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Effect of irrigation regimes on system productivity and profitability under rice (*Oryza sativa*)- based cropping sequence

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Abstract
A field experiment was conducted during 2012-13 and 2013-14 to find out the most remunerative rice based cropping sequence and moisture regimes for sustainable production on sandy loam soil, low in available N and P and medium in K. REY, net returns and water use efficiency was recorded significantly higher in Rice-maize+potato-sesbania (GM) cropping sequence. Under different moisture regimes IW/CPE ratio of 1.2 recorded significantly higher REY, net returns while moisture regimes did not cause significant difference in water use efficiency.

Keywords: Irrigation regimes, Cropping system, Productivity, Profitability

Introduction
Burgeoning human population on one hand and progressively shrinking per capita agricultural land availability on the other warrants intensive cropping.Traditional cropping system needs to be retailored for the intensification in time and space dimensions as well as in resource management. Efforts should be made to utilize all the available resource to agument productivity in a cropping system. Most of the research in the past was confined to the individual crop but now it has to be realized that the focus should be more on the cropping system. The basic need of farmers is not fulfilled only by cereals. To fulfill the demand of increasing population inclusion of oilseed, pulses and vegetables in rice based cropping sequence was found more beneficial than cereal alone (Kumar *et al*., 2008) [4]. Substitution of cereals with legumes in cropping systems were beneficial (Gangwar *et al*., 2005) [1]. Inclusion of legumes in the cropping system increases soil-fertility status (Upadhyay *et al*., 2011) [8]. In view of these facts, the present experiment was conducted with the objective to study the effect of irrigation regimes on system productivity and profitability under rice (*Oryza sativa*)- based cropping sequence

Methods and materials
Burgeoning human population on one hand and progressively shrinking per capita agricultural land availability on the other warrants intensive cropping. Traditional cropping system needs to be retailored for the intensification in time and space dimensions as well as in resource management. Efforts should be made to utilize all the available resource to agument productivity in a cropping system. Most of the research in the past was confined to the individual crop but now it has to be realized that the focus should be more on the cropping system. The basic need of farmers is not fulfilled only by cereals. To fulfill the demand of increasing population inclusion of oilseed, pulses and vegetables in rice based cropping sequence was found more beneficial than cereal alone (Kumar *et al*., 2008) [4]. Substitution of cereals with legumes in cropping systems were beneficial (Gangwar *et al*., 2005) [1]. Inclusion of legumes in the cropping system increases soil-fertility status (Upadhyay *et al*., 2011) [8]. In view of these facts, the present experiment was conducted with the objective to study the effect of irrigation regimes on system productivity and profitability under rice (*Oryza sativa*)- based cropping sequence.

Methodology
A field experiment was conducted during *kharif, rabi* and summer seasons of 2012-13 and 2013-14 at research farm, Rajendra Agricultural University, Bihar, Pusa (Samastipur). The soil of experimental plot was sandy loam in texture with low in available N and P, and medium in

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K having pH 8.2. The experiment on rice based cropping systems with 3 irrigation levels was laid out in split plot design with three replication. Five rice based cropping sequences [rice-potato-groundnut; rice-potato-cowpea (green pod); rice-potato-greengram; rice-maize+potato-sesbania (GM) and rice-maize+garden pea (green pod)] were assigned to main plots and three irrigation levels (IW/CPE-0.8, IW/CPE-1.0 and IW/CPE-1.2) were allocated to sub plots. Rice was grown under system of rice intensification (SRI) in all the cropping sequences. Cultivation practices were followed as per standard recommendation for each crop. The crop residues of *rabi*/summer season crops were incorporated in to the soil after harvest of the crop. Rice equivalent yield (REY) and economics were calculated considering the prevailing market price of the crop. Water use efficiency (WUE) in kg/ha-cm was worked out by dividing the rice equivalent yield of a system by water requirement of different crops in cropping sequence.

Results and Discussion

Result reveals that among the different cropping sequences rice-maize+potato-sesbania (GM) sequence produced significantly higher rice equivalent yield (281.12 q/ha) as compared to rice-potato-cowpea (225.25 q/ha), rice-maize+garden pea (green pod) (229.75 q/ha) and rice-potato-greengram (231.23 q/ha) cropping sequences but was statistically at par with rice-potato-groundnut (277.47 q/ha) sequence. *Rabi* and *zaid* crops mostly influenced the REY of the systems because rice was the base crop. Besides, higher production potential of potato, maize, and better market price of groundnut were instrumental for attaining higher REY by this sequence. Inclusion of sesbania as green manure crop increased the yield of succeeding rice crop and ultimately productivity of the system. (Sharma *et al*. 2004) [5]. However, the maximum net returns (Rs. 230300/ha) was recorded under rice-maize+potato-sesbania (GM) cropping sequence which

was significantly superior to rice-potato-cowpea (green pod) (Rs. 170400/ha) and rice-potato greengram (Rs. 176274/ha) cropping sequences but was statistically at par with rice-maize+garden pea (green pod) (Rs. 226402/ha) and rice-potato-groundnut (Rs. 221998/ha) cropping sequences.This clearly showed that despite having more input, this sequence also produced maximum net returns. (Kumar *et al*. 2008) [4] also recorded the highest net returns owing to inclusion of vegetable crops in rice-based cropping system. The maximum water use efficiency (229.64 kg/ha-cm) was also recorded with rice-maize+potato-sesbania (GM) cropping sequence which showed superiority over rice-potato-cowpea (green pod) (178.10 kg/ha-cm), rice-maize+garden pea (187.59 kg/ha-cm), rice-potato greengram (195.23 kg/ha-cm) but was statistically at par with rice-potato-groundnut (219.51 kg/ha-cm) cropping sequences might be due to higher REY of this system (Stanhill 1986) and (Singh and Prasad 1991) [6] also documented higher water use efficiency due to higher REY of the systems. Among the different moisture regimes IW/CPE ratio of 1.2 recorded significantly higher REY (256.96 q/ha) as compared to 0.8 IW/CPE ratio (239.32 q/ha) but was statistically at par with 1.0 IW/CPE ratio (250.60 q/ha) this might be due to higher grain production of different crops with higher level of soil moisture. Higher grain yield with higher number of irrigation has been reported by (Singh 2003) [7]. The highest net returns (Rs. 214530 /ha) was also obtained at 1.2 IW/CPE ratio but was found statistically similar with 1.0 IW/CPE ratio (Rs. 207020 /ha) and both, inturn, were significantly superior to 0.8 IW/CPE ratio (Rs. 193674 /ha).Water use efficiency was not influenced by different moisture regimes, though the maximum water use efficiency (204.70 kg/ha-cm) was observed at 0.8 IW/CPE ratio which was closely followed by 1.0 (201.56 kg/ha-cm) and 1.2 (199.77 kg/ha-cm) IW/CPE ratios. (Kumar *et al*. 1999) [3] and (Gupta 1991) [2]

Table 1: Rice equivalent yield (REY), economics of the system and water- use efficiency as affected by different treatment (pooled data of 2 years)

Treatments	REY (q/ha)	Economics of the system Net returns (Rs./ha)	Water- use efficiency (kg/ha-cm)
Cropping sequence			
Rice-potato-groundnut	277.47	221998	219.51
Rice-potato-cowpea (green pod)	225.25	170400	178.10
Rice-potato-greengram	231.23	176274	195.23
Rice-maize+potato-sesbania (GM)	281.12	230300	229.64
Rice-maize+garden pea (green pod)	229.75	226402	187.59
SE m (+)	3.63	4790	3.06
CD (P=0.05)	10.89	14362	9.16
Moisture regimes			
IW/CPE = 0.8	239.32	193674	204.70
IW/CPE = 1.0	250.60	207020	201.56
IW/CPE = 1.2	256.96	214530	199.77
SE m(+)	2.47	3262	2.08
CD (P=0.05)	7.05	9323	NS

GM-Green manure

Conclusion

It can be concluded that rice-maize+potato-sesbania (GM) cropping sequence should be adopted in order to get higher system productivity and profitability. Rice-potato-groundnut and rice-maize+garden pea (green pod) could also be a viable alternative cropping sequence. Irrigation scheduling at IW/CPE ratio of 1.2 in *rabi* and *zaid* crops generated the highest system productivity and net income however, was at par with 1.0 IW/CPE ratio.

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