International Journal of Plant & Soil Science

34(23): 1115-1122, 2022; Article no.IJPSS.93322
ISSN: 2320-7035

Effect of Integrated Nutrient Management on Performance of Chickpea in Bundelkhand Region of North India

Veerendra Singh [a], Amit Mishra [a*], A. K. Chaubey [a], G. S. Panwar [b], Ravindra Sachan [c], Rajesh Pal [c], Deepak Kumar [c] and Abhishek Tiwari [c]

[a] Department Soil Science and Agricultural Chemistry, Banda University of Agriculture and Technology, Banda, Uttar Pradesh-210001, India.
[b] Department of Agronomy, Banda University of Agriculture and Technology, Banda, Uttar Pradesh-210001, India.
[c] Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (Uttar Pradesh-208002, India.

Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2022/v34i232524

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93322

Original Research Article

Received 02 September 2022
Accepted 06 November 2022
Published 10 November 2022

ABSTRACT

A field experiment was carried out on chickpea crop during *Rabi* season 2020-21. The experiments were conducted on heavy clay soil at Agriculture Research Farm, College of Agriculture, Banda University of Agriculture & Technology, Banda. The experimental design was randomized block design with eight integrated nutrient management treatments viz. farmer fertilizer practice (T_1), 100 % RDF (T_2), 100% RDF + FYM (T_3), 100 % RDF + FYM + Zn (10 kg ha^{-1}) (T_4), 125 % RDF + FYM+ microbial inoculants (MI) (T_5), 100 % RDF + FYM+MI (T_6), 75% RDF + FYM+MI (T_7) and 50 % RDF +FYM+MI (T_8), all treatments were replicated thrice. The FYM was applied @ 2 t $acre^{-1}$. The experimental results revealed that application of 125% and 100 % RDF along with FYM and microbial inoculants increased significantly nodule number, nodule weight per plant and number of pods per plant, thereby increased grain yield of chickpea significantly in comparison to farmers fertilizer practice (T_1), sole application of 100 % RDF (T_2) and 50 % reduction of RDF along with FYM and microbial inoculants (T_8).

**Corresponding author: E-mail: amitkatayani@gmail.com;*

Keywords: Chickpea; microbial inoculants; FYM; RDF.

1. INTRODUCTION

Soil fertility is vital for the sustainable crop production, as soil is a nonrenewable natural resource and store house of the plant nutrients. The soil fertility is deteriorated in recent competition to produce more from the unit land. The monitoring and maintenance of the soil fertility are important for sustainable production. Since, ignorance of the management of soil had also caused deterioration and deficiency of multi plant nutrients (both macro and micro nutrients deficiency).The soil organic carbon, nitrogen, phosphorus and Sulphur are very low to medium in most of the soils of the Bundelkhand region [1]. Low soil organic carbon is considered as major reason of deteriorating soil productivity and affecting sustainable productivity in this soil [2], (Tomar and Dwivedi, 2007); [3]. The application of organic manure is proven and accepted to improve the soil fertility through increasing total carbon in soils [4,5].The integrated nutrient application is crucial for maintaining higher crop productivity, sustainability of soil health and environmental quality [6,7]. Integrated nutrient management is vital for sustainable productivity [8] Several studies showed that the beneficial effect of INM on crop and soil productivity. India has the first rank in area and production of pulse crop in the world. The pulses are grown in 29.81-million-hectare area with the production 25.43 million tones, and productivity 852 kg ha^{-1}during 2017-18 in India [9]. The pulse crop has rich in protein and also source of thiamin and niacin, Ca, P, and Fe etc. About 100gm of pulses give 345kcal.and per capita pulses are required is 50-60gm/day. Therefore, inclusion of pulse crop in cropping system is utmost important to produce nutritional rich food for vegetarian population. Chickpea has area 10.56 m ha with production 11.23 m tones and productivity 1063 kg ha^{-1} in India during 2017-18 [9]. In case of Uttar Pradesh, chickpea occupied 6.11 lakh ha area, 6.84 lakh ton production with productivity 893 kg ha^{-1} during 2017-18 [9]. Bundelkhand region recognized as a pulse bowl of the Uttar Pradesh, the region has 1.19 lakh ha area and 51.56 thousand tonnes production with productivity of 434 kg ha^{-1} during 2015-16. The productivity is low compare to national average as well as Uttar Pradesh.

There is huge scope in improvement of productivity of pulse crops of this region through agronomic interventions along with improvement in soil fertility. The balance application of fertilizer also ensured the productivity of crops. The challenge is to improve the land productivity and soil fertility without affecting the environment. Therefore, double crop in a year will certainly improve the fertility. However, water scare region where farmers have several constraints to improve cropping intensity. The integrated use of nutrient is a proven option for restoration of the soil fertility.

2. METHODS AND MATERIALS

The present study conducted during *Rabi* season 2020-21 at Agriculture Farm entitled "Effect of Integrated Nutrient Management on Performance of Chickpea and Mustard intercropping system in Bundelkhand Region of North India" with the objective to study the effect of cropping systems and INM on growth, yield attributes and yield of chickpea crop.

2.1 The Experimental Site

The present experiment laid out in Agriculture Research Block, College of Agriculture during *Rabi* season of 2020-21 of Banda University of Agriculture and Technology, Banda (UP). The experimental design was randomized block design with three replications. Treatments consist of 8 combinations of organic manures, inorganic fertilizers and microbial inoculants viz. T_1: Farmer fertilizer practice (18 N : 46 P2O5) , T2: Recommended dose of fertilizer (RDF) (20 N: 60 P2O5: 20 K2O), T3: RDF + 2 t $acre^{-1}$FYM , T4: RDF + Zn (Kg ha^{-1}), T_5: 125 % RDF + 2 t $acre^{-1}$FYM + microbial inoculants (MC), T_6: 100 % RDF + 2 t $acre^{-1}$FYM + microbial inoculants (MC), T_7: 75 % RDF + 2 t $acre^{-1}$FYM + microbial inoculants (MC) and T_8: 50 % RDF + 2 t $acre^{-1}$FYM + microbial inoculants (MC).

2.2 Source of Fertilizer

Urea (46% N), Diammonium phosphate (DAP) (18% N and 46% P_2O_5) and Muriate of Potash (MOP) (60 % K_2O) and $ZnSO_4.7H_2O$ were used as inorganic source of fertilizer. Chickpea crop received all the inorganic fertilizer as a basal application as per the treatments. While fertilizers applied in mustard crop ½ half of nitrogen, full amount of DAP and MOP at the time of basal application and remaining nitrogen dose in form of urea top dressed in two splits.

The FYM was applied to the Rabi season crops as the selected *Rabi* season crops were more fertilizer requirement than *Kharif* season crops. The FYM (25% moisture; 0.50% Nitrogen; 0.25% P_2O_5 and 0.5% K_2O) was applied 15 days before at 25 percent moisture content in designated plots as per the treatment.

The , microbial inoculants (Rhizobium spp., Azotobacter and Phosphorus solubilizing bacteria spp.) applied rate of 400 ml per acre, the consortia was mixed with FYM and incubated overnight and next day applied to the plot before seeding the chickpea crop.

The plant height was determined by the 5 plants tagged randomly within plot at 30, 60 & 90 days after sowing (DAS). The plant biomass was measured by the cutting of 0.5 cm row length at different growth stages i.e. 30, 60 & 90 DAS. The five plants were uprooted from the experiment carefully and washed in running water. The nodules were detached from root and counted and placed in oven at 60℃ for determination of nodule dry weight. The intact 4 sqm area of plot was harvested for the determination of yield attributes, pod yield and biological yield.

The real time data of all operations and input used in crop cultivation had used for the determination cost cultivation. The minimum support price was considered for the calculation of gross and net return.

The collected data was subjected to statistical analysis through online source OPSTAT (http://14.139.232.166/opstat/). The critical difference were used to differentiate the means of different parameters.

3. RESULTS AND DISCUSSION

3.1 Effect of Integrated Nutrient Management on Growth, Yield Attributes and Yield of Chickpea Crop

Periodic interval plant height, plant biomass, nodulation and number of pods per plant data are given in Table 1 and the uniform plant stand was recorded in all the plots. There was no statistically difference in plant stand. The effect of alone and combined application of fertilizer, FYM and, microbial inoculants (MI) did not influence the plant height irrespective of days [10].

Integrated nutrient application had positive impact on number of nodules per plant. The nodule number per plant varied from 11.9 to 16.8 in 100 % applications of RDF (T_2) and 125 % RDF+ 2 t acre^{-1} FYM +, microbial inoculants (T_5) treatment. The T_5 and T_6 treatments had almost similar number of nodules per plant and significantly superior than remaining treatments. The T_5 had 34.4% and 41.2% higher than respective control T_1 and T_2 respectively. Remaining other treatments were statistically similar number of nodules.

On perusal of data crop biomass was found non-significant at 30 DAS, At 60 DAS, the effect was remarkable and higher biomass recorded with the 125 % RDF + 2 t acre^{-1} FYM + , microbial inoculants (T_5) followed by 100 % RDF + 2 t acre^{-1}FYM + , microbial inoculants (T_6), both the treatments were statistically at par with each other. Similar trend was observed at 90 DAS, the plant biomass varied from 18.3 to 23.8 q ha^{-1} in farmer fertilizer practice (T_1) and 125 % RDF + 2 t acre^{-1} FYM +, microbial inoculants (T_5) treatments, respectively.

The highest (110.0) number of pods per plant was recorded with 125 % RDF + 2 t acre^{-1} FYM +, microbial inoculants (T_5),Data on 100 seed weight reveals that all the treatments had similar effect on test weight. T_5 had numerically more test weight followed by $T_{8.}$

As initial status of available phosphorus and organic carbon was poor, hence the combined application of inorganic and organic manures improved soil properties thereby the growth, number of nodules and nodule dry weight and pods per plant. Further, It could be due to microbial inoculants solubulize the organic and inorganic phosphorus present in soil and fixed nutrient thereby improved growth and nodulation characteristics [11,7,12].

3.2 Grain Yield

The Data pertaining to effect of integrated application of fertilizer, FYM and microbial inoculants and sole application of fertilizer on yield component is summarized in Table 2.

Table 1. Effect of different treatments on growth parameters of chickpea crop

Treatment		Plant height (cm)			Plant biomass qha^{-1}			Nodules $plant^{-1}$ (No)			Nodule weight (mg $plant^{-1}$)			No of pod $plant^{-1}$
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	
T_1	Farmer fertilizer practice (FFP)	9.8	28.0	42.0	1.08	5.4	18.3	4.8	12.5	31.8	59.2	172.3	609.2	91.3
T_2	100 % RDF	12.2	30.4	44.7	1.14	5.5	20.2	5.9	11.9	33.8	58.6	179.9	612.3	99.7
T_3	100 % RDF + 2 t $acre^{-1}$FYM	11.2	28.6	44.5	1.17	5.9	21.2	5.3	10.7	33.6	63.3	180.8	661.0	103.1
T_4	100 % RDF + 2 t $acre^{-1}$FYM + {Zinc @4 kg $acre^{-1}$}	11.9	26.9	41.5	1.19	6.3	21.4	4.4	11.1	33.9	52.3	177.8	625.6	104.7
T_5	125 % RDF + 2 t $acre^{-1}$FYM + MI	12.8	33.9	50.7	1.18	7.4	23.8	4.5	16.8	41.6	61.2	269.3	793.1	110.0
T_6	100 % RDF + 2 t $acre^{-1}$FYM + MI	11.0	29.2	44.0	1.15	6.7	23.4	4.6	16.7	42.4	55.7	266.7	738.5	106.2
T_7	75 % RDF + 2 t $acre^{-1}$ FYM + MI	12.0	32.1	42.2	1.15	6.2	21.7	4.3	13.0	37.7	56.2	208.9	634.1	97.5
T_8	50 % RDF + 2 t $acre^{-1}$ FYM + MI	11.7	29.5	44.5	1.04	5.4	19.2	5.7	12.1	37.9	58.1	193.8	629.5	91.0
SE(d)±		1.4	2.2	4.0	0.1	0.4	1.5	0.9	1.5	2.9	9.8	19.9	44.0	4.0
C.V.		15.0	9.0	11.0	7.0	8.7	8.9	22.2	13.8	9.7	20.6	11.8	8.1	4.9
CD(P=0.05)		NS	NS	NS	NS	0.9	3.3	NS	3.2	6.2	NS	43.1	95.2	8.6

On perusal of data, it is evident that different treatments positively influenced the grain, biological yield and harvest index of chickpea crop. The highest grain yield (26.7 q ha^{-1}) was obtained with 125 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_5) followed by the 100 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_6) (26.1 q ha^{-1}). Both these treatments were statistically comparable with each other. T_5 and T_6 treatments were produced remarkable higher yield over the farmer fertilizer practice (T_1), 100 % RDF (T_2) and 50 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_8), respectively. The T_3, T_4, T_5, T_6, T_7 treatments were statistically at par with each other. T_5 had 40.5%, 27.8 % and 29 % higher over the T_1, T_2 and T_8 treatments, respectively, while T_6 had 37.4 %, 24.9 % and 26.1 % statistically higher than T_1, T_2 and T_8, respectively.

3.3 Straw Yield

Although the similar trend recorded with the straw yield, however, the different treatments did not influence statistically the straw yield of the chickpea crop. The numerically more straw yield (33.8 q ha^{-1}) was obtained with T_5 (125 % RDF + 2 t acre^{-1} FYM + microbial inoculants) followed by the T_7 (75 % RDF + 2 t acre^{-1} FYM + microbial inoculants) treatment.

3.4 Biological Yield

The effect of different treatments on biomass yield was pronounced and trend was similar to grain yield. The highest biological yield (60.5 q ha^{-1}) was recorded with T_5 (125 % RDF + 2 t acre^{-1} FYM + microbial inoculants) followed by the (57.2 q ha^{-1}) T_6 (100 % RDF + 2 t acre^{-1} FYM + microbial inoculants) treatments. Both the treatments were statistically at par with each other and notable effect in comparison to T_1, T_2 and T_8 treatments. The T_5 had produced 27.9 %, 21.0 % and 19.1 % higher yield over the treatments T_1, T_2 and T_8, while T_6 had produced 20.9 %, 14.4 % and 12.6 % maximum yield than T_1, T_2 and T_8 treatments, respectively. T_3 and T_4 also had significantly higher yield than farmer's fertilizer practice treatment.

3.5 Harvest Index (HI)

Harvest index of chickpea crop also influenced by the application of integrated nutrients. Data revealed that the highest harvest index (45.6) was found with T_6 (100 % RDF + 2 t acre^{-1} FYM + microbial inoculants) treatment followed by the (45.6) T_5 (125 % RDF + 2 t acre^{-1} FYM + microbial inoculants) treatment, both these treatments were statistically at with each other and T_3, T_4 and T_7. T_6 gave 13.7 %, 10.4 % and 11.5 % higher HI than T_1, T_2 and T_8, respectively.

The improvement in Grain, straw and biological yields might with T5 and T6 treatments be due FYM and microbes increased the utilization efficiency of nutrient provided by fertilizers as well as soil. Moreover, The FYM may also improves soil physic chemical and biological properties , that reflected in yields [12,13].

Table 2. Effect of integrated nutrient management on grain yield, straw yield, biological yield, (q ha^{-1}) and harvest index of chickpea crop

Treatments		Grain Yield (q ha^{-1})	Straw Yield q ha^{-1})	Biological Yield (q ha^{-1})	Harvest Index (%)
T_1	Farmer fertilizer practice (FFP)	19.0	28.3	47.3	40.1
T_2	100 % RDF	20.9	29.7	50.6	41.3
T_3	100 % RDF + 2 t acre^{-1}FYM	24.6	30.7	55.4	44.5
T_4	100 % RDF + 2 t acre^{-1}FYM + {Zinc @4 kg acre^{-1}}	24.6	30.4	55.0	44.7
T_5	125 % RDF + 2 t acre^{-1}FYM + MI	26.7	33.8	60.5	44.2
T_6	100 % RDF + 2 t acre^{-1}FYM + MI	26.1	31.2	57.2	45.6
T_7	75 % RDF + 2 t acre^{-1} FYM + MI	24.8	32.2	57.0	43.5
T_8	50 % RDF + 2 t acre^{-1} FYM + MI	20.7	30.0	50.8	40.9
SE(d)±		1.3	1.5	2.5	1.4
C.V.		6.9	6.1	5.6	3.9
CD(P=0.05)		2.9	NS	5.4	3.0

3.6 Economic Indices

3.6.1 Cost of cultivation

It is evident from the data cost of nutrient was minimum in farmer fertilizer practice (T_1) treatment in both the chickpea and mustard and maximum in treatment 125 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_5). Similarly, the cost of cultivation was minimum with farmer fertilizer practice (T_1) treatment and maximum in treatment 125 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_5) in chickpea crop. In general, it is evident that addition of FYM treatments had higher cost of nutrient as well cost of cultivation than sole application of the fertilizer (Table 3).

3.6.2 Gross return

On perusal of the data, there was no interaction effect on net return. The application of INM irrespective of cropping system was influenced gross return. The significantly highest gross return (Rs 137000/-) was obtained with 125 % RDF + 2 t acre^{-1} + microbial inoculants (T_5) followed by the 100 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_6) treatment. Both the treatment had significant effect on gross return than T_1, T_2, and T_8, respectively. T_3-T_7 was statistically at par with each other (Table 3).

3.6.3 Net return

It is apparent from the data there was no interaction effect on net return. The application of INM irrespective of cropping system was influenced net return. The significantly highest net return (Rs 103119/-) was fetched with 125 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_5) followed by the 100 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_6) treatment. Both the treatment had notable effect on net return than T_1, T_2, T_7 and T_8, respectively. T_3-T_6 was statistically at par with each other (Table 3).

3.6.4 B:C ratio

On perusal of data, it is clearly indicated that there was no interaction effect between the cropping system and integrated nutrient management on Benefit: cost ratio (B:C). Similarly, main factor did not influenced the B:C ratio. Only integrated nutrient management had significant effect on B:C ratio. The highest B:C ratio (3.07) was obtained with 100 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_6) treatment followed by 125 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_5) irrespective of the crop, both the treatments were at par with each other and remarkable effect on B:C ratio in comparison to farmer fertilizer practice (T_1) and 50 % RDF + 2 t acre^{-1} FYM + microbial inoculants (T_8). However, (T_6) was at par with T_3, T_4, T_5 and T_7, respectively. T_6 had 19.2 % 17.17% and 10.3.0 % significantly B:C ratio than T_1, T_2 and T_8. It was evident the application of microbial inoculants with RDF and FYM increased B:C ratio except T_8 (Table 3).

Table 3. Effect of cropping system and integrated nutrient management on Gross return, Net return, B.C. ratio of chickpea crop

Treatment		Gross return (₹)	Net return (₹)	Benefit- Cost ratio (₹)
T_1	Farmer fertilizer practice (FFP)	98119	69895	2.48
T_2	100 % RDF	107743	77958	2.62
T_3	100 % RDF + 2 t acre^{-1}FYM	126234	93950	2.91
T_4	100 % RDF + 2 t acre^{-1}FYM + {Zinc @4 kg acre^{-1}}	125843	91763	2.69
T_5	125 % RDF + 2 t acre^{-1}FYM + MI	137000	103119	3.04
T_6	100 % RDF + 2 t acre^{-1}FYM + MI	133386	100627	3.07
T_7	75 % RDF + 2 t acre^{-1} FYM + MI	127178	65540	3.02
T_8	50 % RDF + 2 t acre^{-1} FYM + MI	107082	76566	2.79
Mean		120323	88677	0.3
Factor B (CD@ 5%)		8822	8822	0.1

4. CONCLUSIONS

The study concludes that conjunctive use of fertilizer (125 % or 100 % RDF), FYM and microbial inoculants had positively influenced the chickpea. Thus, the application of 100 % RDF along with 2 t acre^{-1} FYM and microbial inoculants is suggested for better growth and enhancing yield attributes of chickpea.

Although the addition of FYM has increased the cost of fertilizer, thereby cost of cultivation, the combination of 125 % RDF with 2 t acre^{-1} FYM and microbial inoculants (T_5) had a better gross return. The net return is at par with 100 % RDF along with 2 t acre^{-1} FYM and microbial inoculants (T_6) than the sole application of fertilizer in FFP, 100 % RDF. Further, the B:C ratio was better with 100 % RDF along with 2 t acre^{-1} FYM and microbial inoculants. It is therefore, can be recommended to farmers after the validation on the farmer fields. The study also suggests that reducing the 50 % fertilizer even with FYM and microbial inoculants can be detrimental as it has adversely affected the crop performance and minimum B:C ratio in the first year of cultivation. The higher economic gain by the application of T_5 and T_6 treatments could be attributed as improvement in grain yield of chickpea reflected in Net return and B:C ratio. The similar results reported by [11,14,12].

ACKNOWLEDGEMENT

We acknowledge the research and development project entitled “Centre of Excellence on Dry land Agriculture with focus on Pulses and Oilseed” for support and funding of this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Srinivasan R, Tripathi SB, Rai AK, Das SK, Rao DVKN, Ghosh PK. Strides in soil research: soil health management and fodder production. ICAR-Indian grassland and fodder Research Institute, Jhansi. 2016;284;003:1-91.
2. Ghosh PK, Dayal D, Mandal KG, Wanjari RH, Hati KM. Optimization of fertilizer schedules in fallow and groundnut based cropping system and an assessment of system sustainability. Field Crops Res. 2003;80(2):83-98.
3. Bandyopadhyay KK, Misra AK, Ghosh PK, Hati KM. Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. Soil Till Res. 2010;110(1):115-25. doi: 10.1016/j.still.2010.07.007.
4. Manna MC, Ghosh PK, Ganguly TK. Comparative performance of four sources of enriched phosphorus compost and inorganic fertilizer application on yield, uptake of nutrients and biological activity of soil under soybean–wheat rotation. J Food Agric Environ. 2003;1(2): 203-8.
5. Meena R, Dhakal Y, Bohra J, Singh S, Singh M, Sanodiya P et al. Influence of bioinorganic combinations on yield, quality and economics of mung Bean. Am J Exp Agric. 2015;8(3):159-66.
6. Narayan S, Kanth RH, Narayan R, Khan FA, Saxena A, Hussain T. Effect of planting dates and integrated nutrient management on productivity and profitability of potato (*Solanum tuberosum*) in Kashmir valley. Indian J Agron. 2014;59(1):145-50.
7. Venkatesh MS, Hazra KK, Ghosh PK, Mishra JP. Integrated phosphorus management in maize-chickpea rotation inmoderately-alkaline inceptisol in Kanpur; 2017.
8. Verma G, Mathur AK, Bhandari SC, Kanthaliya PC. Long term effect of integrated nutrient management on properties of a typic Haplustept under maize- wheat cropping system. J Indian Soc Soil Sci. 2010;58(3):299-302.
9. Pulse revolution from food to nutritional security. A report published by Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, Krishi Bhawan, New Delhi, India; 2018. Available:https://farmer.gov.in/SucessReport2018-19.pdf. Accessed date 05/05/2020
10. Cocharan WG, Cox GM. Experimental designs. New York: Wiley; 1957.
11. Arya RL, Varshney J, Kumar L. Effect of Integrated Nutrient application in Chickpea/Mustard intercropping system in the semi arid tropics of North India. Commun Soil Sci Plant Anal. 2007; 38(1):229-40.
12. Shivran RK, Pankaj K, Jat RK, Vinay PN. Effect of Integrated Nutrient Management

practices on growth, yield and economics of chickpea in Maize chickpea/ wheat cropping system. J Pharmacogn Phytochem. 2017;6(6S):115-8.
13. Dimple K, Rana NS, Vivek, Dhyani BP. Effect of different row ratios and nutrient management strategies on growth yield and quality of mustard in chickpea+mustard intercropping system. J Pharmacogn Phytochem. 2020;9(3):852-7.
14. Ramesh K, Patra AK, Biswas AK. Best management practices for soybean-wheat system to minimize the impact of climate change. Indian J Fert. 2017;13(2):42-55.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/93322