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

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 - 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 C_5 cropping system which was significantly superior to C_1 and at par with C_2, C_3 and C_4 cropping system. Maximum Production Efficiency (92.13 kg/ha/day) and Profitability (1156.49 ₹ /ha/day) was found at C_4 cropping system which was significantly superior to C_1, C_2, C_3 and C_5 Cropping system. In sub plots maximum Production Efficiency (56.72 kg/ha/day), and Profitability (685.88 ₹ /ha/day) was found at I_3 which was significantly superior to I_2 and I_1. Relative Production efficiency was found to be maximum in C_4 (204.36 %) and I_3 (13.58 %) cropping system.

Key words: Diversification Effect, Productivity, System Productivity, Profitability

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 (Ministry of Agriculture and Farmers Welfare, 2022-2023). 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 (Kumari *et al.*, 2018). Zero tillage wheat along with direct seeded rice 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 kharif 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

UNDER PEER REVIEW

its long root along with nitrogen fixing capacity build the soil condition. It increased the nitrogen content of soil. It also enhances the microbial population which led to improves in other nutrient content of soil. 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. Therefor the present study was undertaken to identify the suitable cropping system for Bihar in terms of system productivity and profitability.

Materials and Methods

Experimental sites

This experiment was conducted at pusa farm of RPCAU, situated at 25º 59'N, 5º 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 ^{0}C with mean maximum and minimum temperature is 35.4 to 36.6 ℃ during April to June and 7.9-10^{0}C during January. Site was under continue rice-wheat system for last five year. Soil of the experimental site have initial pH 8.34, EC 0.417 dSm-1with alkaline in nature. Soil having bulk density 1.44 g/cc with low in available nitrogen158.45kh/ha (Alkaline permanganate method, Subbiah and Asijia, 1954), medium in phosphorous 28.35 kg/ha (Olsen method 1954) and potassium 134.56 kg/ha (Flame photometer method, Jackson, 1967).

Experimental detail

The experiment comprised of five cropping system in main plots and three level of moisture regimes in sub plots in three replications. Each plot size was of 5x4.2 m^2 having buffer zone of one meter with one and half meter of irrigation channel. Cropping system consist of C_1 - Rice - Wheat - Fallow, C_2 - Rice - Wheat - Green Gram, wheat was sown by zero tillage , C_3 - Rice - Maize – Dhaincha, C_4 - Rice - Maize + Potato – Dhaincha, C_5 - Rice - Maize + Green Pea – Dhaincha rice was sown by direct seeded method 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 treatments at: I_1 - IW/CPE = 0.6, I_2 - IW/CPE = 0.8, I_3 - IW/CPE = 1.0 with 6 cm of water. Management practices were done as per recommendation. Fertiliser were applied to all crop 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 weedicides, hand weeding and plant protection measure were taken as per requirement. Crop were harvested manually at their full maturity stage. For comparison between different crop in a sequence, yield of different crop was converted into system productivity.

Production efficiency was calculated by using duration of different crop 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 (Tomar and Tiwari 1990).

UNDER PEER REVIEW

$$PE\ (kg/ha/day)\ \frac{\text{Total productivity of system (kg/ha)}}{duration\ \ of\ the\ system\ \ (day)}$$

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

$$\text{Profitability (₹/ha/day)}\ \frac{Net\ Return\ (₹/ha)}{duration\ \ of\ the\ system\ \ (day)}$$

The data collected from the experiment were statistically analysed using ANOVA as suggested by Gomez and Gomez (1984).

Results and Discussion:

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.

System productivity

System productivity includes production efficiency and relative production efficiency 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) and Rice - Wheat - Green Gram (36.99 kg/ha/day) and Rice - Wheat – Fallow (30.27 kg/ha/day) cropping system. 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 (53.34 kg/ha/day) and minimum was in 0.6 (49.60 kg/ha/day) IW/CPE ratios.

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 %), Rice - Wheat - Green Gram (22.20 %) cropping system. Among the moisture regimes higher relative production efficiency (13.58 %) was observed under 1.0 IW/CPE ratio followed by 0.8 (7.54 %) IW/CPE ratio.

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.

UNDER PEER REVIEW

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-00.8	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	-	

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, IW:CPE – Irrigation water : cumulative pan evaporation.

Discussion

Maximum grain yield was found under Rice - Maize + Green Pea – Dhainch. This was because rice was succeeded by dhaincha which gave a comparable economical yield in three system with maximum observed where alone with dhaincha garden pea was taken which improved the physical, chemical and biological properties of 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 is applied to all treatment.

Maximum production efficiency (92.13 kg/ha/day) 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 soil moisture along with residues which increased the yield of winter crops. Maize and potato intercropping have higher yield potential, thus, have high production efficiency. This was in harmony with (Nandan *et al*., 2018). Production efficiency increased with increasing moisture level with maximum recorded at 1.0 IW/CPE ratio. This is because production efficiency is directly related to yield of the crops, higher the yields higher the production efficiency. Similar finding was observed by (Kumari *et al.*, 2017)

UNDER PEER REVIEW

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 crop as compared to other level of moisture.

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 have higher net return because of higher production along with higher market price thus have higher profitability. In different moisture level 1.0 IW/CPE ratio recorded maximum profitability. This is because moisture level having higher net return have higher profitability.

Conclusion

System having potato and maize inter cropping have higher production efficiency, profitability and relative production efficiency. In north zone of Bihar system Rice - Maize + Potato - Dhaincha intercropping is good in terms of production and profitability.

Reference:

Gomez K, Gomez A. Statistical procedures for agricultural research. New York: John Wiley and Sons, Inc; 1984. 8.

Jackson ML. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi. 1967;498. 7.

Kumari R, Kumar M, Kumar V, Nandan R, Choudhary SK. Effect of irrigation regimes on system productivity and profitability under rice (Oryza sativa)- based cropping sequence. Journal of Pharmacognosy and Phytochemistry sp. 2017;1:1040- 1042.

Kumari, A., Kumar, R., Kumar, V., Kumar, V. and Kumar P. 2018. Effect of moisture regimes and weed management on direct seeded rice. International Journal of Microbiology and Applied Science. 7:1248-1256.

Ministry of agriculture and farmer's welfare; 2019-20. (online) Available:https://www.indian .gov.in

Nandan, R.,Singh, S.S., Kumar, V., Singh, V., Hazra, K.K., Nath, C.P., Malik, R.K., Poonia, S.P.and Solanki, Ch. H. 2018. Crop establishment with conservation tillage and crop residue retention in rice- based cropping systems of Eastern India: yield advantage and economic benefit. *Paddy and Water Environment*. **16**:477–492.

Olsen, S.R., Cole, C.U., Watanable, F.S. and Dean, L.A. 1954. Estimation of available phosphate in soils by extraction with $NaHCO_3$. USDA Circular, 939.

UNDER PEER REVIEW

Subbiah, B.V. and Asija, G. L. 1956. A rapid procedure for assessment of available nitrogen in rice soil. *Current Science* **31**: 196 Subramanian, E., Martin, G. J., Suburayalu, E. and Mohan, R. 2007. Aerobic rice: water saving rice production technology Publications.jwmi.org /pdf/ H042902. Pdf 2007.

Tomar, S.S. and Tiwari, A.S. 1990. Production potential and economic of different cropping sequences. *Indian Journal of Agronomy* **35** (1& 2) : 30-35.

UNDER PEER REVIEW