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# Effect of Integrated Nutrient Management on Chickpea Productivity and Soil Fertility Status under Rice – Chickpea Cropping System at Farmers Field of Balaghat District of Madhya Pradesh, India

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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

Chickpea (*Cicer aeritinum*) is one of most important pulse crop which is grown in rabi season. The availability of nutrients in the soil for plant utilization is known to be affected not only by the inherent soil characteristics but also by the use of fertilizers and management practices followed for crop production. Therefore, a study on the effect of integrated application of inorganic fertilizers and organic manure (vermicompost) on rice productivity at farmer field was carried out at Balaghat

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district of Madhya Pradesh. In between the technology intervention, human resource development components were also included to improve the farmers understanding and skills about the demonstrated technology on nutrient management aspects. The demonstrations were conducted at different farmers' field at villages viz. Koppe, Chillod and Lendejhari on chickpea (variety JG 63) during rabi season 2018-19 and 2019-20 under Indian Council of Agricultural Research funded Project on Farmer FIRST, College of Agriculture, Balaghat (M.P.). Based on the basic soil properties of farmer’s field, the present experiment included four treatments viz., $T_1$ = Farmer Practice (as Control), $T_2$ = 100% NPK, $T_3$ = 100% NPK + Zn, $T_4$ = 75% NPK+ 5t/ha FYM ha and $T_5$ = 75% NPK + 5t FYM ha$^{-1}$+ Biofertilizers (BGA/*Rhizobium*& PSB). Results indicated that the highest average yield of chickpea was achieved in 75% NPK + 5t FYM ha$^{-1}$+ Biofertilizers treatment, whereas, lowest yield was recorded in farmer’s practice. The highest increase in yield (50.7%) was observed with 75% NPK + 5t FYM ha$^{-1}$+ Biofertilizers, followed by 75% NPK + 5t FYM ha$^{-1}$ treatments (47.5%) over farmer’s practice.

*Keywords: Chickpea; integrated nutrient management; rice-chickpea cropping system; nutrient balance; crop productivity.*

## 1. INTRODUCTION

“Rice (*Oryza sativa* L.) - chickpea (*Cicer arietinum* L.) is the prevalent cropping system in Chhattisgarh plain agro-climatic zone of Balaghat district. Chickpea is the third most important pulse crop, after dry bean or peas produced in the world. It accounts for about 20% of the world pulses production. India is one of the largest producers of chickpea. Chickpea is grown over an area of about 13.99 million ha, with a production of about 13.75 mt and productivity is about 982.0 kg ha$^{-1}$” [1]. “Madhya Pradesh state is the single largest producer in the country, accounting for over 42 per cent of total production. The area under chickpea cultivation in Madhya Pradesh is 28.55 lakh ha which produces 29.65 lakh mt with an average yield of 10.4 q ha$^{-1}$.Nutritionally, chickpea contains 18-22% protein, 60-65% carbohydrates and 3.0-3.2% minerals” [2].

Chickpea is capable of fixing atmospheric nitrogen to meet out their nitrogen requirement, add organic matter to soil and thus are capable of enriching the soil for succeeding crops. Therefore, chickpea proved their suitability for inclusion in different cropping systems. However, rice is used as a premier food grain crop in Madhya Pradesh and India. As rice is a cereal and chickpea is a legume pulse crop, together they complement each other in the cropping system and helps in maintaining and/or sustaining the soil health. Therefore, rice – chickpea cropping system is not only, economically viable and eco-friendly for sustaining soil fertility but also for obtaining higher productivity in long term. Thus, rice – chickpea cropping system emerged as an efficient cropping system of Madhya Pradesh and India.

“It has been observed that a major part of the applied nutrient gets fixed and only a small part of it becomes available to the crop plants at farmer’s field” [3]. “The organic matter like FYM being the storehouse of nutrients, combined application of organic and inorganic fertilizers can increase the yield, improve the fertility status of soil, improve the input-use efficiency by the crop and can certainly cut down the expenditure on costly fertilizers” [4,5]. “However, the biofertilizers i.e. BGA (*Cyanobacteria*), *Rhizobium* for $N_2$ fixation and Phosphate-Solubilizing Bacteria (PSB) for phosphorous solubilzation offer great promise to the crops enabling the inoculated plants for more uptake of nutrients particularly nitrogen and phosphorus from the soil. Further, the integration of inorganic fertilizers with organic manures and biofertilizers will not only sustain the crop production but also improving soil health and nutrient use efficiency” [6,7,8]. Therefore, different field demonstrations were undertaken to assess the impact of integrated nutrient management on sustainable chickpea productivity and soil fertility under rice – chickpea cropping system.

## 2. MATERIALS AND METHODS

The present investigation is a part of the ongoing ICAR funded project on Farmer FIRST at College of Agriculture, Balaghat, Madhya Pradesh, India. The study area has a semi-arid and sub-tropical climate with a characteristic feature of dry summer and cold winter. In winter season *i.e.* from November to February months, the temperature ranges from 4 to 33$^{o}$C and the relative humidity varies from 70 to 90%. Dry and warm weather usually prevails during the months of March to June. The temperature in the month of May rise as high as 46$^{o}$C. Monsoon season extends from mid-June to mid-September. The temperature during this period ranges from 25 to 35$^{o}$C and the relative humidity ranges between70 to 80%. The total annual rainfall varies from 1400 to1500 mm with the mean value of around 1400 mm.

"Different tools of Participatory Rural Appraisal (PRA) were used to explore the detailed information of study area" [9]. "In between the technology intervention HRD components (Trainings/ Soil health camp/ Field day etc.) were also included to improve the farmers understanding and skill about the demonstrated technology on integrated nutrient management" [10].

The demonstrations were conducted on chickpea crop variety JG 63 during rabi season 2018-19 and 2019-20 at the farmer's field of adopted villages viz. Koppe, Chillod and Lendejhari. Information on soil condition of the farmer fields used in this experiment was ranged as, soil pH 6.02 to 7.10, EC 0.19 to 0.29 dSm$^{-1}$, organic carbon 0.62 to 0.86%, available nitrogen 229 to 298 kg ha$^{-1}$, available phosphorus 3.49 to 19.54 kg ha$^{-1}$ and available potassium 235 to 449 kg ha$^{-1}$. The experiment was conducted with five treatments comprising of different combinations of inorganic fertilizers, organic manures and biofertilizers. The details of the treatments were $T_1$ = Farmer Practice (as Control), $T_2$ = 100% NPK, $T_3$ = 100% NPK + Zn, $T_4$ = 75% NPK+ 5t FYM ha$^{-1}$ and $T_5$ = 75% NPK + 5t FYM ha$^{-1}$+ Biofertilizers (BGA/*Rhizobium* & PSB).

The 100% optimal NPK doses based on soil test values were 100:60:40 and 20:60:20 (N: $P_2O_5$: $K_2O$) kg ha$^{-1}$ for rice and chickpea, respectively. The sources used for N, P and K supply were urea, single super phosphate and muriate of potash, respectively. In rice crop 50% N, 100% P and 100% K were applied as basal before last harrowing and rest 50% N was applied in two equal splits first half at 21–25 days and rest at 51-55 days after transplanting. While, in chickpea crop all the nutrients (NPK) were applied as basal before last harrowing. In addition to these applications, $ZnSO_4$ was applied @ 25 kg ha$^{-1}$ only in rice crop to the treatment with Zn. The farm yard manure was applied @ 5 t ha$^{-1}$ yr$^{-1}$ to rice crop only 10 – 15 days before transplanting. The different biofertilizers used in different crops *i.e*. BGA in rice, *Rhizobium* in chickpea and PSB was applied @ 3 – 5 kg ha$^{-1}$ in both the crops. In Farmer Practice treatments, application of only Di-ammonium Phosphate (DAP) fertilizer was done @ 125 kg ha$^{-1}$ in both the crops just before transplanting and/or sowing. Urea was applied only in rice crop @ 250 kg ha$^{-1}$ in two equal split doses.

Rice variety JR-206 was grown as rainfed in the first/second week of July during *Kharif* and harvested in115 - 120 days which was followed by chickpea variety JG-63 was sown in the first week of November as also rainfed situation during *rabi* and harvested in100 – 105 days. Chemical herbicides *i.e.* Bispyribac sodium @ 250 mlha$^{-1}$ for rice and Pendimethalin @ 1.25 L ha$^{-1}$ for chickpea were used for weed control. Insects and diseases were kept under control by following suitable control measures.

The grain yield of chickpea (q ha$^{-1}$) was recorded from each demonstrated plots. The soil samples at 0 –15 cm depth were collected after harvesting of chickpea crop during 2019-20. The soil samples were analyzed through standard laboratory procedures for different soil properties *i.e.* soil pH, organic carbon, available N, P and K.

## 3. RESULTS AND DISCUSSION

### 3.1 Crop Productivity

The data pertaining to the grain yield of chickpea has been presented in Table 1. The data indicated that highest average grain yield of chickpea (15.19 q ha$^{-1}$) was recorded in treatment 75% NPK with organic manure and biofertilizers (75% NPK + FYM + BF) and the lowest yield of chickpea (10.08 q ha$^{-1}$) were recorded in control plot (Farmers Practice). Balance fertilization is the key to efficient fertilizer utilization for sustaining high yields. These findings indicated that integrated use of inorganic fertilizer, organic manure and biofertilizers treatment was superior over optimal application of fertilizers [9,11,12]. "Thus, the balance use of fertilizer either alone or in combination with organic manure is necessary for sustaining soil fertility and productivity of crops" [13,14,15].

### 3.2 Extension and Technology Gap

"Extension gap was calculated by subtracting farmer's practice yield from demonstrated yield. The difference of this gap is denoted that there is a sufficient chance to increase in chickpea yield by adopting recommended technologies. The data presented in Table 2, indicated that the 75% NPK + FYM + BF treatment had the highest average extension gap (5.11 q $ha^{-1}$) followed by 75% NPK + FYM treatment (4.79 q $ha^{-1}$). The lowest average extension gap (3.85 t $ha^{-1}$) was recorded in 100% NPK treatment. The results are in close conformity with results of researchers and they were reported that 39.8 per cent of the farmers had low and medium adopted use of recommended dose of fertilizers" [3] "These results are also in line with the findings of the trial on impact of FYM and potassium on yield, nutrient uptake and economics of wheat" [9].

"Technological gap was calculated by subtracting demonstrated yield from yield potential of particularly variety. This gap is express that there is need to guide and educate for adopting recommended technology. The data presented in Table 2, indicated that the Farmer's Practices treatment had the highest average technology gap (9.92 q $ha^{-1}$) followed by 100% NPK treatments i.e. 6.08 q $ha^{-1}$. Lowest average technology gap 4.81 q $ha^{-1}$ was recorded in 75% NPK + FYM + BF treatments" [3,9].

### 3.3 Soil Test Values

The soil test values of all demonstrated farmer fields were presented in Table 3. The result revealed that the soil pH ranged between 5.98 - 7.10 and soil EC values were varied from 0.18 to 0.37 dS $m^{-1}$ in soil before sowing. The organic carbon ranged between 0.62 to 0.86%, available nitrogen 229 to 298 kg $ha^{-1}$, available phosphorus 3.49 to 19.54 kg $ha^{-1}$ and available potassium 235 to 449 kg $ha^{-1}$.

**Table 1. Effect of different treatments on grain yield of chickpea (q $ha^{-1}$)**

| Treatments | Grain Yield (q $ha^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Koppe | | Chillod | | Lendejhari | | Average |
| | 2018-19 | 2019-20 | 2018-19 | 2019-20 | 2018-19 | 2019-20 | |
| Farmer Practice | 10.12 | 10.28 | 9.80 | 10.10 | 9.90 | 10.26 | **10.08** |
| 100% NPK | 14.10 | 13.90 | 13.70 | 13.95 | 13.70 | 14.18 | **13.92** |
| 100%NPK+Zn | 14.40 | 14.28 | 14.22 | 14.40 | 14.20 | 14.56 | **14.34** |
| 75%NPK+FYM | 15.12 | 14.60 | 14.80 | 15.10 | 14.70 | 14.90 | **14.87** |
| 75%NPK+FYM+BF | 15.48 | 14.90 | 15.10 | 15.30 | 15.10 | 15.24 | **15.19** |
| Average | 69.22 | 67.96 | 67.62 | 68.85 | 67.60 | 69.14 | |

**Table 2. Effect of different treatments on extension and technology gap of chickpea productivity**

| Treatments | Name of Villages | | | | | | Average |
|---|---|---|---|---|---|---|---|
| | Koppe | | Chiloud | | Lendejhari | | |
| | 2018-19 | 2019-20 | 2018-19 | 2019-20 | 2018-19 | 2019-20 | |
| **Extension Gap** | | | | | | | |
| Farmer Practice | - | - | - | - | - | - | - |
| 100% NPK | 3.98 | 3.62 | 3.90 | 3.85 | 3.80 | 3.92 | 3.85 |
| 100%NPK+Zn | 4.28 | 4.00 | 4.42 | 4.30 | 4.30 | 4.30 | 4.27 |
| 75%NPK+FYM | 5.00 | 4.32 | 5.00 | 5.00 | 4.80 | 4.64 | 4.79 |
| 75%NPK+FYM+BF | 5.36 | 4.62 | 5.30 | 5.20 | 5.20 | 4.98 | 5.11 |
| **Technology Gap** | | | | | | | |
| Farmer Practice | 9.88 | 9.72 | 10.20 | 9.90 | 10.10 | 9.74 | 9.92 |
| 100% NPK | 5.90 | 6.10 | 6.30 | 6.05 | 6.30 | 5.82 | 6.08 |
| 100%NPK+Zn | 5.60 | 5.72 | 5.78 | 5.60 | 5.80 | 5.44 | 5.66 |
| 75%NPK+FYM | 4.88 | 5.40 | 5.20 | 4.90 | 5.30 | 5.10 | 5.13 |
| 75%NPK+FYM+BF | 4.52 | 5.10 | 4.90 | 4.70 | 4.90 | 4.76 | 4.81 |

**Table 3. Soil test value of thirty (05 from each villages) farmer's field**

| S. no. | Farmers Name | pH | EC ($dSm^{-1}$) | OC (%) | Available Nutrients (kg $ha^{-1}$) N | P | K |
|---|---|---|---|---|---|---|---|
| **Village – Koppe** | | | | | | | |
| 1. | Naganlal Patle | 6.45 | 0.22 | 0.86 | 298 | 19.20 | 363 |
| 2. | Tejram Shirsagar | 6.13 | 0.27 | 0.81 | 284 | 19.54 | 272 |
| 3. | Ram Prasad Thakre | 6.33 | 0.28 | 0.73 | 267 | 8.73 | 324 |
| 4. | Neelesh Tembhre | 6.42 | 0.29 | 0.85 | 298 | 5.93 | 288 |
| 5. | Dhanulal Katre | 6.30 | 0.28 | 0.83 | 287 | 3.49 | 269 |
| **Village – Chillod** | | | | | | | |
| 1. | Rajkumar Rawde | 6.46 | 0.26 | 0.84 | 294 | 5.93 | 311 |
| 2. | Jaglal Matre | 6.19 | 0.21 | 0.67 | 251 | 10.47 | 322 |
| 3. | Sunita Bhautekar | 6.14 | 0.21 | 0.62 | 229 | 3.84 | 336 |
| 4. | Sardar Singh Maskole | 7.01 | 0.24 | 0.76 | 272 | 13.61 | 243 |
| 5. | Maheshwari Pancheshwar | 6.50 | 0.23 | 0.83 | 287 | 6.98 | 449 |
| **Village – Landejhari** | | | | | | | |
| 1. | Khemlata Sonekar | 6.21 | 0.29 | 0.73 | 267 | 6.28 | 238 |
| 2. | Shivlal Uike | 6.18 | 0.19 | 0.84 | 294 | 7.33 | 237 |
| 3. | Dasharam Uike | 6.02 | 0.28 | 0.72 | 266 | 5.58 | 245 |
| 4. | Rooplal Shende | 6.50 | 0.27 | 0.85 | 298 | 14.31 | 235 |
| 5. | Ravind Nikuse | 7.10 | 0.22 | 0.65 | 240 | 18.85 | 318 |
| Minimum Value:- | | 6.02 | 0.19 | 0.62 | 229 | 3.49 | 235 |
| Maximum Value:- | | 7.10 | 0.29 | 0.86 | 298 | 19.54 | 449 |

"The application of fertilizers could not exhibit any adverse effect on the soil physico-chemical properties due to its inherent high buffering capacity. Similar finding has also been reported from an experiment conducted on continuous applications of nutrient inputs on spatial changes of soil physicochemical properties of a medium black soil" [16,17,18]. "The data also indicated (Table-4) that organic carbon content in soil found to increase with increasing levels of fertilizer addition application thereby, lower content was found in farmer's practice as compared to 75% NPK + FYM + BFapplication followed by 75% NPK + FYM treatments. Organic carbon content in soil indicated that the contribution of organic carbon content appeared due to decomposition of plant and root residues" [19,20,21]. "Similarly, the available N, P and K contenting soil was found to be higher with 75% NPK + FYM + BF treatment; however, the lowest nutrients content was noted in farmer's practice" [22,23,24].

**Table 4. Effect of different treatments on nutrient status of soil after harvest of chickpea crop (2019–20)**

| Treatment | Soil pH | EC ($dSm^{-1}$) | OC (%) | Available Nutrients (kg/ha) N | P | K |
|---|---|---|---|---|---|---|
| Farmer Practice | 7.20 | 0.18 | 0.63 | 260 | 16.1 | 241 |
| 100% NPK | 7.10 | 0.21 | 0.67 | 297 | 18.3 | 266 |
| 100%NPK+Zn | 7.20 | 0.22 | 0.68 | 302 | 18.7 | 268 |
| 75%NPK+FYM | 7.10 | 0.20 | 0.71 | 306 | 19.5 | 273 |
| 75%NPK+FYM+BF | 7.00 | 0.20 | 0.72 | 310 | 20.4 | 274 |

**Table 5. Human resource development components**

| HRD Components | Frequency | Beneficiaries |
|---|---|---|
| Training | 06 | 330 |
| Soil Health Camp / Day | 02 | 180 |
| Field Day | 14 | 270 |
| Popular article / leaf let /Pamphlets | 04 | Mass |
| Training Handout /manuals/booklets | 05 | 210 |
| Kisan Mela | 06 | Mass |

### 3.4 Human Resource Development (HRD)

"During the study period, Human Resources Development Components i.e. training, soil health camp/day, field day, focused group discussion and Kisan Mela(Table 5) were also organized and disseminate information through popular articles/leaf lets/pamphlets, training handouts/manuals/booklets etc. to increase the farmers understanding and skill about the recommended practice on soil test crop response" [9,25,26].

## 5. CONCLUSION

Trainings on soil health/quality and the events like field day are the effective medium to disseminate information on different agriculture technologies among farming communities with extension publications. Balanced and integrated nutrient management concept should improve the soil properties as well as increases chickpea productivity. Soil test values helps farmers to calculate the amount of fertilizers required for the particular crop during whole growth period. We experienced the gap between farmers-scientist before the Farmer FIRST Project for technology dissemination other extension activities. After implementation of the project this gap is merged and farmers benefited with the new technologies. Integrated nutrient management technology helps farmers to increase 50.7% chickpea yield over traditional system.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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