



Effect of Diversification on System Productivity and Profitability under North Bihar Condition

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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/IJECC/2023/v13i103067

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/106531>

Original Research Article

Received: 11/07/2023

Accepted: 18/09/2023

Published: 25/09/2023

ABSTRACT

A field experiment was conducted during three seasons of 2019-20 at RPCAU, Pusa to evaluate the Effect of Diversification on System Productivity and Profitability under North Bihar Condition. Treatment 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:

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IW/CPE = 0.8, I₃: IW/CPE = 1.0 and one or two irrigation in *zaid* season if required. Maximum rice grain yield (5.36 t/ha) was observed at C₅ cropping system which was significantly superior to C₁ and at par with C₂, C₃ and C₄ cropping system. Maximum Production Efficiency (92.13 kg/ha/day) and Profitability (1156.49 ₹/ha/day) was found at C₄ cropping system which was significantly superior to C₁, C₂, C₃ and C₅ Cropping system. In sub plots maximum Production Efficiency (56.72 kg/ha/day), and Profitability (685.88 ₹/ha/day) was found at I₃ which was significantly superior to I₂ and I₁. Relative Production efficiency was found to be maximum in C₄ (204.36 %) and I₃ (13.58 %) cropping system.

Keywords: Diversification effect; productivity; system productivity; profitability.

1. INTRODUCTION

Rice – Wheat is the most prevalent cropping system on Indo-Gangatic plain of India. In India rice is cultivated in around 463.79 lakh hectare having production of 130.29 million tonnes with average productivity of 2809 kg/ha [1]. Rice is sown by transplanting method and wheat after preparing a fine seed bed with good tillage operation. Transplanting method of rice required more labour and water as compared to direct seeded rice. Direct seeded rice eliminates the nursery raising and transplanting process thus it save a lot of water. Apart from that it also allows the timely sowing of next *rabi* season crop. Transplanting method of sowing along with heavy tillage operation destroy the soil structure and stagnate the production and profitability of the system in long run [2]. Zero tillage wheat along with direct seeded rice is better option over transplanted rice and fine seed bed sowing of wheat in terms of sustainability and productivity.

Current rice- wheat conventional farming system need to be diversified with other cereals, pulses and vegetable which give higher return along with sustainability of the system. Apart from Rice and Wheat, *rabi* maize is also popular in Bihar zone. Its productivity is very high as compared to *khari* maize. Inter cropping of maize with potato and green pea is gaining popularity as it is complementary in nature. Inclusion of leguminous crop in a system is also found to be beneficial as its long root along with nitrogen fixing capacity builds the soil condition. It increases the nitrogen content of soil. It also enhances the microbial population which led to improvements in other nutrient contents of soil too. Incorporation of green biomass into the system increases the organic carbon content of soil which enhances the soil structure, water holding capacity infiltration rate and nutrient availability of soil. It also reduces the nutrient losses by forming chelates and improved the physical, chemical and biological properties of

soil. Therefore the present study was undertaken to identify the suitable cropping system for Bihar in terms of system productivity and profitability.

2. MATERIALS AND METHODS

2.1 Experimental Sites

This experiment was conducted at pusa farm of RPCAU, situated at 25° 59'N, 5° 48'E, with altitudes of 52.92 m above sea level. It is situated at bank of Budhi Gandak River. Climate condition of Pusa is subtropical and sub humid type with an annual rainfall of 1234.7 mm, out of which 89.7 % of total rainfall received during monsoon season from June to September. This zone also received some shower during winter season from December to February. The average temperature of this zone is 19-30 °C with mean maximum and minimum temperature of 35.4 to 36.6°C during April to June and 7.9-10°C during January respectively. Site was under continue rice-wheat system for last five year. Soil of the experimental site had initial pH of 8.34 and EC of 0.417 dSm⁻¹, which show its alkaline nature. The bulk density of the soil was found as 1.44 g/cc. Soil of the experimental site had lower available nitrogen contents (158.45 kg/ha), measured by the alkaline permanganate method [3], medium phosphorous contents (28.35 kg/ha), measured following the Olsen method [4] and medium potassium contents (134.56 kg/ha) as measured by the Flame photometer method [5].

2.2 Experimental Details

The experiment comprised of five cropping systems in main plots and three levels of moisture regimes in sub plots with three replications. Each plot size was of 5x4.2 m² having buffer zone of one meter with one and half meter of irrigation channel. Cropping system consisted of C₁: Rice - Wheat - Fallow, C₂: Rice - Wheat - Green Gram, C₃: Rice - Maize – Dhaincha, C₄: Rice - Maize + Potato – Dhaincha,

C₅: Rice - Maize + Green Pea – Dhaincha. Rice was sown by direct seeded and wheat by zero tillage with residue incorporation after harvest of each crop. In rice, irrigation was applied at 3 days disappearance of ponded water. In *rabi* season irrigation was applied as per the treatments- I₁: IW/CPE = 0.6, I₂: IW/CPE = 0.8, I₃: IW/CPE = 1.0 with 6 cm of water. Management practices were done as per recommendation. Fertilisers were applied to all the crops on soil test basis. Source of nutrients were urea (46 % N), DAP (18% N, 46% P), Muriate of potash (60% K). Other management practices like hand weeding, application of weedicides and different plant protection measures were carried out as per requirement. Crops were harvested manually at their full maturity stage. For comparison between different crops in a sequence, yield of different crops was converted into system productivity.

Production efficiency was calculated by using duration of different crops in a system and yield.

Production efficiency is calculated by dividing the system productivity by total duration of the system and was expressed in kg/ha/day [6].

$$PE \left(\frac{kg}{ha \cdot day} \right) = \frac{\text{Total productivity of system (kg/ha)}}{\text{Duration of the system (day)}}$$

Profitability in terms of net return is computed by using net return and duration of the system.

$$\text{Profitability} \left(\frac{₹}{ha \cdot day} \right) = \frac{\text{Net Return (₹/ha)}}{\text{Duration of the system (day)}}$$

The data collected from the experiment were statistically analysed using ANOVA as suggested by Gomez and Gomez [6].

3. RESULTS AND DISCUSSION

3.1 Rice Grain Yield

Rice grain yield (Table 1) vary significantly with varying cropping system and non-significantly with varying moisture regimes with maximum grain yield was observed in Rice - Maize + Green Pea – Dhaincha (5.36 t/ha) cropping system which was significantly superior to Rice - Wheat – Fallow (4.38) and was statistically at par with Rice - Maize + potato – Dhaincha (5.27 t/ha), Rice - Maize – Dhaincha (5.14 t/ha), and Rice - Wheat - Green Gram (4.93 t/ha) system.

3.2 System Productivity

System productivity includes production efficiency and relative production efficiency, which were presented in Table 1. Maximum production efficiency (92.13 kg/ha/day) was observed in Rice - Maize + Potato – Dhaincha cropping system which was significantly superior to Rice - Maize + Green Pea – Dhaincha (61.94 kg/ha/day), Rice - Maize – Dhaincha (44.76 kg/ha/day), Rice - Wheat - Green Gram (36.99 kg/ha/day) and Rice - Wheat – Fallow (30.27 kg/ha/day) cropping systems. Among the moisture regimes, maximum production efficiency (56.72 kg/ha/day) was observed at 1.0 IW/CPE ratio which was significantly higher than 0.8 IW/CPE ratio (53.34 kg/ha/day) and minimum was in 0.6 (49.60 kg/ha/day) IW/CPE ratio.

Table 1. Rice grain yield, Production Efficiency, Relative Production Efficiency and Profitability as affected by different treatment

Treatments	Rice grain yield (t/ha)	Production Efficiency (kg/ha/day)	Relative Production efficiency (%)	Profitability (₹/ha/day)
Cropping system				
C ₁	4.38	30.27	-	265.71
C ₂	4.93	36.99	22.20	367.72
C ₃	5.14	44.76	47.86	533.21
C ₄	5.27	92.13	204.36	1156.49
C ₅	5.36	61.94	104.62	804.80
S.Em (±)	0.16	1.51		27.42
CD (P=0.05)	0.52	4.91		89.16
Moisture Regimes				
IW:CPE = 0.6	4.88	49.60	-	562.54
IW:CPE = 0.8	5.00	53.34	7.54	628.34
IW:CPE = 1.00	5.16	56.72	13.58	685.88
S.Em (±)	0.10	0.97	-	17.55
CD (P=0.05)	NS	2.85	-	

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 relative production efficiency (204.36 %) was found under Rice - Maize + Potato – Dhaincha cropping system followed by Rice - Maize + Green Pea – Dhaincha (104.62 %), Rice - Maize – Dhaincha (47.86 %) and Rice - Wheat - Green Gram (22.20 %) cropping system. Among the moisture regimes, higher relative production efficiency of 13.58 % was observed under 1.0 IW/CPE ratio (I_3) followed by 7.54 %, recorded under 0.8 IW/CPE ratio (I_2).

3.3 Profitability

Profitability of the system (Table 1). indicate higher profitability (1156.49) was observed under Rice - Maize + Potato – Dhaincha cropping system which was significantly superior to Rice - Maize + Green Pea – Dhaincha (804.80 kg/ha/day), Rice - Maize – Dhaincha (533.21 kg/ha/day) and Rice - Wheat - Green Gram (367.72 kg/ha/day) and Rice - Wheat – Fallow (265.71kg/ha/day) cropping system.

3.4 Discussion

Maximum grain yield was found under Rice - Maize + Green Pea – Dhaincha. This was because rice was succeeded by dhaincha which gave a comparable economical yield in three systems with maximum observed where along with dhaincha, garden pea was taken which improved the physical, chemical and biological properties of the soil leading to more congenial environment for plant growth. Rice yield was found to be non-significant in moisture regimes as equal amount of water was applied to all the treatments.

Maximum production efficiency (92.13 kg/ha/day) recorded under Rice - Maize + Potato - Dhaincha cropping system which was significantly superior to rest of the cropping systems. Significant effect of residue retention was observed in all season crops but the effect was more prominent during *rabi* season crop. This is due to the soil moisture as well as the residues which increased the yield of the winter crops. Maize and potato intercropping have higher yield potential, thus, has high production efficiency. This was in harmony with Nandan et al., [8]. Production efficiency increased with increasing moisture level with the highest of it recorded at 1.0 IW/CPE ratio. This is because production efficiency is directly related to the yield of the crops; higher the yields, higher the production efficiency. Similar findings were observed by Kumari et al., [9,10]

Relative production efficiency shows relative increase in yield of one cropping system over Rice- Wheat fallow, most popular cropping system of Bihar. Maximum relative production efficiency was observed under Rice - Maize + Potato - Dhaincha cropping system. This is because both potato and maize have high yield potential, and inter cropping of potato and maize are complimentary to each other. Under moisture regimes having higher production shows higher production efficiency. IW/CPE ratio of 1.0 recorded maximum relative production efficiency as higher yield obtained in different crops as compared to other levels of moisture regimes.

Maximum profitability was observed under Rice - Maize + Potato - Dhaincha cropping system. Profitability was calculated on the basis of net return. System having potato and maize intercropping has higher net return because of higher production along with higher market price, thus, leading to higher profitability. Among the different moisture levels, 1.0 IW/CPE ratio recorded the maximum profitability. This is because that the moisture level having higher net return has higher profitability.

4. CONCLUSION

The system comprising of potato and maize inter cropping has higher production efficiency, profitability and relative production efficiency. In north zone of Bihar, Rice - Maize + Potato - Dhaincha intercropping system seems good in terms of production and profitability.

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:
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