Current Journal of Applied Science and Technology

39(20): 132-137, 2020; Article no.CJAST.60069
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

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.

Article Information

DOI: 10.9734/CJAST/2020/v39i2030832
Editor(s):
(1) Dr. Ogunlade, Clement Adesoji Adeleke University, Nigeria.
Reviewers:
(1) Camila Seno Nascimento, Universidade Estadual Paulista, Brazil.
(2) Fabio Luiz Checchio Mingotte, University Estadual Paulista, Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60069

Original Research Article

Received 24 May 2020
Accepted 30 July 2020
Published 01 August 2020

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: C_1 - Rice - Wheat - Fallow, C_2 - Rice - Wheat - Green Gram, C_3 - Rice - Maize - Dhaincha, C_4 - Rice - Maize + Potato - Dhaincha, C_5 - 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 *rab*i season I_1 - IW/CPE = 0.6, I_2 - IW/CPE = 0.8, I_3 - IW/CPE = 1.0. Maximum number of tillers (273.55/m^2), dry matter production (1464.91g/m^2), number of panicles/m^2 (267.80 m^2), grain yield (52.21q/ha) of rice was observed in C_5 cropping system and panicle length (23.99 cm cm), number of grains /panicle (160.05), straw yield (69.58 q/ha) in C_4 which was significantly superior than C_1 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

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t/ha and Production efficiency (PE) 73.97 kg/ha/day was observed in C_4 which was significantly superior to rest of treatments. In sub plot maximum REY (15.905 t/ha) and PE (49.81 kg/ha/day) were observed in IW/CPE ratio 1 which was significantly superior to IW/CPE ratio 0.6 and 0.8.

Keywords: Cropping system; IW/CPE ratio; REY; PE and LUE.

1. INTRODUCTION

Rice based cropping system is most pre-dominant cropping system of Indo Gangetic plain with area of 95.73lakh hectare and production of 117.47 MT [1]. In northern part of India, Rice is most widely grwn 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 fulfil the need of current burgeoning population is goes 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 need to be identified which enhances system productivity and profitability. Inclusion of pulses and vegetable in system is more remunerative due to continuous increasing demands and more profits. The crop in a cropping system needs to be evaluated on the basis of net profit but on the same time emphasis should be given on soil health.

Conservation agriculture like direct seeded rice needs to b e adopted in place of transplanted rice. It requires less labour, water and time as compared to transplanted rice. It also allows timely sowing of subsequent crops and eliminates the puddling & transplanting process thus can grow in less water and solve the production problems in increasing water scarcity. DSR need 34% of total labour and saves 27 % of total cost of transplanting [3]. Inclusion of pulses in a system improves the soil health by improving its physical, chemical and biological properties by improving soil structure, water stable aggregates, water holding capacity, nutrient content and biological activities of soil. Inclusion of leguminous crop in summer season improves the soil health as well as increases the yield of subsequent *kharif* and *rabi* season crops thus bring sustainability in a system. Leguminous crop are hardy, requiring less moisture and are short duration in nature, requiring less inputs, further have unique characters of nitrogen fixing capacity, enhances the nitrogen content of soil. Residue incorporation in cropping systems restore the organic flow of nutrient in soil and maintaine the C: N ratio of soil. Considering this, the present investigation was under-taken 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 calender 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 dSm^{-1}, bulk density 1.44 g/cc with low in available nitrogen158.45kh/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: C_1 - Rice - Wheat - Fallow, C_2 - Rice - Wheat - Green Gram, C_3 - Rice - Maize – Dhaincha, C_4 - Rice - Maize + Potato – Dhaincha, C_5 - 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: I_1 - IW/CPE = 0.6, I_2 - IW/CPE = 0.8, I_3 - IW/CPE = 1.0 with three replications. Residues of crops were incorporated after harvest of economical yield. Gross plots of 5x4.2 m^2 were separated by 1.5 m irrigation channel and one-meter path. Experiment was started from summer season with Green gram and Dhaincha a. 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 $ZnSO_4$ as basal through diammonium phosphate, muriate of potash, and zinc sulphate. Rest 50% nitrogen was applied in

two 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℃ 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 and subsequent *rabi* season crops were sown. Rice equivalent yield (REY) was calculated by using formula:

$$REY\ (t/ha)\frac{Economicyieldofcrop(t/ha)xpriceofrespectivecrop\ (₹/t)}{pricepertonnesofrice}$$

Minimum support price of 2018-19 was used in calculation of REY. The data collected from the experiment were statistically analysed using ANOVA as suggested by [7].

3. RESULTS AND DISCUSSION

3.1 Growth Characters

The growth of plants was measured in terms of plant height, numbers of tillers and dry matter production which vary significantly under varying cropping systems and non significantly affected by moisture regimes (Table 1). Plant height was non significantly affected by both cropping system and moisture regimes. The maximum plant height (112.26 cm) was observed at 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/m^2) 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/m^2) 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/m^2, length of panicles, numbers of grain/ panicles, and 1000 grain weight (Tables 1 and 2) Number of panicles/m^2, number of grains/panicle and panicle length were significantly affected by cropping system with maximum number of panicles/m^2 (267.80 m^2) 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 grain/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 (52.21q/ha) and straw (69.58q/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**
C_1	108.48	237.44	1077.20	209.1	22.31
C_2	110.81	255.77	1288.36	240.93	23.95
C_3	111.72	263.00	1460.53	263.44	23.95
C_4	111.72	263.00	1460.53	263.44	23.99
C_5	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					
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

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

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**
C_1	115.80	20.97	45.57	53.12	46.34
C_2	150.19	21.00	47.33	62.71	43.11
C_3	159.42	21.29	50.17	66.34	43.18
C_4	160.05	21.38	50.99	69.58	42.60
C_5	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					
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)	NS	NS	NS	NS	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

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-00.8	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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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60069