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CROP DIVERSIFICATION AND LAND CONFIGURATIONS FOR INCREASED PRODUCTIVITY UNDER IRRIGATED RICE- WHEAT SYSTEM

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ABSTRACT

A field experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (India) during year 2014-2015 to intensify and diversify rice-wheat cropping system by inclusion of legumes, cash crops, fodder and vegetables under different land configuration for developing need based bio-intensive cropping system for small land holders of irrigated tarai region of Uttrarakhand. Among the tested diversification options, rice (DSR) - Potato -Cowpea (Grain) was most productive with highest system productivity (30.91 t/ha) followed by Maize + Cowpea+ Sesbania – Vegetable pea + Toria – Groundnut + Mentha (21.35 t/ha) under broad bed system, both being significantly higher than rice-wheat system. These were more efficient in productivity as compared to rice – wheat system (9.67 t/ha) and Rice (TPR) - Vegetable pea – Summer Rice (TPR) (19.78 t/ha) which is most widely adopted cropping pattern of irrigated *tarai* region. Therefore, diversification and land configuration changes helped not only in obtaining better system productivity and profitability but also better efficiency in terms of water and energy savings.

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INTRODUCTION

The rice-wheat is the principal cropping system in south Asian countries that occupies about 13.5 million hectares in the Indo-Gangetic Plains (IGP), of which 10 million hectares are in India. This cropping system is dominant in most Indian states as Punjab, Haryana, Bihar, Uttrakhand, Uttar Pradesh and Madhya Pradesh, and contributes to 75% of the national food grain production (Gupta and Seth 2007). To meet the increasing food demand, the productivity of the rice-wheat cropping system need to increased and continued. Development or adoption of new crop establishment methods, changing management practices and inclusion of new crops in the system may be some of the ways of increasing productivity and resource conservation. Potential agronomic advantages of beds include improved soil structure due to reduced compaction through controlled trafficking, reduced water logging and timely machinery operations due to better surface drainage. Beds also create the opportunity for mechanical weed control and improved fertilizer placement (Singh *et al,* 2002). The diversification and land configuration in the rice-wheat system helps to sustain the productivity, improve soil fertility, conserve water resources and increase the profitability of the system (Hobbs and Morris, 1996 and Tabbal *et al.,* 2002). Sravan and Murthy (2014) reported that Productivity was the highest with bhendi-rice-rice fallow blackgram, while sunnhemp improved both rice and rice fallow blackgram yields and hence sunnhemp -rice-rice fallow blackgram was suggested for North Coastal Zone of Andhra Pradesh. Growing short duration vegetable pea or legumes, potato, corn and mentha etc in rice-wheat system with alteration in planting techniques and land configuration may ameliorate soil fertility and break the cycle of weed and disease complex as against continuous rice-wheat system over extended period of time (Prasad and Nagrajan 2004 and Singh, 2001). Therefore, a field experiment was conducted on intensification of diversified rice – wheat cropping system involving of legumes, cash crops, fodder and vegetables, along with land configuration changes to increase the productivity and profitability of system, and improve, soil fertility, input use efficiency and farmer income.

MATERIALS AND METHODS

A field experiment was conducted in E_2 Block of Norman E. Borlaug Crop Research center, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand (India), during 2014-15. The experiment was laid out in a randomized block Design (RBD) with nine treatment combinations comprising of diversification with different crops and land configuration and planting technique changes viz; Transplanted Rice (TPR), Direct seeded Rice (DSR), Furrow irrigated raised Bed System (FIRBS), Narrow Bed System (NBS) and Broad bed System (BBS). Treatments were T_1 (Rice (TPR) – Wheat – Continue), T_2 (Rice (TPR) - Vegetable pea - Groundnut, T_3 (Rice (DSR) - Vegetable pea - Maize (Grain), T_4 (Rice (DSR) - Potato -Cowpea (Grain), T_5 (Rice (DSR) - Vegetable pea - Maize (cob + fodder), T_6 (Rice (DSR) - Yellow Sarson - Black Gram, T_7 Rice (DSR) (B) + Sesbania (F)- 2:1 (FIRBS

45cm * 30 cm) -Vegetable pea (B) + Toria (F)-2:1 (FIRBS) - Maize (B) (cob + fodder) + Mentha (F) 1:1(FIRBS), T_8 Soybean (B) + Rice (DSR) (F)-2:1 (NBS 60cm * 30 cm) - Wheat + Mentha (3:1) (NBS 60cm * 30 cm) - Continue (NBS 60cm * 30 cm), T_9 Maize (B) (cob + fodder) + Cowpea (B) + Sesbania (F)-2:1:2 (BBF 105cm * 30 cm) - Vegetable pea + Toria-3:1 (BBF) - Groundnut + Mentha-3:1(BBF) in Kharif, Rabi and Summer season respectively and replicated thrice. The crop was sown as per the package of practices recommended for different crops. The fertilizer was applied through NPK mixture (12:32:16), Urea and potassium chloride (MOP) as per requirement of crops. The soil of the experimental site was deep loam in texture having pH of 7.2, EC of 0.18 dS/m, bulk density 1.43 Mg/m^3,and was high in organic carbon (0.82%), low in available N status (260.4 kg ha^{-1}), medium in available phosphorus (18.4 kg P ha^{-1}) and high in available potassium (178 kg K ha^{-1}) content. The crops were irrigated as per need. To compare crop systems, the yield of all crops were changed into rice equivalent on price basis (Verma and Mudgal, 1983). The productivity of different cropping systems was compared by calculating their economic rice equivalent yield (REY) using formula given by Ahlawat and Sharma (1993), where:

$$REY = \frac{\text{Grain yield of test crop (kg ha}^{-1}) \times \text{Grain price of test crop (Rs. kg}^{-1})}{\text{Price of rice grain (Rs.kg}^{-1})}$$

Production-efficiency values in terms of kg/ha/day were worked out by total production in a crop rotation divided by total duration of crop in that rotation.

Statistical analysis

The statistical method described by Panse and Sukhatme (1961) was followed for statistical analysis and interpretation of the experimental results. In order to evaluate the comparative performance of the various treatments, the data were analysed by the technique of analysis of variance described by Fisher (1950). All the tests of significance were made at 5 % level of significance. To judge the significance of difference between two treatments, critical difference (CD) was worked out.

RESULTS AND DISCUSSION

System productivity and Production Efficiency

Among all the treatments, significantly higher total rice equivalent yield was recorded in Rice (DSR)-potato- cowpea (grain) rotation (30.91 t/ha) followed by Maize + Cowpea + Sesbania – Vegetable pea + Toria – Groundnut + Mentha (21.35 t/ha), Rice (TPR) - Vegetable pea – Rice (TPR) under BBF (19.78 t/ha), Rice (DSR) (B) + Sesbania (F)- 2:1 -Vegetable pea (B) + Toria (F)-2:1 - Maize (B) (cob + fodder) + Mentha (F) 1:1 under FIRBS (19.73 t/ha) and Rice (DSR) - Vegetable pea - Maize (cob + fodder) (18.68 t/ha) (Table 1). It may be due to diversification of rice- wheat cropping system with different crops especially legumes which not only increase crop yields and system productivity but also improve soil fertility. Diversification of rice –wheat system along with changes in planting techniques and land configurations increased production efficiency from 40.02 to 219 per cent in Rice (DSR) - Yellow Sarson - Black Gram and Rice (DSR) - Vegetable pea - Maize (cob + fodder) treatments, respectively

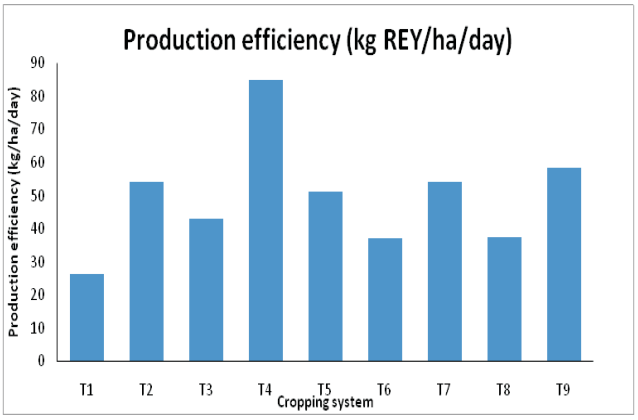

Figure 1: Production efficiency (kg REY/ ha/day) in different cropping systems

Table 1: System productivity of different cropping systems and land configurations.

Treatment	REY (q ha^{-1}) Kharif	Rabi	Summer	System productivity (t REY ha^{-1})
Rice (TPR) – Wheat	42.5	54.23	0.0	9.67
Rice (TPR) - Vegetable pea – Rice (TPR)	44.0	81.86	71.9	19.78
Rice (DSR) – Early Vegetable pea – Late wheat	43.73	113.06	0.0	15.67
Rice (DSR) - Potato -Cowpea (Grain),	42.67	206.61	59.85	30.91
Rice (DSR) - Vegetable pea - Maize (cob + fodder)	45.00	72.55	69.28	18.68
Rice (DSR) - Yellow Sarson - Black Gram	41.87	34.19	59.33	13.54
Rice (DSR) (B) + Sesbania (F)- 2:1 (FIRBS 45cm * 30 cm) -Vegetable pea (B) + Toria (F)-2:1 (FIRBS) - Maize (B) (cob + fodder) + Mentha (F) 1:1(FIRBS)	33.33	67.40	96.57	19.73
Soybean (B) + Rice (DSR) (F)-2:1 (NBS 60cm * 30 cm) - Wheat + Mentha (3:1) (NBS 60cm * 30 cm) - Continue (NBS 60cm * 30 cm Maize (B) (cob + fodder) + Cowpea (B) + Sesbania (F)-2:1:1	60.60	46.91	29.92	13.74
(BBF 105cm * 30 cm) - Vegetable pea + Toria-3:1 (BBF) - Groundnut + Mentha-3:1(BBF)	77.10	75.84	60.60	21.35
CD (p = 0.05)	3.58	4.88	1.88	6.14

Abbreviations used: 1-T: Treatment, 2- TPR: Transplanted rice, 3-DSR: Direct seeded rice 4-B.: On raised bed 5-F: Furrow, 6-FIRB: Furrow raised bed system, 7-NBS: Narrow bed system and 8 -BBF: Broad bed system, 9-SP: System productivity, 10-PE: Production efficiency

(Fig. 1). Similar is confirmed with the finding of different researchers (Jaiswal, 1994; Kharub *et al*., 2003; Chaudhary *et al.,* 2001; Yadav *et al.,* 2005; Mubarak and Singh, 2009; Chatrath and Singh, 2010). Rice-maize was also found to be better option as compared to the rice-wheat system and produced the higher total productivity of around 84.28 qha-1 (Ashok *et al.,* 2015).

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