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Rice based cropping systems for augmentation of productivity and profitability of farmers of Dibrugarh district, Assam

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Abstract
The present field demonstration was conducted for three consecutive years during 2019-20, 2020-21 and 2021-22 under Krishi Vigyan Kendra (AAU), Dibrugarh, Assam, India to assessed four rice-based cropping system under rainfed medium land situation of Dibrugarh district of Assam. The highest land use index (62.74%) was observed in winter Rice-Toria cropping sequence followed by winter Rice-Potato sequence (61.37%). The Rice-Potato cropping sequences provided the most employment generation (316 man days ha^{-1}) followed by winter Rice-blackgram sequence (280 man days ha^{-1}). The highest rice equivalent yield (152.04 q ha^{-1}) was recorded in potato grown during rabi after rice followed by blackgram (75.34 q ha^{-1}). A significant productivity efficiency was found in winter Rice – potato sequence (67.88 kg ha^{-1} day^{-1}), followed by winter Rice–blackgram sequences (34.56 kg ha^{-1} day^{-1}). The economic efficiency was found significant in Rice–potato (770.13 ha^{-1} day^{-1}) followed by winter Rice–blackgram sequences (395.40 ha^{-1} day^{-1}). The maximum gross return (298.27 ha^{-1}) and net return (172.51 ha^{-1}) were observed in case of winter Rice– potato sequence. The highest benefit: cost ratio (1:2.37) was recorded in winter rice-potato sequence. The highest relative economic efficiency over winter rice-fallow was recorded in winter rice-potato (231.58%) followed by winter rice-blackgram cropping sequence (65.68%).

Keywords: Rice, potato, toria, blackgram, cropping system, yield, return

Introduction
Agriculture is the main income source for over 70 percent of the rural population of Assam which contributes about 17 percent of the state domestic product. More than 75 percent farmers are small and marginal having land holding less than 1.0 ha and. Rice in North Easter Region of India grown in varied ecosystems and the predominant cropping sequences are winter rice–fallow where the diversification index is heavily influenced by rice. The predominant cropping systems in Dibrugarh is mainly rice mono-cropping, in few pocket rice-rice, rice-rapeseed (Toria), and rice-vegetables are followed. Besides in farmer's level, productivity and financial benefits act as guiding principles in practicing for a particular crop/cropping system. Therefore, diversification and intensification of cropping system with the proper use of available and irrigation facility can provide higher yield as well as better net returns under the prevailing climatic conditions of Assam (Banjara, *et al*. 2022) [1]. Addition of pulse and oilseed is more beneficial than cereals after cereals in rice based cropping system (Banjara, *et al*. 2021 and Sarkar, 2015) [2, 8]. To replace the rice by any other crop is very difficult during rainy season due to prevailing soil and climatic condition of the region, intensification and diversification of rice-based cropping system can only be the alternative option. Crop like oilseeds and pulses are gaining more attention owing to higher price due to increase market demand. Inclusion of these crops in a sequence, changes the economics of the cropping sequences (Gangwar & Prasad, 2005) [3]. Moreover, double and triple cropping are more focusing points for increasing farmers income in recent years, adoption of cropping systems with efficient crops like pulses, oilseeds and vegetables has great scope to maximized net profit per unit land area. So, keeping in view there is a need of identification of a suitable rice based cropping sequence to enhance the system productivity, profitability and cropping intensity of the region.

Materials and Methods
Over the period 2019-20, 2020-21 and 2021-22 an experiment of three year duration was carried out under KVK, Dibrugarh, Assam to evaluate four rice based cropping sequences

intensified with pulses, oilseeds and tuber crops for enhancing productivity and profitability of farmers. The experiment was composed of three phases covering both kharif, rabi and summer crops, A good agricultural practices was followed to have a good crop by following all recommended packages. The treatments comprised of Four rice based cropping sequences viz. winter rice-Fallow; winter rice-Toria, winter rice-blackgram and Rice- potato. The experiment was laid out in Randomized Block Design (RBD) with five replications. The yields of all the crops in the sequences were converted into rice equivalent yield (REY) for comparison between different cropping systems. The REY of the systems were calculated in terms of winter rice using the formula given by Kumar *et al.* (2019) [6]

$$REY = \Sigma Yi \times Pi / P(p)$$

where, Yi= yield of non rice crops; Pi= price of respective crops and P(p)= price of rice.

Productivity values in terms of $kgha^{-1}day^{-1}$ was calculated by dividing the production of the sequence by 365 days and profitability in terms of Rs. $ha^{-1}day^{-1}$was obtained by dividing net returns of the sequence by total duration of the sequence (Reddy and Suresh, 2009) [10]. The economics and the rice-equivalent yield were computed as per market prices during crop season. Land utilization index (%) was estimated as a percentage of number of days during which the crops in a sequence occupy the main field during a year to the total number of days in a year, i.e., 365 (Gangwar and Prasad, 2005) [4]. Production efficiency (PE) was expressed as the ratio of system productivity in kg/ha rice yield to total duration of the system in days (Gangwar and Prasad, 2005) [4]. The relative economic efficiency (REE) of the system was calculated and expressed in percentage (Chauhan *et al*. 2013) [3].

$$REE = ((B–A)/A) \times 100$$

Where,
A = Net return of existing system
B = Net return of diversified cropping system

In order to compare the treatments, the mean data of three years of experiment were taken and the analysis of variance (ANOVA) technique was carried out. The significance of the treatment effect was determined using F-test at 5% probability level.

Result and Discussion

Land use efficiency and employment generation

The Land use efficiency (%) of all the four cropping sequences are presented in (Table 1) and the highest land use efficiency of 62.74% was observed in rice-toria cropping sequences with greater combined yield followed by rice-potato sequence with 61.37% which had given relatively lower yield due to its longer duration with less return (Chouhan *et al.* 2013) [3]. The rice-potato cropping sequences provided the most employment generation (316 man days ha^{-1}) followed by rice - blackgram sequence (280 man days ha^{-1}).

Rice equivalent yield of cropping system

The average of three years rice equivalent yield ($qtha^{-1}$) of all the cropping system are presented in (Table 2). The highest rice equivalent yield (152.04 qt ha^{-1}) was recorded in potato grown during *rabi* after winter rice followed by blackgram with 75.34 qt ha^{-1}. On the other hand, different rice based cropping sequences significantly influenced the average rice equivalent yield of the system. The highest REY was recorded in rice–potato sequence, followed by winter rice–blackgram as compared to the other cropping sequences.

The effect of different rice-based cropping sequences on productivity efficiency (kg ha^{-1} day^{-1}) and economic efficiency (ha^{-1} day^{-1}) are presented in (Table 2). Data showed that the effect on system productivity efficiency was significant with the highest value in winter rice–potato (67.88 kg ha^{-1} day^{-1}), followed by winter rice–blackgram sequences (34.56 kg ha^{-1} day^{-1}). The economic efficiency was significant with the highest value in winter rice–Potato (770.13 ha^{-1} day^{-1}), followed by winter rice–blackgram sequences (395.40 ha^{-1} day^{-1}). The lowest productivity efficiency was found in winter rice–toria sequence (30.95). The present results is in conformity with the findings of Kalita *et al*., 2015 [5].

Economics of rice-based cropping system

The gross returns, net returns and benefit: cost ratio was significantly affected by rice-based cropping systems (Table-3). The highest gross return (298.27 ^{000}' ha^{-1}) and net return (172.51 ^{000} ha^{-1}) were recorded in case of winter rice–Potato sequence which were significantly superior over all other cropping sequences. This might be owing to higher production of Potato in this sequence. On the other hand, the highest benefit: cost ratio (2.37) was recorded in winter rice-Potato sequence which was statically significant over all other cropping sequences which might be attributed to higher production and more remunerative price of Potato. The relative economic efficiency (REE) was recorded and presented in (Table 3). The highest relative economic efficiency (231.58%) over pre-dominant cropping system winter rice-fallow was recorded in winter rice-Potato sequence followed by 65.68% in winter rice-blackgram. The lowest relative economic efficiency (57.76%) over predominant cropping system winter rice-fallow was recorded in winter rice-toria sequence.

Table 1: System duration and Land use efficiency (%) in different Cropping sequence

Treatments	Cropping sequence		System duration (Days)	Land utilization index (%)	Man days ha^{-1}
	Kharif	Rabi/Summer			
T_1	Rice	Fellow	138	37.81	179
T_2	Rice	Toria	229	62.74	276
T_3	Rice	Blackgram	218	59.73	280
T_4	Rice	Potato	224	61.37	316

Table 2: Different cropping systems with Crop yield, REY and other parameters

Treatments	Mean crop yield (qha^{-1})		Rice Equivalent Yield (REY) (qha^{-1})	Productivity efficiency (kg ha^{-1} day^{-1})	Economic efficiency (Rs ha^{-1} day^{-1})
	Kharif	Rabi			
Rice-Fellow	47.66	-	47.66	34.54	378.45
Rice-Toria	47.44	9.56	70.87	30.95	358.42
Rice- Blackgram	46.91	7.25	75.34	34.56	395.40
Rice-Potato	47.73	85.12	152.04	67.88	770.13
CD (5%)	-	-	5.20	2.92	6.56

Data are the mean of 3 years

Table 3: Economics of different cropping systems

Treatments	Gross cost (000'Rs)	Gross return (000'Rs)	Net return (000'Rs)	B:C ratio	Relative Economic efficiency (%)
Rice-Fellow	45.20	97.23	52.03	2.15	
Rice-Toria	62.50	144.58	82.08	2.31	57.76
Rice-Black gram	67.50	153.69	86.20	2.28	65.68
Rice-Potato	125.76	298.27	172.51	2.37	231.58
CD (5%)	-	4.91	5.81	0.85	-

Data are the mean of 3 years, MSP Rice Rs. 2040/-, Toria Rs. 4000/-Black gram Rs. 8,000 Potato Rs. 2500/- qt^{-1}

Conclusion

It can be concluded that under rainfed condition of Dibrugarh district of Assam the existing rice based monocropping system can effectively be diversified with inclusion of potato and Blachgram during *rabi* season which can act as viable systems in productivity and economical point of view. Among all the tested cropping sequences, winter Rice-Potato is the feasible sequence in terms of both productivity as well as economical point of view followed by winter rice-blackgram sequence.

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