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Impact of Intercropping on Agronomic Traits of Irrigated Rice

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ABSTRACT: Monocropping is the practise of cultivating the same crop every year which affects production and soil quality because of this, a stationary field experiment was conducted. Ten cropping systems were tested during the Kharif season in a field experiment at JNKVV, Rewa (Madhya Pradesh). The soil had texture silty clay loam, a pH of 7.25, medium levels of organic carbon (0.56%), moderate levels of nitrogen (224 kg/ha), phosphorus (8.20 kg/ha) and high levels of K (315 kg/ha) that was readily available. The most sound grains possible/ panicle were noted in garlic-rice followed by berseem-rice and chickpea-rice cropping systems. Rice produced the most grains 52.76 q/ha in berseem-rice followed by 52.37q/ha potato-wheat-rice and these farming techniques provided 12.5 % to 16.13 % higher grain yield over existing wheat-rice system. These cropping systems availed 15.45 % to 15.97 % higher gross return and 27.1 % to 29.48 % higher net return than existing wheat-rice system. The B: C ratio 2.46 was most in mustard-green manure-rice cropping system followed by 2.42 in potato-wheat-rice and 2.41 in berseem-rice cropping system.

Keywords: Cropping Systems, B: C Ratio, Gross Return and Harvest index.

INTRODUCTION

One of the biggest problems of this century is rooted in agriculture is that the difficulties of providing for the unmet and expanding nutritional needs of the world's increasing the population and repairing environmental harm caused by farming activities at the same time (Foley *et al*., 2011). Most farmers use the principal cropping systems of rice-wheat, rice-chickpeas and rice-lentils due to consistent output and a need for less labour (Kumar et al, 2001). But, Continuous use of such cropping pattern has resulted to the problem of specific weeds, reduced soil fertility in root zone, the emergence of soil disease and an infestation of pests and illnesses of a similar nature which ultimately resulted in decline in the efficiency and productivity of this cropping pattern (Katyal, 2003; Kumar and Yadav 2005).

It is caused by the usage of regional varieties, irregular and uneven rainfall distribution, and extended dry spells throughout the rainy season. Pulses and oil seeds are better introduced into the system than cereal after cereal succession (Umarani *et al*., 1992).

Intercrops, cover crops, catch crops, companion plants, or living mulch crops are examples of non-conventional agricultural approaches and additional guardians of biodiversity can expand capability of soil organic carbon (Poeplau *et al.,* 2015), soil aggregate stability (Rucknagel *et al.,* 2016), water holding and infiltration (Wick *et al.,* 2017); reduce water erosion (Prosdocimi *et al.,* 2016); up the biological (enzymatic) activity of the soil (Piotrowska and Wilczewski 2012), control the soil's CO_2 and N_2O releases and lower the number of weeds and pests in the crop (El-Fakharany *et al.*, 2012). Intercrops can improve nutrient supply and uptake by the current or subsequent crop, as well as prevent nutrient leaching.

Systems of intercropping encourage harmony and minimise conflict between the primary crop and the intercrops for light, moisture and nutrients (Munkholm and Hansen 2012; Hollander *et al.,* 2007) because of how their rivalry affects the main crop's yield and quality.

Involvement of pulses, oilseeds and vegetables in cropping system are more beneficial than cereals after cereals (Kumpawat, 2001). Over the past year, intercropping's perceived worth has seen a significant shift. According to experimental results, intercropping significantly increases yields to sole cropping. These

benefits could be particularly significant because they are achieved not by means of costly input but by simple expedient of growing crops together.

Rice-potato-wheat system made the maximum use of water closely followed by medium duration rice-berseem system. Between rice and wheat, vegetable crops like potatoes and peas grew more organic carbon by 8.9% and 17.1 %, available N by 6.3% and 8.3 %, Olsen, s production by 6.3% and 19%, respectively in soil as compared to rice-wheat sequence (Kharub *et al.*, 2003).

MATERIALS AND METHODS

Experimental site: In JNKVV, the experiment was set up at farm of Kuthulia, COA, Rewa (M.P.). The chosen location served as a good representation of the region's primary rice-growing area in which transplanted rice were grown in kharif followed by wheat, gram, berseem, potato, garlic, toria, mustard, pea and gram + linseed, barley in rabi.

Soil. The soil in the test field has a texture similar to silty clay loam, neutral in reaction (pH 7.25), medium in organic carbon (0.56. %) and low availability of phosphorus and nitrogen and high in potash (315 kg/ha).

Climate and weather conditions. Rewa is situated in North Eastern part of Madhya Pradesh at 24º 30′ North latitude, 81º15′ East longitude and 365.7 meters above mean sea level. The average annual rainfall of the tract is 1140 mm.

Temperature. The highest and lowest temperatures measured during the crop season were 44.14ºC and 11.27ºC in the month of June and December respectively.

Experimental details. The experiment's design used a randomised block layout (RBD) with four replications. The 10 cropping systems (T1-wheat-rice, T2-chickpae-rice, T3-berseem-rice, T4 –potato-wheat-rice, T5-garlic-rice, T6-toria-onion-rice, T7-barley-green manure-rice, T8-pea-wheat-rice, T9-chickpae + linseed-rice, T10-mustard-green manure-rice) were tried. These cropping systems were randomly allocated in each replication. The present experiment was started in the year 2007-08 and same layout has been adopted for current year also. The Treatment information is provided in Table 1.

RESULTS AND DISCUSSION

Ten cropping systems were taken for study

Performance of rice - *Growth parameters*. The growth parameters given in Table 3-5 revealed that plant height, total tillers/hill and leaf area index of rice increased at boosted rate up to 50 DAT thereafter the advancement of plant grown was slow up to harvest stage of rice in general. The number of tillers/hill was least in rice grown after chickpea + linseed followed by barley.

The maximum number of tillers/hill, plant height, leaf area index and other growth character of rice were observed in those treatment in which rice crop was grown after berseem, mustard-green manure, garlic and potato-wheat (Table 3-5). Compared to other cropping methods, these ones provided rice with higher growth and development to existing wheat-rice system. The crops like berseem, mustard, garlic and potato-wheat grown in *Rabi* season have good cumulative and lasting effects on succeeding rice by providing commending soil atmosphere and enhancing the soil fertility by which growth of rice were increase in these cropping system. These findings are in conformity with the findings of Sharma and Jain (1997); Upadhyay *et al*. (2007); Tarwaria and Maurya (2013); Yadav *et al*. (2014).

Yield contributing character of rice. Yield is often thought of as the final phase of the physiological and metabolic activities of plant and is governed by the various factors.

According to the current research, the contributing characters yield Viz. number of productive tillers/m row length, weight of panicle, number of sound grains/panicle and grain yield/panicle have been given in Table 7-8 revealed that when rice started to be grown after Berseem, these characters were superior in rice, potato-wheat, garlic and mustard-green manure by which grain yield per panicle of rice was increased by 8.42 % in mustard-green manure-rice, 10.55 % garlic-rice, 5.04 % in potato-wheat-rice, and 9.17 % in berseem-rice cropping system. Berseem, sunhemp-green manure, pea and gram have some leftover and lingering effect on succeeding rice by which growth of rice was more in berseem-rice, potato-wheat-rice and mustard-green manure-rice cropping systems. The residual effect of preceding *Rabi* crops like berseem, mustard-green manure and potato-wheat on succeeding *rice* was also reported by Sharma and Jain (1997); Tarwaria and Maurya (2013); Yadav *et al*. (2014).

Grain Yield. The rice grain and straw yield in relation to various planting systems have been given in Table 8 revealed that grain yield of rice 52.76 q/ha was maximum in berseem-rice followed by 52.37 q/ha in potato-wheat-rice, 51.9 q/ha in mustard-green manure-rice and 51.11 q/ha in garlic-rice cropping systems. The grain yield in these cropping systems was increased by 12.5 % to 16.13 % as compared to existing system. It might be due to constructive residual effect of preceding *Rabi* crops like berseem, potato-wheat, garlic and mustard-green manure by which growth of rice were increased significantly. The yield contributing character like number of productive tillers/m row length, number of sound grains/panicle and grain yield/panicle were increased significantly as compared to rice grown after wheat. It might result from increased soil fertility by adding organic matter in soil by berseem, sunhemp-green manure and garlic.

Harvest index. The grain yield to total biomass ratio is known as the harvest index (grain + staw) yield as depicted in Table 8.0 revealed that harvest index of rice was maximum in berseem-rice followed by chickpea-rice and barley-green manure-rice. It might be on account of positive residual effect of these cropping systems on sink or yield attributing character of the plant by which grain yield of rice were increase significantly in comparison to straw yield results were confirmed by Pereira *et al*. (2011).

Economics. The performance of various farming systems is directly correlated to their economics of any cropping system and the extra input and output due to different cropping system. The net profit and benefit cost ratio of rice depicted in Table 9.0 revealed that net profit Rs 52015/ha and benefit: cost ratio 2.46 of rice were maximum in mustard-green manure-rice followed by Rs 51317/ha with benefit cost ratio 2.42 in potato-wheat-rice and Rs 51059/ha with benefit: cost ratio 2.41 in berseem-rice cropping system. This is due to the fact that rice's grain and straw yields were recorded in these systems enhanced the total market trading of the produce which increased the net income and benefit cost ratio. Upadhyay *et al.* (2007) reported that rice farming was profitable following berseem. The same results were also reported by Tarwariya and Maurya (2013); Yadav *et al.* (2014).

Table 1: Major cropping sequence with varieties and fertilizer dose.

Treatments		Fertilizers dose NPK kg/ha
T1	Wheat –Rice	K - 120:60:40 R - 120:60:40
T2	Chick pea – Rice	K - 120:60:40 R - 20:60:20
T3	Berseem (fodder + seed) - Rice	K – 120:60:40 R – 20:60:20
T4	Potato-Wheat – Rice	K – 120:60:40 P – 120:100:100 R – 100:60:40
T5	Garlic – Rice	K – 120:60:40 R - 100:75:50
T6	Toria-Onion – Rice	K - 120:60:40 T – 60:30:20 O -120:60:40
T7	Barley-Green manure – Rice	K - 120:60:40 R - 20:60:20
T8	Pea-Wheat – Rice	K – 120:60:40 P - 20:60:20 W-120:60:40
T9	Chickpea + Linseed – Rice	K – 120:60:40 R - 20:60:20
T10	Mustard – Green manure- Rice	K - 120:60:40 R – 120:60:40

Table 2: Average plant population/m^2 under different cropping systems at different stages of rice.

Treatment	Number of hills/m^2 at 10 DAT	Number of hills/ m^2 at harvest
T1 Wheat –Rice	34.50	34.50
T2 Chick pea - Rice	33.50	33.50
T3 Berseem (fodder+seed) - Rice	34.25	34.25
T4 Potato-Wheat - Rice	34.50	34.50
T5 Garlic - Rice	33.75	33.75
T6 Toria-Onion - Rice	33.25	33.25
T7 Barley-Green manure - Rice	34.25	34.25
T8 Pea-Wheat – Rice	33.50	33.50
T9 Chickpea + Linseed - Rice	34.75	34.75
T10 Mustard – Green manure- Rice	34.00	34.00
Sem±	**0.536**	**0.536**
CD at 5%	**NS**	**NS**

Table 3: Average number of tillers/hill of rice under different cropping systems at different stages.

Treatment	Number of tillers/hill		
	25 DAT	**50 DAT**	**75 DAT**
T1 Wheat –Rice	11.30	12.15	12.15
T2 Chick pea - Rice	11.55	12.75	12.75
T3 Berseem (fodder+seed) - Rice	13.30	13.53	13.53
T4 Potato-Wheat - Rice	12.65	13.03	13.03
T5 Garlic - Rice	12.08	13.00	13.00
T6 Toria-Onion - Rice	10.13	11.70	11.70
T7 Barley-Green manure - Rice	10.68	11.31	11.31
T8 Pea-Wheat – Rice	11.25	11.51	11.51
T9 Chickpea + Linseed - Rice	9.85	11.30	11.30
T10 Mustard – Green manure- Rice	12.53	13.10	13.10
Sem±	**0.324**	**0.500**	**0.500**
CD at 5%	**0.941**	**1.450**	**1.450**

Table 4: Average plant height at different stages of rice under different cropping systems.

Treatment	Plant height in cm		
	25 DAT	50 DAT	75 DAT and At harvest
T1 Wheat –Rice	40.75	52.40	55.30
T2 Chick pea - Rice	40.68	51.85	52.80
T3 Berseem (fodder+seed) - Rice	38.83	57.20	58.10
T4 Potato-Wheat - Rice	38.15	56.60	57.20
T5 Garlic - Rice	39.68	55.10	56.85
T6 Toria-Onion - Rice	38.80	54.30	55.35
T7 Barley-Green manure - Rice	38.95	50.10	52.70
T8 Pea-Wheat – Rice	38.50	48.20	50.50
T9 Chickpea + Linseed - Rice	39.63	52.70	54.45
T10 Mustard – Green manure- Rice	38.05	56.45	58.55
Sem±	**0.394**	**0.425**	**0.525**
CD at 5%	**1.144**	**1.232**	**1.50**

Table 5: Average Leaf area index of rice under different cropping systems.

Treatment	Leaf area index	
	50 DAT	75 DAT
T1 Wheat –Rice	5.21	3.51
T2 Chick pea - Rice	4.95	3.25
T3 Berseem (fodder+seed) - Rice	5.70	4.01
T4 Potato-Wheat - Rice	5.57	4.12
T5 Garlic - Rice	5.44	3.94
T6 Toria-Onion - Rice	5.09	3.50
T7 Barley-Green manure - Rice	4.41	3.69
T8 Pea-Wheat – Rice	4.91	3.53
T9 Chickpea + Linseed - Rice	4.59	3.39
T10 Mustard – Green manure- Rice	5.43	3.96
Sem±	**0.268**	**0.138**
CD at 5%	**NS**	**NS**

Table 6: Average number of days of panicle emergence and maturity stage under different cropping systems.

Treatment	Days of panicle emergence		Days of maturity stage
	50%	100%	
T1 Wheat –Rice	51.00	55.25	72.50
T2 Chick pea - Rice	50.25	54.50	72.25
T3 Berseem (fodder+seed) - Rice	51.50	54.75	74.00
T4 Potato-Wheat - Rice	50.75	55.75	71.50
T5 Garlic - Rice	49.50	55.00	73.50
T6 Toria-Onion - Rice	50.75	55.50	73.50
T7 Barley-Green manure - Rice	51.00	53.75	73.00
T8 Pea-Wheat – Rice	47.75	53.50	72.75
T9 Chickpea + Linseed - Rice	49.50	56.25	73.50
T10 Mustard – Green manure- Rice	48.25	56.00	74.25
Sem±	**1.598**	**0.876**	**1.316**
CD at 5%	**3.279**	**1.798**	**NS**

Table 7: Average of different yield attributing characters of rice under various cropping systems.

Treatment	Number of productive tillers/m row at harvest	Number of unproductive tillers/m row at harvest	Panicle length (cm)	Weight of panicle (g)
T1 Wheat –Rice	82.75	7.25	22.55	2.66
T2 Chick pea - Rice	81.50	4.25	22.15	2.70
T3 Berseem (fodder+seed) - Rice	96.50	4.50	23.16	2.92
T4 Potato-Wheat - Rice	94.25	7.25	23.83	2.66
T5 Garlic - Rice	91.00	3.75	23.66	2.89
T6 Toria-Onion - Rice	77.50	8.00	22.41	2.84
T7 Barley-Green manure - Rice	74.50	8.00	23.17	2.66
T8 Pea-Wheat – Rice	82.00	5.75	22.66	2.43
T9 Chickpea + Linseed - Rice	76.00	8.25	22.99	2.64
T10 Mustard – Green manure- Rice	92.00	6.50	23.41	2.52
Sem±	**4.09**	**2.019**	**0.582**	**0.096**
CD at 5%	**11.82**	**5.860**	**NS**	**0.277**

Table 8: Average of different yield attributing characters of rice as influenced by different cropping systems.

Treatment	Number of sound grains/panicle at harvest	Number of chaffy grains/panicle at harvest	Grain yield/panicle(g)	Test weight (g)
T1 Wheat –Rice	91.55(0.00%)	21.20(0.00%)	2.18(0.00%)	23.68
T2 Chick pea - Rice	93.90(2.56%)	22.45(5.89%)	2.33(6.88%)	24.80
T3 Berseem (fodder+seed) - Rice	98.25(7.31%)	26.30(20.05%)	2.38(9.17%)	24.16
T4 Potato-Wheat - Rice	88.55(-3.27%)	20.60(-2.83%)	2.29(5.04%)	25.92
T5 Garlic - Rice	101.25(10.59%)	17.90(-15.56%)	2.41(10.55%)	23.87
T6 Toria-Onion - Rice	87.00(-4.96%)	20.05(-5.42%)	2.22(1.83%)	25.81
T7 Barley-Green manure - Rice	93.55(2.18%)	18.70(11.79%)	2.29(5.04%)	24.42
T8 Pea-Wheat – Rice	86.65(-5.35%)	23.75(12.02%)	2.04(-6.42%)	23.64
T9 Chickpea + Linseed - Rice	85.45(-6.66%)	22.10(4.24%)	2.09(-4.12%)	24.36
T10 Mustard – Green manure- Rice	92.15(0.65%)	23.65(11.55%)	2.36(8.42%)	25.65
Sem±	**5.34**	**2.45**	**0.111**	**1.033**
CD at 5%	**15.45**	**7.09**	**0.326**	**NS**

*Figures in parentheses are per cent increase or decrease (-) over rice-wheat system.

Table 9: Cost of cultivation, gross return, net return and B:C ratio of rice under different cropping systems.

Treatment	Cost of cultivation Rs/ha	Gross return Rs/ha	Net return Rs/ha	B:C ratio
T1 Wheat –Rice	35280	75451 (0.00%)	40171 (0.00%)	2.13 (0.00%)
T2 Chick pea - Rice	35280	75520 (0.09%)	40240 (0.17%)	2.14 (0.46%)
T3 Berseem (fodder+seed) - Rice	36052	87112 (15.45%)	51059 (27.10%)	2.41 (13.14%)
T4 Potato-Wheat - Rice	36052	87370 (15.79%)	51317 (27.74%)	2.42 (13.61%)
T5 Garlic - Rice	36052	85409 (13.19%)	49357 (22.86%)	2.36 (10.79%)
T6 Toria-Onion - Rice	35486	84291 (11.71%)	48804 (21.49%)	2.37 (11.26%)
T7 Barley-Green manure - Rice	35486	72164 (-4.35%)	36677 (-8.69%)	2.03 (-4.69%)
T8 Pea-Wheat – Rice	35280	81727 (8.31%)	46447 (15.62%)	2.31 (8.47%)
T9 Chickpea + Linseed - Rice	36052	74554 (-1.18%)	38501 (-4.15%)	2.06 (-3.78%)
T10 Mustard – Green manure- Rice	35486	87502. (11.49%)	52015 (29.48%)	2.46 (15.49%)

*Figures in parentheses are per cent increase or decrease (-) over rice-wheat system.

CONCLUSION

The rice crop performed superior in berseem-rice, potato-wheat-rice, mustard-green manure-rice and garlic-rice cropping system. These cropping systems provided better growth yield contributing characters and increased the yield of rice by 12.5 % to 16.13 % higher as compared to existing wheat-rice cropping system. Berseem-rice was the best cropping system out of all the others. Additionally, rice crop performed better in potato-wheat-rice system as compared to existing system. Mustard-green manure-rice cropping system gave most net return and benefit cost ratio proceeded by potato-wheat-rice and berseem-rice. The rice crop did better under residual effect of this cropping pattern as compared to existing wheat-rice system.

FUTURE SCOPE

With the intercropping system, crops can be intensified both spatially and temporally to meet future demand. Multiple advantages of intercropping include increased yield, environmental security, production sustainability, and increased ecosystem services.

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