Effect of Residue Management and Cropping System on Direct Deeded Rice and System Productivity

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Authors’ contributions

This work was carried out in collaboration among all authors. Author AK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VK, RK and MK managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during three seasons of 2018-19 at RPCAU, Pusa to evaluate the Effect of Residue Management and Cropping Systems on direct seeded rice and System productivity. Treatments comprised cropping systems in main plots: C¹ - Rice - Wheat - Fallow, C² - Rice - Wheat - Green Gram, C³ - Rice - Maize - Dhaincha, C⁴ - Rice - Maize + Potato - Dhaincha, C⁵ - Rice - Maize + Green Pea - Dhaincha and moisture regimes in sub plots with 3 days disappearance of ponded water in kharif season, three levels of IW/CPE ratio in rabi season I₁ - IW/CPE = 0.6, I₂ - IW/CPE = 0.8, I₃ - IW/CPE = 1.0. Maximum number of tillers (273.55/m²), dry matter production (1464.91g/m²), number of panicles/m² (267.80 m²), grain yield (52.21q/ha) of rice was observed in C⁵ cropping system and panicle length (23.99 cm), number of grains /panicle (160.05), straw yield (69.58 q/ha) in C⁴ which was significantly superior than C¹ cropping system. Plant height and 1000 grain weight, harvest index and Land Use Efficiency (LUE) were non significantly affected by different cropping systems. Maximum Rice Economic Yield (REY) of 24.26
Keywords: Cropping system; IW/CPE ratio; REY; PE and LUE.

1. INTRODUCTION

Rice based cropping system is most predominant cropping system of Indo Gangetic plain with area of 95.73 lakh hectare and production of 117.47 MT [1]. In northern part of India, Rice is most widely grown crop of kharif season. It is found that around 30% of rice producing area remain fallow in rest of year and 82% of this area found in North East, Chhattisgarh, Jharkhand, Madhya Pradesh, Assam, Bihar, Odisha [2]. Under this situation, Intensification of current agriculture system is important to fulfill the need of current burgeoning population is going on rising in one hand and agricultural fertile land is shrinking on the other hand. Rice is stable crop of kharif season. It is difficult to replace rice in kharif season due to soil, climate and choice of farmers, only option left is rabi and summer season. Therefore, a suitable cropping system needs to be identified which enhances system productivity and profitability. Inclusion of pulses in a cropping system helps to maintain the C:N ratio of soil. Considering this, the present investigation was undertaken to study Effect of Residue Management and Cropping Systems on direct seeded rice and System productivity

2. MATERIALS AND METHODS

A field experiment was carried out during three season of calendar year 2018-19 at RPCAU, Pusa farm situated at 25º 59' north latitudes and 85º 48' east longitudes with an altitudes of 52.92 meter above sea level. The soil of experimental plot was alkaline in nature having initial pH 8.34, EC 0.417 dSm¹, bulk density 1.44 g/cc with low in available nitrogen158.45 kg/ha [4], medium in phosphorous 28.35 kg/ha [5] and potassium 134.56 kg/ha [6]. The experiment was laid out in split plot design with five treatments of cropping system in main plots: C1 - Rice - Wheat - Fallow, C2 - Rice - Wheat - Green Gram, C3 - Rice - Maize – Dhaincha, C4 - Rice - Maize + Potato – Dhaincha, C5 - Rice - Maize + Green Pea – Dhaincha and in sub plots 3 days disappearance of ponded water in kharif season and three level of moisture regimes in rabi season: I1 - IW/CPE = 0.6, I2 - IW/CPE = 0.8, I3 - IW/CPE = 1.0 with three replications. Residues of crops were incorporated after harvest of economical yield. Gross plots of 5x4.2 m² were separated by 1.5 m irrigation channel and one-meter path. Experiment was started from summer season with Green gram and Dhaincha. After harvest of green gram pods green gram residue and dhaincha at 40 days were incorporated into their subsequent plots. Rice variety Sahbhagi was sown on 2 July 2018 by direct seeding methods using seed drill. Crop was raised with recommended package and practices. Recommended dose of fertiliser 120:60:40-25 were applied with 50% nitrogen and full phosphorous potash and ZnSO4 as basal through diammonium phosphate, muriate of potash, and zinc sulphate. Rest 50% nitrogen was applied in
three equal splits at tillering and panicle initiation stage of rice through urea. Weedicide, hand weeding and other plant protection measures were taken as per recommendation. Irrigation was applied as per treatments on the basis of IW:CPE ratio with 6 cm depth of water. Time of irrigation water applied was calculated on the basis of given formula:

\[ t = \frac{AXD}{Q} \]

Where Q is the rate of discharge, A is the area of the plots, D is the depth of irrigation and t is the time of irrigation. Observation of yield and yield attributing characters were recorded at the time of harvesting. Plant height and numbers of tillers were taken from each plots to the selected five sample plants. Dry weight of plants were recorded from sample rows then converted into meter square before sun drying and oven drying at 65±5°C till constant weight is reached. The crop was harvested when 90% of grain were turn into yellow colour and data of grain and straw yield were recorded after sun drying the bundle of grain with straw. After threshing and winnowing grain yield was obtained and straw yield was obtained by subtracting grain yield from biological yield. Residues of rice was incorporated into their plots after taking reading of harvest in Rice - Maize + Green Pea - Dhaincha cropping system and minimum plant height was recorded in Rice - Wheat - Fallow. Numbers of tillers was significantly affected by cropping system with maximum numbers of tillers (273.55/m²) was observed in Rice - Maize + Green Pea - Dhaincha cropping system which was significantly superior to Rice - Wheat – Fallow cropping system but statistically at par with Rice - Wheat - Green Gram, Rice - Maize - Dhaincha, Rice - Maize + Potato – Dhaincha cropping system. The maximum dry matter (1464.91 g/m²) of rice at harvest was observed in Rice - Maize + Green Pea - Dhaincha cropping system which was significantly superior to Rice - Wheat - Fallow cropping system and statistically showing parity with other system. This might be due to previous two leguminous crop which enriched the soil with nutrient and residue incorporation of crop increased the organic content of soil. Thus, improved the nutrient contents of soil.

3.2 Yield and Yield Attributing Characters

Yields attributing characters includes numbers of panicles/m², length of panicles, number of grain/panicles, and 1000 grain weight (Tables 1 and 2). Number of panicles/m², number of grains/panicle and panicle length were significantly affected by cropping system with maximum number of panicles/m² (267.80 m²) was observed in Rice - Maize + Green Pea – Dhaincha but statistically at par with Rice - Wheat - Green Gram, Rice - Maize - Dhaincha, Rice - Maize + Potato – Dhaincha cropping system and number of grains/panicles (160.05) and panicle length (23.99 cm) were observed maximum in Rice - Maize + Potato - Dhaincha cropping system which was significantly superior to Rice - Wheat - Fallow cropping system and statistically at par with other system. Test weight and Harvest Index were non significantly affected by cropping systems. This is because test weight is genetical character and is not influenced by changing any external factors. Grain and straw yields were significantly affected by cropping system with maximum grain (52.21t/ha) and straw (69.58t/ha) yield were observed in Rice - Maize + Green Pea – Dhaincha and Rice - Maize + potato - Dhaincha cropping system which were significantly superior to Rice - Wheat - Fallow cropping system and statistically at par with other system.
Table 1. Growth parameters and yield attributes of rice as affected by different treatments

| Treatments  | Plant height (cm at harvest) | Numbers of tillers/m² | Dry weight of plants (g/m²) at harvest | Number of panicles/m² | Length of panicle (cm) |
|-------------|-------------------------------|-----------------------|----------------------------------------|-----------------------|-----------------------|
| Cropping sequence | 2018-19 | 2018-19 | 2018-19 | 2018-19 | 2018-19 |
| C1          | 108.48 | 237.44 | 1077.20 | 209.1 | 22.31 |
| C2          | 110.81 | 255.77 | 1288.36 | 240.93 | 23.95 |
| C3          | 111.72 | 263.00 | 1460.53 | 263.44 | 23.93 |
| C4          | 111.72 | 263.00 | 1460.53 | 263.44 | 23.99 |
| C5          | 112.26 | 273.55 | 1464.91 | 267.80 | 23.97 |
| S.Em(±)     | 1.71   | 5.53   | 70.81   | 14.50  | 0.37  |
| CD (P=0.05) | NS     | 18.05  | 230.92  | 47.27  | 1.20  |

Moisture Regimes

| Treatments  | Plant height (cm at harvest) | Numbers of tillers/m² | Dry weight of plants (g/m²) at harvest | Number of panicles/m² | Length of panicle (cm) |
|-------------|-------------------------------|-----------------------|----------------------------------------|-----------------------|-----------------------|
| IW:CPE-0.6  | 110.08 | 256.93 | 1274.53 | 243.15 | 23.70 |
| IW:CPE-00.8 | 111.39 | 258.80 | 1300.49 | 242.37 | 23.64 |
| IW:CPE-1.00 | 111.75 | 261.20 | 1428.23 | 245.80 | 23.57 |
| S.Em(±)     | 0.94   | 7.95  | 47.74   | 8.64  | 0.43  |
| CD (P=0.05) | NS     | NS    | NS      | NS    | NS    |

Table 2. Yield attributes and Yield of rice as affected by different treatments

| Treatments  | Number of grains/panicle | 1000-grain weight (g) | Grain yield (q/ha) | Straw yield (q/ha) | Harvest index (%) |
|-------------|--------------------------|-----------------------|--------------------|--------------------|-------------------|
| Cropping sequence | 2018-19 | 2018-19 | 2018-19 | 2018-19 | 2018-19 |
| C1          | 115.80 | 20.97 | 45.57 | 53.12 | 46.34 |
| C2          | 150.19 | 21.00 | 47.33 | 62.71 | 43.11 |
| C3          | 159.42 | 21.29 | 50.17 | 66.34 | 43.18 |
| C4          | 160.05 | 21.38 | 50.99 | 69.58 | 42.60 |
| C5          | 159.90 | 22.04 | 52.21 | 66.41 | 44.07 |
| S.Em(±)     | 7.75   | 0.46  | 1.39  | 2.93  | 1.46  |
| CD (P=0.05) | 25.26  | NS    | 4.54  | 9.55  | NS    |

Moisture Regimes

| Treatments  | Number of grains/panicle | 1000-grain weight (g) | Grain yield (q/ha) | Straw yield (q/ha) | Harvest index (%) |
|-------------|--------------------------|-----------------------|--------------------|--------------------|-------------------|
| IW:CPE-0.6  | 141.90 | 21.23 | 47.97 | 60.56 | 44.52 |
| IW:CPE-00.8 | 148.85 | 21.25 | 48.98 | 63.69 | 43.68 |
| IW:CPE-1.00 | 156.46 | 21.52 | 50.81 | 66.64 | 43.38 |
| S.Em(±)     | 4.56   | 0.39  | 0.81  | 1.73  | 0.72  |
| CD (P=0.05) | 4.56   | NS    | NS    | NS    | NS    |

3.3 System Productivity

Rice Equivalent Yields, Production Efficiency and Land Use Efficiency were significantly affected by cropping systems and moisture regimes. Maximum rice equivalent yield (24,261 t/ha) was observed in Rice - Maize + Potato – Dhaincha cropping system which was significantly superior to Rice - Maize + Green Pea – Dhaincha, Rice - Maize – Dhaincha, Rice - Wheat - Green Gram and minimum REY was observed in Rice - Wheat – Fallow cropping system. This is because rice is base crop in every system, REY was mainly influenced by rabi and summer season crops. In Rice - Maize + Potato – Dhaincha cropping system, higher yield of potato and maize increased the REY [8]. In sub plot treatments maximum REY (15.905 t/ha) was observed in IW: CPE ratio 1.0 which was significantly superior to IW: CPE ratio 0.6 and 0.8. This might be due to more frequent irrigation in rabi season crops which increased the yield of crops and thus the REY [9].
### Table 3. Rice equivalent yield, production efficiency and land use efficiency as by different treatments

| Treatments          | Rice equivalent yield (q/ha) | Production efficiency (kg/ha/day) | Land use efficiency (%) |
|---------------------|------------------------------|----------------------------------|-------------------------|
| Cropping sequence   | 2018-19                      | 2018-19                          | 2018-19                 |
| C1                  | 7.70                         | 30.09                            | 70.13                   |
| C2                  | 11.78                        | 35.38                            | 91.23                   |
| C3                  | 13.81                        | 42.11                            | 89.86                   |
| C4                  | 24.26                        | 73.97                            | 89.86                   |
| C5                  | 18.22                        | 55.57                            | 89.86                   |
| S.Em(±)             | 0.46                         | 1.42                             | 0.00                    |
| CD (P=0.05)         | 1.51                         | 4.64                             | NS                      |
| **Moisture Regimes**|                              |                                  |                         |
| IW:CPE-0.6          | 14.43                        | 45.13                            | 86.19                   |
| IW:CPE-0.08         | 15.13                        | 47.34                            | 86.19                   |
| IW:CPE-1.00         | 15.90                        | 49.81                            | 86.19                   |
| S.Em(±)             | 1.90                         | 0.59                             | 0.00                    |
| CD (P=0.05)         | 0.56                         | 1.73                             | NS                      |

C1 - Rice - Wheat - Fallow, C2 - Rice - Wheat - Green Gram, C3 - Rice - Maize - Dhaincha, C4 - Rice - Maize + Potato - Dhaincha, C5 - Rice - Maize + Green Pea - Dhaincha, IW:CPE – Irrigation water : cumulative pan evaporation

Maximum Production efficiency (73.97 kg/ha/day) was observed in Rice - Maize + Potato – Dhaincha cropping system which was significantly superior to Rice - Maize + Green Pea – Dhaincha, Rice - Maize – Dhaincha, Rice - Wheat - Green Gram and minimum production efficiency was observed in Rice - Wheat – Fallow cropping system. In sub plots maximum production efficiency (49.81kg/ha/day) was observed with IW: CPE ratio 1 which was significantly superior to IW: CPE ratio 0.8 and 0.6. This is because production efficiency is directed related with REY, maximum REY showed maximum production efficiency. Maximum land use efficiency (91.23%) was observed in Rice - Wheat - Green Gram cropping sequence followed by Rice - Maize + Potato – Dhaincha, Rice - Maize + Green Pea – Dhaincha and Rice - Maize – Dhaincha and minimum LUE was observed in Rice - Wheat – Fallow. In sub plot treatments same LUE (86.192%) was observed in all the treatments.

### 4. CONCLUSION

Yield of rice was highest in Rice - Maize + Green Pea – Dhaincha cropping system. Incorporation of leguminous crop in a cropping system improved the nutrient status of soil and thus yield of succeeding crop rice is improved. Rice equivalent yield found maximum in Rice - Maize + Potato – Dhaincha cropping system. Intercropping of maize with potato increased the yield of system.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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