Influence of Establishment Methods and Nutrient Management on Productivity of Kharif Rice (Oryza sativa L.) and their Residual Effect on Succeeding Chickpea (Cicer arietinum L.) Crop

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Abstract

A field experiment was conducted at Agriculture Instructional cum Research Farm, IGKV Raipur during kharif and rabi seasons of three consecutive years of 2015-16, 2016-17 and 2017-18 with three rice establishment methods; six nutrient management in rice and two nutrient management in chickpea. Dry direct seeded rice before onset of monsoon produced grain and straw yield similar to transplanting method, but higher net return and B: ratio. The seed yield of chickpea under dry direct seeded rice was 9.53 to 27.89% higher over transplanting method of rice. Combined application of 100% RDF and 5t/ha FYM in rice produced grain yield of rice, seed yield and net return of chickpea comparable to 150% RDF. In rice-chickpea cropping system, dry direct seeded rice before onset of monsoon produced 4.85 to 14.72% higher rice equivalent yield and 22.64 to 27.93% net return compared to compared to transplanting method of rice. Combined application of 100% RDF and 5 t/ha FYM recorded higher rice equivalent yield and net return which was however, comparable to application of 150% RDF in net return. Application of 100% RDF in chickpea recorded an increase of 9.37 to 11.72% in seed yield.

Keywords
Dry direct seeded rice, Nutrient management, Leaf colour chart, Rice-chickpea cropping system, Seed yield, Net return, Integrated nutrient management

Introduction

Rice is a staple food for nearly half of the world’s seven billion people. However, more than 90% of this rice is consumed in Asia, where it is a staple for a majority of the population. The rising per capita consumption along with the growing population has enhanced global rice consumption from 150 during 1960-61 to more than 450 million tons during 2010-11 (Mohanty, 2013). It is the leading crop of India grown in 43.19 million ha with productivity of 2550 kg/ha during 2016-17 (Annual Report 2017-18). In Chhattisgarh state, known as rice bowl of India, it is cultivated in about 70% area during kharif season with average productivity of 2212 kg/ha during 2016-17 (Anonymous,
Pulses are the most important source of protein in vegetarian diets. United Nations declared 2016 as the International Year of Pulses looking into its dietary essentiality. Chickpea is the most important rabi season crop grown in the Chhattisgarh state with an area of 0.37 million ha and productivity of 1100 kg (Krishi Darshika, 2018) and as a pulse crop, it is important for nutritional security along with improving soil fertility.

Cultivation of rice with different establishment methods is unique feature of the state. The most popular transplanting method of rice cultivation requires huge number of labour for different farm operations from sowing to harvesting. In Asia, labour forces in agriculture are declining at 0.1-0.4%, with an average of 0.2% per year (Dawe, 2005). However, due to the decreasing availability of farm labours, less labour requiring technique is required for rice cultivation to sustain its production. The decreasing water availability for agricultural crops has also forced to evolve technologies which need less water with higher productivity of rice.

In Asia, the share of water in agriculture declined from 98% in 1900 to 80% in 2000, and is likely to further decline to 72 % by 2020 (Kumar and Ladha, 2011). Presently, direct seeded rice is one of the options to meet out problems of shortage of labour and water. DSR refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. It has been recognized as the principal method of rice establishment since 1950’s in developing countries (Pandey and Velasco, 2005).

The nutrients play important role in enhancing productivity and profitability of rice crop which differs in different establishment methods due to variation in microclimate. Application of fertilizer dose may also differ in these establishment methods due to change in mobilization and availability of nutrients in rice ecosystem. The performance of succeeding crop depends not only on fertilizers applied in previous crop but also on methods of establishment followed due to change in soil physico-chemical properties. Chickpea, as being a deep rooted crop can mine nutrients from deeper layer and however, it may depends on root penetration and also capacity to make available those nutrients. Thus, an experiment was laid out to study the effect of different nutrient management practices on productivity of rice crop in varying establishment methods as well as to study their residual effect on performance of succeeding chickpea crop.

Materials and Methods

A field experiment was conducted at Agriculture Instructional cum Research Farm, IGKV Raipur during kharif and rabi seasons of three consecutive years of 2015-16, 2016-17 and 2017-18 in the same field. The experimental soil was clay in texture, neutral in reaction, normal in electrical conductivity, low in available nitrogen, medium in available phosphorus and high in available potassium.

The experiment was laid out in split-split plot design with three replications. The main plot treatments consisted of three rice establishment methods viz., M1- Dry direct seeded rice before onset of monsoon with normal seed rate, M2- Dry direct seeded rice after monsoon with reduced seed rate and M3- Transplanting; sub-plot treatments consisted of six nutrient management practices in rice viz. S1-100%RFD (Inorganic), S2-100% RDF (75% Inorganic+25% Organic), S3-150% of RDF (Inorganic), S4- LCC based N application and P& K at RD, S5-100%RFD (Organic)+ 5t FYM and
Control and sub-sub plot treatments consisted of two nutrient management practices in chickpea viz., F0-control and F1-100% RDF (Inorganic). The recommended dose of fertilizer (RDF) was 100:60:40 kg NPK/ha for rice and 20:50:30 kg NPK/ha for chickpea applied through urea, single super phosphate and muriate of potash applied as per treatments. The test variety was IGKV R1 (125 days) of rice and JG-130 (115 days) of chickpea.

The date of sowing for dry direct seeded rice after monsoon (M2) and transplanting (M3) was same whereas, dry direct seeded rice before monsoon (M1) was done 3-4 days before anticipation of monsoon and irrigation was given for establishment of the crop. The rice crop was harvested at maturity and sowing of chickpea was done after field preparation. The date of sowing for chickpea was same in all the treatments.

The observations were recorded from net plot area in each treatment and were statistically analyzed as suggested by Gomez and Gomez (1983) for interpretation of the result. Cost of cultivation was calculated based on market price of the inputs and outputs. B:C ratio was calculated by dividing gross return to cost of cultivation of the respective treatments.

Results and Discussion

Number of total tillers and panicles of rice

Dry direct seeded rice before onset of monsoon with normal seed rate registered significantly higher number of total tillers and panicles compared to other methods. Dry direct seeded rice after monsoon with reduced seed rate recorded significantly the least number of total tillers and panicles per unit area. Regarding nutrient management in rice, combined application of 100% RDF and 5 t/ha FYM produced number of total tillers and panicles of rice comparable to 150% RDF which was significantly higher than other nutrient management practices. Nitrogen application based on LCC recorded statistically at par number of total tillers and panicles per unit area compared to 100% RDF (Inorganic) and 100% RDF (75% inorganic+25% organic) (Table 1).

Panicle weight and test weight of rice

Transplanting method of rice recorded significantly higher panicle weight compared other methods of establishment. However, test weight was not influenced significantly by establishment methods.

Regarding nutrient management in rice, combined application of 100% RDF and 5 t/ha FYM registered panicle weight and test weight comparable to 150% RDF and significantly higher than other nutrient management practices. Nitrogen application based on LCC recorded statistically at par panicle weight and test weight compared to 100% RDF (Inorganic) and 100% RDF (75% inorganic+25% organic) (Table 2).

Grain and straw yield of rice

Grain and straw yield of rice was significantly influenced by establishment methods and nutrient management practices. Dry direct seeded rice before onset of monsoon with normal seed rate produced grain and straw yield statistically comparable to transplanting method. Higher grain yield in DSR is also reported by Gill et al., (2006) and Hayanshi et al., (2007). Dry direct seeded rice after monsoon with reduced seed rate recorded lesser grain and straw yield. The reduction was 4.12 to 7.53 % in grain yield and 4.40 to 12.07 % in straw yield compared to transplanting method in different years. Regarding nutrient management in rice, combined application of 100% RDF and 5
t/ha FYM produced grain and straw yield of rice comparable to 150% RDF which was significantly higher than other nutrient management practices. The increase was 3.23 to 8.82% in grain yield and 3.46 to 6.57% in straw yield of rice over 100% RDF in different years.

Nitrogen application based on LCC recorded statistically at par grain and straw yield compared to 100% RDF (Inorganic) whereas, application of 100% RDF (75% inorganic+25% organic) recorded statistically lesser grain and straw yield (Table 3).

**Economics of rice**

Dry direct seeded rice before onset of monsoon with normal seed rate recorded significantly higher net return and B:C ratio compared to other methods, though B:C ratio was comparable to dry direct seeded rice after monsoon with reduced seed rate. Transplanting method of rice gave significantly least net return and B:C ratio.

Higher net return and B: ratio in dry direct seeded rice was due to reduction in labour expenses in transplanting and other operations. Sumita and Ando (2001) report that conventionally planted rice uses 37% higher labour in as compared to DSR, which is mainly because of transplanting operation.

Regarding nutrient management in rice, combined application of 150% RDF recorded significantly higher net return compared to all other treatments however it was comparable to 100% RDF. The higher net return in 150% RDF was due to higher grain and straw yield along with lesser cost of chemical fertilizers compared to organic manures. Nitrogen application based on LCC recorded statistically at par net return and B: ratio compared to 100% RDF (Inorganic) (Table 4).

**No. of pods/plant and 100 seed weight of chickpea**

Dry direct seeded rice before onset of monsoon and after onset of monsoon registered comparable number of pods per plant of chickpea and significantly higher than transplanting method of rice. This may be due to better growth of chickpea in unpuddled condition causing prevention of compactness of soil which results in better root growth of plants. Although, 100 seed weight of chickpea was influenced by establishment method of rice.

Regarding nutrient management in rice, combined application of 100% RDF and 5 t/ha FYM recorded number of pods per plant of chickpea comparable to 150% RDF and 100% RDF. The 100 seed weight of chickpea was not influenced by nutrient application in rice. Application of 100% RDF in chickpea recorded significantly higher number of pods per plant and 100 seed weight compared to no application of nutrients (Table 5).

**Seed and straw yield of chickpea**

Establishment methods and nutrient management practices in rice significantly influenced the seed and straw yield of chickpea in succeeding season. Dry direct seeded rice before onset of monsoon and after onset of monsoon produced comparable and higher seed and straw yield of chickpea and significantly higher than transplanting method of rice.

The increase in seed yield of chickpea was 9.53 to 27.89% and in straw yield was 10.27 to 30.09% over transplanting method of rice in different years. This may be due to better expression of growth and yield attributes of chickpea under unpuddled condition which results in better root growth of plants (Table 6).
Although puddling is known to be beneficial for growing rice, it can adversely affect the growth and yield of subsequent upland crops because of its adverse effects on soil physical properties, which includes poor soil structure, sub-optimal permeability in the lower layers and soil compaction (Gathala et al., 2011). Regarding nutrient management in rice, combined application of 100% RDF and 5 t/ha FYM recorded seed and straw yield of chickpea comparable to 150% RDF and 100% RDF.

Balanced nutrient application in previous crop maintains soil fertility which might have resulted in higher yield of succeeding chickpea crop. The higher seed yield of chickpea with 100% RDF in rice was also reported by Mansuri (2016). Application of 100% RDF in chickpea recorded significantly higher seed and straw yield of chickpea compared to no application of nutrients. The increase was 9.37 to 11.72% in seed yield and 9.52 to 11.69% in straw yield of chickpea over no application of nutrients in chickpea in different years.

**Economics of chickpea**

Establishment methods and nutrient management practices in rice significantly influenced the net return and B:C ratio of chickpea in succeeding season. Dry direct seeded rice before onset of monsoon and after onset of monsoon produced comparable and net return and B:C ratio of chickpea and significantly higher than transplanting method of rice. This was be due to higher seed and straw yield of chickpea under these treatments. Regarding nutrient management in rice, combined application of 100% RDF and 5 t/ha FYM recorded net return and B:ratio of chickpea compared to no application of nutrients in chickpea in different years.

**Table.1 Number of total tillers and panicles of rice as influenced by different establishment methods and nutrient management**

| Treatments                      | Total tillers, no./m² | Panicles, no./m² |
|---------------------------------|-----------------------|------------------|
|                                 | 2015  | 2016 | 2017 | Mean | 2015 | 2016 | 2017 | Mean |
| **Rice establishment methods**  |        |      |      |     |      |      |      |      |
| M1-Dry DSR before monsoon      | 378   | 412  | 407  | 399  | 241  | 269  | 286  | 265  |
| M2-Dry DSR after monsoon       | 342   | 323  | 391  | 352  | 194  | 232  | 280  | 235  |
| M3-Transplanting               | 325   | 341  | 370  | 345  | 224  | 249  | 261  | 245  |
| CD (P=0.05)                    | 22    | 27   | 24   | 8    | 17   | 7    |      |      |
| **Nutrient management in rice**|        |      |      |     |      |      |      |      |
| S1-100% RFD (Inorganic)        | 369   | 373  | 387  | 376  | 225  | 264  | 275  | 255  |
| S2-100% RDF (75% Inorg+25% Org) | 358   | 351  | 371  | 360  | 204  | 234  | 265  | 234  |
| S3-150% RDF                    | 388   | 399  | 408  | 398  | 237  | 267  | 288  | 264  |
| S4-LCC based nitrogen          | -     | 359  | 380  | 370  | -    | 234  | 269  | 252  |
| S5-100% RDF+ 5t FYM            | 383   | 411  | 399  | 398  | 247  | 266  | 280  | 264  |
| S6-Control                     | 242   | 259  | -    | 251  | 184  | 233  | -    | 209  |
| CD (P=0.05)                    | 25    | 30   | 19   | 19   | 23   | 5    |      |      |
Table.2 Panicle weight and test weight of rice as influenced by different establishment methods and nutrient management

| Treatments                      | Panicle weight, g/panicle | Test weight, g |
|--------------------------------|---------------------------|---------------|
|                                | 2015  | 2016  | 2017  | Mean | 2015  | 2016  | 2017  | Mean |
| Rice establishment methods     |        |        |       |      |        |        |       |      |
| M1-Dry DSR before monsoon      | 2.91   | 3.62   | 3.27  | 3.27 | 29.8  | 31.5  | 31.1  | 30.8 |
| M2-Dry DSR after monsoon       | 3.03   | 4.03   | 3.45  | 3.50 | 29.9  | 31.6  | 31.4  | 31.0 |
| M3-Transplanting               | 3.17   | 4.28   | 3.83  | 3.76 | 30.0  | 32.1  | 31.2  | 31.1 |
| CD (P=0.05)                    | 0.09   | 0.34   | 0.35  |      | NS    | NS    | NS    |      |
| Nutrient management in rice    |        |        |       |      |        |        |       |      |
| S1-100% RFD (Inorganic)        | 3.09   | 4.16   | 3.50  | 3.58 | 30.0  | 32.0  | 30.8  | 30.9 |
| S2-100% RDF (75% Inorg+25% Org)| 2.97   | 3.91   | 3.32  | 3.40 | 29.5  | 31.9  | 31.2  | 30.9 |
| S3-150% RDF                    | 3.22   | 4.37   | 3.82  | 3.80 | 31.1  | 32.0  | 31.2  | 31.4 |
| S4-LCC based nitrogen          |        | 4.01   | 3.40  | 3.71 |        | 31.8  | 31.3  | 31.3 |
| S5-100% RFD+ 5t FYM            | 3.32   | 4.47   | 3.55  | 3.78 | 30.9  | 32.2  | 31.6  | 31.6 |
| S6-Control                     | 2.59   | 2.93   | -     | 2.76 | 28.1  | 30.4  | -     | 29.3 |
| CD (P=0.05)                    | 0.10   | 0.38   | 0.27  |      | 0.68  | 0.72  | NS    |      |

Table.3 Grain and straw yield of rice as influenced by different establishment methods and nutrient management

| Treatments                      | Grain yield, kg/ha | Straw yield, kg/ha |
|--------------------------------|-------------------|-------------------|
|                                | 2015  | 2016  | 2017  | Mean | 2015  | 2016  | 2017  | Mean |
| Rice establishment methods     |        |        |       |      |        |        |       |      |
| M1-Dry DSR before monsoon      | 4784  | 4980  | 5051  | 4938 | 5841  | 6359  | 6477  | 6226 |
| M2-Dry DSR after monsoon       | 4411  | 4844  | 4773  | 4676 | 5195  | 5884  | 6240  | 5773 |
| M3-Transplanting               | 4770  | 5118  | 4978  | 4955 | 5434  | 6692  | 6964  | 6363 |
| CD (P=0.05)                    | 89    | 170   | 178   |      | 333   | 751   | 524   |      |
| Nutrient management in rice    |        |        |       |      |        |        |       |      |
| S1-100% RFD (Inorganic)        | 4974  | 5225  | 4919  | 5039 | 5679  | 6367  | 6557  | 6201 |
| S2-100% RDF (75% Inorg+25% Org)| 4630  | 5119  | 4598  | 4782 | 5542  | 6219  | 5915  | 5892 |
| S3-150% RDF                    | 5225  | 5532  | 5353  | 5370 | 5923  | 6783  | 6967  | 6558 |
| S4-LCC based nitrogen          |        | 5164  | 4722  | 4943 |        | 6226  | 6379  | 6303 |
| S5-100% RFD+ 5t FYM            | 5318  | 5676  | 5078  | 5357 | 5941  | 6644  | 6784  | 6456 |
| S6-Control                     | 3129  | 3168  | -     | 3149 | 4364  | 5737  | -     | 5051 |
| CD (P=0.05)                    | 122   | 210   | 215   |      | 319   | 604   | 383   |      |
### Table 4 Economics of rice as influenced by different establishment methods and nutrient management

| Treatments                          | Net return, Rs/ha | B:C ratio |
|-------------------------------------|-------------------|-----------|
|                                     | 2015   | 2016   | 2017   | Mean   | 2015   | 2016   | 2017   | Mean   |
| **Rice establishment methods**      |        |        |        |        |        |        |        |        |
| M1-Dry DSR before monsoon           | 43226  | 55101  | 55628  | 51318  | 2.44   | 2.75   | 2.74   | 2.64   |
| M2-Dry DSR after monsoon            | 38720  | 53539  | 52493  | 48251  | 2.34   | 2.78   | 2.72   | 2.61   |
| M3-Transplanting                    | 37765  | 53128  | 49991  | 46961  | 2.08   | 2.44   | 2.34   | 2.29   |
| CD (P=0.05)                         | 1422   | 1134   | 3105   | 0.05   | 0.09   | 0.10   |        |        |
| **Nutrient management in rice**     |        |        |        |        |        |        |        |        |
| S1-100% RFD (Inorganic)             | 46344  | 54980  | 55237  | 52187  | 2.58   | 2.83   | 2.81   | 2.74   |
| S2-100% RDF (75% Inorg+25% Org)     | 36153  | 49159  | 44130  | 43147  | 2.05   | 2.40   | 2.23   | 2.23   |
| S3-150% RDF                         | 47380  | 56332  | 59934  | 54549  | 2.49   | 2.72   | 2.81   | 2.67   |
| S4-LCC based nitrogen               | 54211  | 52666  | 53439  | 50492  | 2.26   | 2.50   | 2.39   | 2.38   |
| S5-100% RFD+ 5t FYM                 | 44992  | 54930  | 51554  | 50492  | 0.06   | 0.11   | 0.10   |        |
| CD (P=0.05)                         | 1862   | 3540   | 3222   | 0.06   | 0.11   | 0.10   |        |        |

### Table 5 Residual effect of establishment methods and nutrient management of kharif rice on number of pods/plant and seed weight of chickpea

| Treatments                          | No. of pods/plant | 100 seed weight, g |
|-------------------------------------|-------------------|--------------------|
|                                     | 2015   | 2016   | 2017   | Mean   | 2015   | 2016   | 2017   | Mean   |
| **Rice establishment methods**      |        |        |        |        |        |        |        |        |
| M1-Dry DSR before monsoon           | 39.2   | 39.2   | 40.8   | 39.7   | 22.53  | 23.54  | 23.55  | 23.21  |
| M2-Dry DSR after monsoon            | 38.8   | 39.2   | 39.9   | 39.3   | 22.24  | 23.54  | 23.66  | 23.15  |
| M3-Transplanting                    | 35.3   | 36.4   | 36.2   | 36.0   | 22.68  | 23.45  | 24.03  | 23.39  |
| CD (P=0.05)                         | 1.0    | 0.9    | 2.5    | NS     | NS     | NS     |        |        |
| **Nutrient management in kharif rice** |        |        |        |        |        |        |        |        |
| S1-100% RFD (Inorganic)             | 38.0   | 39.9   | 39.9   | 39.3   | 22.50  | 23.69  | 23.79  | 23.33  |
| S2-100% RDF (75% Inorg+25% Org)     | 37.2   | 37.9   | 37.9   | 37.7   | 22.67  | 23.32  | 23.84  | 23.28  |
| S3-150% RDF                         | 38.4   | 40.1   | 38.9   | 39.1   | 22.33  | 23.67  | 23.81  | 23.27  |
| S4-LCC based nitrogen               | 36.6   | 37.8   | 37.2   | -      | 23.33  | 23.56  | 23.45  |        |
| S5-100% RFD+ 5t FYM                 | 39.6   | 40.6   | 40.3   | 40.2   | 22.72  | 23.74  | 23.72  | 23.39  |
| S6-Control                          | 35.7   | 34.5   | -      | 35.1   | 22.20  | 23.31  | -      | 22.76  |
| CD (P=0.05)                         | 1.5    | 1.3    | 1.2    | NS     | NS     | NS     |        |        |
| **Nutrient management in Chickpea** |        |        |        |        |        |        |        |        |
| F0-Control                          | 35.7   | 36.0   | 36.9   | 36.2   | 22.30  | 23.34  | 23.62  | 23.09  |
| F1-100% RDF                         | 39.8   | 40.6   | 41.0   | 40.5   | 22.68  | 23.68  | 23.87  | 23.41  |
| CD (P=0.05)                         | 1.3    | 1.0    | 1.0    | 0.35   | 0.26   | 0.15   |        |        |
### Table 6: Residual effect of establishment methods and nutrient management of kharif rice on seed and straw yield of chickpea

| Treatments                        | Seed yield, kg/ha | Straw yield, kg/ha |
|-----------------------------------|-------------------|--------------------|
|                                   | 2015  | 2016  | 2017  | Mean | 2015  | 2016  | 2017  | Mean |
| Rice establishment methods        |       |       |       |      |       |       |       |      |
| M1-Dry DSR before monsoon         | 2068  | 2319  | 2334  | 2240 | 3908  | 4331  | 4432  | 4224 |
| M2-Dry DSR after monsoon          | 2090  | 2303  | 2308  | 2234 | 3931  | 4351  | 4366  | 4216 |
| M3-Transplanting                  | 1888  | 1848  | 1825  | 1854 | 3544  | 3474  | 3407  | 3475 |
| CD (P=0.05)                       | 64    | 55    | 81    | 95   | 133   | 155   |       |      |
| Nutrient management in kharif rice|       |       |       |      |       |       |       |      |
| S1-100% RFD (Inorganic)           | 2041  | 2215  | 2158  | 2138 | 3821  | 4180  | 4079  | 4027 |
| S2-100% RDF (75% Inorg+25% Org)   | 1591  | 2128  | 2102  | 2060 | 3707  | 3963  | 4000  | 3890 |
| S3-150% RDF                       | 2033  | 2130  | 2190  | 2118 | 3801  | 4018  | 4109  | 3976 |
| S4-LCC based nitrogen             | -     | 2069  | 2066  | 2068 | -     | 3907  | 3899  | 3903 |
| S5-100% RFD+ 5t FYM               | 2084  | 2225  | 2263  | 2191 | 3954  | 4183  | 4255  | 4131 |
| S6-Control                        | 1967  | 2172  | -     | 2070 | 3689  | 4063  | -     | 3876 |
| CD (P=0.05)                       | 71    | 99    | 89    | -    | 130   | 180   | 182   |      |
| Nutrient management in Chickpea   |       |       |       |      |       |       |       |      |
| F0-Control                        | 1890  | 2037  | 2050  | 1992 | 3559  | 3827  | 3865  | 3750 |
| F1-100% RDF                       | 2141  | 2277  | 2262  | 2227 | 4030  | 4277  | 4272  | 4193 |
| CD (P=0.05)                       | 35    | 54    | 52    | 78   | 111   | 111   |      |      |

### Table 7: Residual effect of establishment methods and nutrient management of kharif rice on net return and B: C ratio of chickpea

| Treatments                        | Net return, Rs/ha | B:C ratio |
|-----------------------------------|-------------------|-----------|
|                                   | 2015  | 2016  | 2017  | Mean | 2015  | 2016  | 2017  | Mean |
| Rice establishment methods        |       |       |       |      |       |       |       |      |
| M1-Dry DSR before monsoon         | 46051 | 65818 | 71691 | 61187| 2.63  | 3.26  | 3.42  | 3.10 |
| M2-Dry DSR after monsoon          | 46838 | 65166 | 70567 | 60857| 2.66  | 3.24  | 3.38  | 3.09 |
| M3-Transplanting                  | 39596 | 46520 | 49532 | 51527| 2.40  | 2.60  | 2.67  | 2.56 |
| CD (P=0.05)                       | 2277  | 2253  | 3497  | 1277 | 0.08  | 0.08  | 0.12  |      |
| Nutrient management in kharif rice|       |       |       |      |       |       |       |      |
| S1-100% RFD (Inorganic)           | 45071 | 61580 | 64034 | 56895| 2.59  | 3.12  | 3.16  | 2.96 |
| S2-100% RDF (75% Inorg+25% Org)   | 41885 | 57972 | 61613 | 53823| 2.49  | 2.99  | 3.08  | 2.85 |
| S3-150% RDF                       | 44772 | 58069 | 65385 | 56075| 2.59  | 2.99  | 3.20  | 2.93 |
| S4-LCC based nitrogen             | -     | 55666 | 60039 | 57823| -     | 2.92  | 3.02  | 2.97 |
| S5-100% RFD+ 5t FYM               | 46659 | 61979 | 68585 | 59074| 2.65  | 3.13  | 3.31  | 3.03 |
| S6-Control                        | 42422 | 59801 | -     | 51112| 2.50  | 3.06  | 2.78  |      |
| CD (P=0.05)                       | 2522  | 4035  | 3879  | 0.09 | 0.14  | 0.13  |      |      |
| Nutrient management in Chickpea   |       |       |       |      |       |       |       |      |
| F0-Control                        | 41680 | 56288 | 61354 | 53107| 2.59  | 3.08  | 3.22  | 2.96 |
| F1-100% RDF                       | 46643 | 62047 | 66508 | 58399| 2.54  | 2.99  | 3.09  | 2.87 |
| CD (P=0.05)                       | 1248  | 2215  | 2277  | 0.05 | 0.08  | 0.08  |      |      |
Rice equivalent yield and net return of rice-chickpea cropping system as influenced by rice establishment methods and nutrient management in rice and chickpea

| Treatments                                | Rice equivalent yield, Kg/ha | Net return, Rs/ha |
|-------------------------------------------|------------------------------|-------------------|
|                                           | 2015 | 2016 | 2017 | Mean | 2015 | 2016 | 2017 | Mean  |
| Rice establishment methods                |      |      |      |      |      |      |      |      |
| M1-Dry DSR before monsoon                 | 9916 | 11291| 11451| 10886| 89277| 116976| 127319| 111191|
| M2-Dry DSR after monsoon                  | 9599 | 11110| 11102| 10604| 85558| 114773| 123060| 107797|
| M3-Transplanting                          | 9457 | 10145| 9982 | 9861 | 77361| 95096 | 99526 | 90661 |
| CD (P=0.05)                               | 216  | 251  | 203  |      | 3408 | 4124  | 3546  |      |
| Nutrient management in kharif rice        |      |      |      |      |      |      |      |      |
| S1-100% RFD (Inorganic)                   | 10039| 11253| 10836| 10709| 91415| 116560| 119271| 109082|
| S2-100% RDF (75% Inorg+25% Org)           | 9474 | 10909| 10362| 10248| 78038| 107132| 105743| 96971 |
| S3-150% RDF                               | 10270| 11327| 11356| 10984| 92153| 118401| 125319| 111958|
| S4-LCC based nitrogen                     | -    | 10795| 10387| 10591| -    | 109817| 112705| 111261|
| S5-100% RFD+ 5 t FYM                      | 10492| 11731| 11284| 11169| 91651| 116909| 120138| 109566|
| S6-Control                                | 8012 | 9079 | -    | 8546 | 67070| 88872 | -     | 77971 |
| CD (P=0.05)                               | 204  | 303  | 317  |      | 3180 | 4930  | 4904  |      |
| Nutrient management in Chickpea           |      |      |      |      |      |      |      |      |
| F0-Control                                | 9346 | 10523| 10554| 10141| 81584| 106069| 114058| 100570|
| F1-100% RDF                               | 9969 | 11175| 11136| 10760| 86547| 111828| 119212| 105862|
| CD (P=0.05)                               | 86   | 147  | 144  |      | 1248 | 2215  | 2277  |      |

**Rice equivalent yield and net return of rice-chickpea cropping system**

Dry direct seeded rice before onset of monsoon produced significantly the highest rice equivalent yield and net return of rice-chickpea cropping system with significant difference to other methods. Transplanting method recorded the least equivalent yield and net return. The increase was 4.85 to 14.72% in rice equivalent yield and 22.64 to 27.93% in net return over transplanting method of rice in different years. Regarding nutrient management in rice, combined application of 100% RDF and 5 t/ha FYM recorded the highest rice equivalent yield with significant difference to other nutrient management practices, however it was closely followed by 150% RDF.

Moreover, regarding net return, application of 150% registered the highest net return which was comparable to 100% RDF and 5 t/ha FYM and with significantly higher than other nutrient management practices. Application of 100% RDF in chickpea recorded significantly higher rice equivalent yield of the system compared to no application of nutrients. The increase was 5.51 to 6.67% in rice equivalent yield and 4.52 to 6.08% in net return in different years.

In rice-chickpea cropping system, Dry direct seeded rice before onset of monsoon with normal seed rate produced significantly the highest rice equivalent yield and net return compared to transplanting method of rice with increase of 4.85 to 14.72% in rice equivalent yield and 22.64 to 27.93% in net return.
Combined application of 100% RDF and 5 t/ha FYM recorded higher rice equivalent yield and net return which was however, comparable to application of 150% RDF in net return. Application of 100%RDF in chickpea recorded an increase of 9.37 to 11.72% in seed yield of chickpea and 5.51 to 6.67% in rice equivalent yield over no application of nutrients.

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