF treatment). These two treatments showed a significantly higher seed yield in comparison to Treatments T_{10}, T_9 and T_8 which were in turn superior in seed yield from rest of the treatments. These results are in conformity with results reported by Saiful Islam et al*.* (2019). Like seed yield, straw yield also increased significantly with combined application of chemical fertilizer, organic inputs and biofertilizers. Treatments T_{11} (Half RDF + FYM + Jeevamrit + Rhizobium + PSB) and T_2 (Full RDF) were at par with each other in terms of recorded straw yield followed by Treatments T_{10} and T_9 which were found to be significantly superior to the rest of the treatments. Khan et al. [21] and Hussainndar et al*.* [29] also observed significant response of chickpea to integrated use of chemical fertilizers and microbial inoculants in terms of seed yield and straw yield.

3.4 Economics

The adoption of any technology is modern agriculture con only be feasible and accepted to farmers if it is economically viable. The highest cost of cultivation, Gross return (≠ ha^{-1}), net returns, benefits: cost ratio and profitability were recorded in Soil nutrient amendment as chemical fertilizers@ half potency (10N: 20 P: 0 K) + Organic Inputs-IV [Organic Inputs-I (FYM + Jeevamrit) + Organic Inputs-III (Rhizobium + PSB), while the lowest in the control treatment (Table-). Application of soil amendments with biofertilizers resulted in higher value of all economics parameters than sole application of chemical fertilizers.

The cost of cultivation was calculated to be highest (≠ 32483) for the plots under Treatment T_{11} which was amended with Rhizobium and PSB with FYM, Jeevamrit and 50% RDF followed by T_{10} (50% RDF + Rhizobium and PSB). Both of these treatments were comparable to each other and significantly recorded higher cost of cultivation than rest of the treatments. Data on cost of cultivation indicated that there was significant variation due to various organic bio-inputs and chemical fertilizer applications. All the organic bio-inputs with chemical fertilizer recorded significantly higher gross return than control (T_1) which had recorded minimum gross return (≠ 27112). Rhizobium, PSB with FYM, Jeevamrit and 50% RDF produced maximum gross return which was significantly superior to rest of the other treatments. By using organic inputs Kumar et al*.* [19] also observed similar findings.

Maximum gross return (≠ 88795) was obtained from Treatment T_{11} which was amended with Rhizobium and PSB with FYM, Jeevamrit and 50% RDF followed by T_{10} (50% RDF + Rhizobium and PSB) while T_{10}, T_9, T_2 were comparable to each other and significantly recorded higher gross return than rest of the treatments. Data on gross return indicated that there was significant variation due to various organic bio-inputs and chemical fertilizer applications. All the organic bio-inputs with chemical fertilizer recorded significantly higher gross return than control (T_1) which had recorded minimum gross return (≠ 52116). Rhizobium, PSB with FYM, Jeevamrit and 50% RDF produced maximum gross return which was significantly superior to rest of the other treatments. Farooq et al. [32] and Kumar et al. [21] reported similar findings in terms of economic returns from chickpea crop amended with organic and inorganic inputs.

The net return was calculated to be highest (≠ 56312) for the plots under Treatment T_{11} which was amended with Rhizobium and PSB with FYM, Jeevamrit and 50% RDF followed by T_2 (100% RDF). Both of these treatments were comparable to each other and significantly recorded higher net return than rest of the treatments. Data on net return indicated that there was significant variation due to various organic bio-inputs and chemical fertilizer applications. All the organic bio-inputs with chemical fertilizer recorded significantly higher net return than Treatment (T_3) which had recorded minimum net return (≠ 21680). Rhizobium, PSB with FYM, Jeevamrit and 50% RDF produced maximum net return which was significantly superior to rest of the other treatments. Farooq et al*.* [32] reported similar results by using different organic inputs.

The effect of various treatments on benefit cost ratio under chickpea crop. Data revealed that the benefit cost ratio was calculated to be highest (1.73) for the plots under Treatment T_{11} which was amended with Rhizobium and PSB with FYM, Jeevamrit and 50% RDF followed by T_{10}. Both of these treatments were comparatively better than the other treatments while T8 and T_6 was at par with each other. Treatment (T_3) was recorded minimum value (0.76) applied 50 % RDF by in the form of chemical fertilizers.

4. SUMMARY AND CONCLUSIONS

Recommended dose of fertilizers (RDF) 100% and 50% along with bio-fertilizer in chickpea promotes growth and nodulation which increases yield. P is important for shoot hardiness, it improves grain quality, regulates photosynthesis. Data for growth and yield attributing parameters of plants from each plot was recorded before and after harvesting of the crop as per experimental plan. Data obtained from all observations were analyzed statistically using standard statistical method to work out the significance and effect of treatments on the tested parameters. The salient findings of this study are summarized below.

1. On the basis of current investigation it may be concluded that application of 50% RDF along with bio-fertilizers (Rhizobium and PSB) significantly increased the growth, yield as well as soil fertility viz. plant height, nodule population, no. of seeds per pod and overall biological yield of the crop. Based on the results obtained, the highest yield was recorded in T_{11} (with application of 50% RDF along with FYM, Jeevamrit and Rhizobium + PSB Biofertilizer).
2. The highest net income of ≠ 56312 ha^{-1} was computed in the T_{11} where 50% RDF along with FYM and Rhizobium +PSB were applied.

Overall analyses of data suggest that treatment T_{11} with 50% RDF along with FYM and Rhizobium +PSB has been proved to be the best among the studied treatments with maximum crop yield, with better grain quality. On the basis of experimental findings and discussion it could be concluded that supplementation of inorganic fertilizers application with organic inputs and a gradual increase in the percentage of latter would prove to be a better and cost effective alternative for farmers in enhancing their crop yield vis-à-vis maintaining sustainability in soil fertility of their crop fields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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