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Identification of Suitable Cropping System for *Terai Zone* of West Bengal under Medium Land Situation

P.S. Patra[1*], A. Sarkar[2], A.S. Ahmad[3], B. Kanjilal[3], A. Hoque[3] and H. Meena[3]

[1]Assistant Professor, Agronomy, Regional Research Station, Terai Zone, Uttar Banga Krishi Viswavidyalaya, P.S- Pundibari, District-Cooch Behar (West Bengal), India.

[2]Professor, Agricultural Economics and Assistant Directorate of Research, Uttar Banga Krishi Viswavidyalaya, P.S- Pundibari, District-Cooch Behar, West Bengal (West Bengal), India.

[3]Research Scholar, Department of Agronomy, Uttar Banga Krishi Viswavidyalaya, P.S- Pundibari, District-Cooch Behar, West Bengal (West Bengal), India.

(Corresponding author: P.S. Patra)*

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ABSTRACT: Continuous adoption of similar kind of cropping system helped in more disease and insect outbreak as a result system productivity and profitability declined day by day. Keeping the above fate in mind a field experiment was conducted during 2015-16, 2016-17 and 2017-18 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar to find out the suitable cropping system for the medium land situation. Treatment comprises of nine cropping systems namely C_1= Jute -Rice-Potato, C_2= Jute -Rice-Bengal Gram, C_3= Jute -Rice-Mustard, C_4= Jute -Rice-Wheat, C_5= Jute -Rice-Lentil, C_6= Groundnut -Rice-Potato, C_7= Maize -Rice-Cabbage, C_8= Okra- Rice-Chili and C_9= Bitter gourd -Rice-Garden pea.

Three years mean data of the experiment showed that Jute -Rice-Potato cropping system recorded 3.97 and 44.60 % higher system productivity over Groundnut -Rice-Potato and Maize -Rice-Cabbage system, while Okra- Rice-Chili and Bitter gourd -Rice-Garden pea system achieved 53.77 and 15.22 % higher rice equivalent yield over Jute -Rice-Potato system. Highest Land Utilization Index of 85.91% was found with Jute -Rice-Bengal Gram and lowest being observed in Groundnut -Rice-Potato system (74.69%). Economic analysis of data clearly indicated that Okra -Rice-Chili system fetched 9.49 % higher net return ha^{-1} over Jute -Rice-Potato system, while Groundnut -Rice-Potato was found most cost-effective system as it gave 23.53%, 31.25%, 52.17 % and 156.10 % higher benefit over Jute -Rice-Potato, Okra- Rice-Chili, Bitter gourd -Rice-Garden pea and Maize -Rice-Cabbage systems respectively.

Keywords: Cropping System, Land Utilization Index, Rice Equivalent Yield, System Productivity and Economics.

INTRODUCTION

Cropping systems of a region are decided by a number of soils and climatic factors which regulate overall agro-ecological setting for nourishment and suitability of a crop or crops for cultivation (Liebhardt *et al*., 1989; Mueller *et al.,* 2002). Cropping system is pondered imperative in mitigating food security, poverty, soil health and for creation of employment (Ahmed *et al.,* 2019; Rahman *et al.,* 2018).

Nevertheless, at farmers' level, potential productivity and monetary benefits act as guiding principles while opting for a particular crop or cropping system. These decisions with respect to choice of crops and cropping systems are further narrowed down under influence of several other forces related to infrastructure facilities which includes irrigation, transport, storage, trade and marketing, post-harvest handling and processing etc., socio-economic factors including financial resource base, land ownership, size and type of land holding, household needs of food, fodder, fuel, fibre and finance, labour availability etc. and technological factors like improved varieties, cultural requirements, mechanization, plant protection, access to information, etc. (Hart, 1984; Harris *et al.,* 1994; Drinkwater *et al.,* 1998; Peterson *et al.,* 1999).

This region generally has a subtropical humid climate with a prolonged rainy season. The rainy season starts from 1st week of May and continues up to last week of September having intermittent, drizzling and occasional heavy rainfall. The average rainfall of this zone varies between 2100 to 3300 mm. The maximum rainfall, *i.e.,* about 80% of the total, is received from south-west monsoon during the rainy months of June to September. The temperature range of this area varies from minimum of 7-8°C to maximum of 24-33.2°C. The average relative humidity of the area at 8.30 am is 58% and 87%, respectively in March and July. The relative humidity at afternoon at 17.30 hr is 48% and 84%, respectively in March and November. As a result, the area as a whole is humid and warm except having a short winter spell during December to February. This varied climatic situation makes the agro-ecological condition more complex and dynamic.

Though the sandy to sandy loam soil of terai region is congenial for cultivation of groundnut, potato, maize, vegetable crops like cabbage, tomato, cauliflower, chilli etc., some soil constraints are there which prevent the farmers from taking some positive outlook about cultivation of this crop. Soil of North Bengal is mostly acidic which aggravates the problem of fixation of phosphorus and lowered availability of micro-nutrients like zinc, boron, molybdenum etc., which leads to improper nodulation and poor yield of number of pulse and oilseed crops under the *fabaceae* family.

Jute-Rice-Potato is the dominating cropping system followed by the majority of farmers. Due to fluctuating market price of Jute and potato farmers often realizes economic loss. Yield of potato is recurrently varied due to unsuitable climatic condition particularly during tuber formation stage and retting of jute become difficult day by day owed to non-availability of water. Keeping the above realities in mind present experiment has been conceptualized to identify suitable cropping systems based on climate, soil and water availability for realizing the potential production levels through efficient use of available resources.

MATERIALS AND METHODS

The experiment were conducted during 2015-16, 2016-17 and 2017-18 in medium land situation at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar to find out the suitable cropping system for this region. Nine cropping system was taken based on the farmers acceptance of the region by keeping rice as a common crop during kharif season.

Soil of the experimental field was sandy loam in texture, slightly acidic having 169.34 kg ha^{-1} available nitrogen, 16.81 kg ha^{-1} available phosphorus and 69.44 kg ha^{-1} available potassium. 10 m × 5 m plot size was maintained. During pre-kharif season of 2015 trail was started with Jute, Maize, Okra, Groundnut & Bitter gourd. Jute was taken as pre-kharif crop in five of the cropping system. All the crops were sown during first week of March except groundnut. Groundnut was sown in the second week of February. After harvesting of pre-kharif crops transplanted rice was taken as kharif crop. Rice variety Parijat was used during 2015 and Nayanmoni were used in the year 2016 & 2017 respectively in the experiment. Kharif rice were transplanted in the second week of July and harvested at the middle of November. After harvesting of kharif rice, rabi crops namely Potato, Bengal gram, Mustard, Wheat, Lentil, Cabbage, Chili& Garden Pea were sown. Standard agro-techniques were followed for all crops. Data related to economic yield were recorded after harvesting of each crop from 50 m^{-2} experimental fields and then converted into tones ha^{-1}. System yield was worked out by adding the yield of component crops. Economic analysis was done based on prevailing market price of the crops and thereafter by totaling the gross returns of the component crop system return was done.

To relate the systems, crop yields were transformed into Jute equivalent yield (JEY) with the economic yield of each crop and their price of output during pre-kharif season and Potato equivalent yield (PEY) during rabi season as majority of farmer took potato as a rabi crop. Land utilization index (LUI), was assessed as a proportion of number of days during which the crops in sequence inhabit the land during a year to the total number of days in a year, *i.e.* 365 (Tomar and Tiwari 1990).

RESULTS AND DISCUSSION

***Crop performance during pre-kharif season*:** Jute was taken as pre-kharif crop in five of the experimental cropping system. Mean yield data of the Maize, Okra, Groundnut and Bitter gourd was converted to Jute Equivalent Yield (JEY) and presented in Table 1. Data clearly showed that okra recorded highest JEY of 14.22 t ha^{-1} followed by bitter gourd (6.27 t ha^{-1}) was solely due to higher productivity as well as better market price compared to other crops. Mean yield of maize (6.11 t ha^{-1}) though higher than jute (3.04 t ha^{-1}) but due to proportionately lower market price of maize compared to jute ultimately recorded lower JEY of 2.67 t ha^{-1}. Lowest JEY of 1.95 t ha^{-1} was recorded by groundnut just due to lower economic yield.

Table 1: Crop yield (t ha^{-1}) of during pre-kharif season of 2015, 2016 and 2017.

Crop	Variety	Yield (t ha^{-1})			Mean yield over three years (t ha^{-1})	JEY (t ha^{-1})
		2015	2016	2017		
Jute	JRO-524	2.98	3.12	3.03	3.04	3.04
Maize	10V10	6.27	5.60	6.45	6.11	2.67
Okra	Arka Anamika	17.55	16.10	16.79	16.81	14.22
Groundnut	TAG-24	1.36	1.40	1.57	1.44	1.95
Bitter gourd	Arka Harit	8.19	7.60	8.75	8.18	6.27

Crop performance during kharif season: Rice was taken as a kharif crop in all the experimental cropping system and grain yield of rice was presented in the Fig 1. From the figure it is clear that yield of rice was differed with the year of experimentation due to varietal change and weather during the growing season.

Lowest yield (3.38 t ha^{-1}) was recorded during 2015 when rice variety Parijat was grown while highest yield of 4.04 t ha^{-1} was achieved during 2017 with rice variety Nayanmoni. Among the variety used in the systems Nayanmoni performed better compared Parijat in both the year 2016 and 2017.

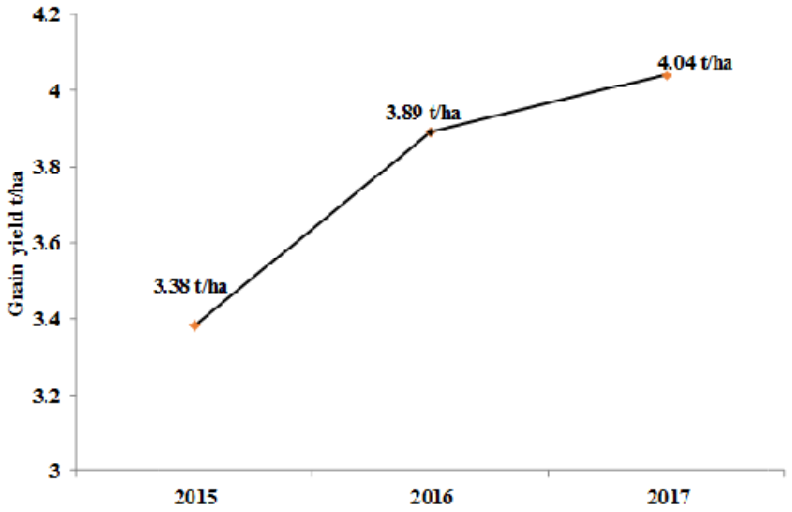

Fig. 1. Yield of kharif rice during the period of experimentation.

Crop performance during Rabi season: During rabi season eight crops were taken namely Potato, Bengal gram, Mustard, Wheat, Lentil, Cabbage, Chilli and Garden pea. Year wise yield and variety used in the experiment was mentioned in the Table 2. As majority of the area during rabi season of the region was occupied by potato and the crop is having highest productivity, therefore all the mean yield data of the other crops were converted to Potato Equivalent Yield (PEY). Highest PEY of 32 t ha^{-1} was obtained from cabbage followed by Garden pea (29.20 t ha^{-1}), chilli (15.09 t ha^{-1}), wheat (9.86 t ha^{-1}), mustard (7.03 t ha^{-1}) and Bengal gram (6.94 t ha^{-1}). Lowest PEY of 5.87 t ha^{-1} was registered by lentil simply due to expressively lowest productivity which could not compensate with higher selling price of the crop.

System Productivity, REY and Land Utilization Index: System productivity, Rice Equivalent Yield (REY) and Land Utilization Index (LEI) was calculated and presented in table. Mean data of three years clearly showed that Jute-Rice-Potato recorded highest system productivity of 41.92 t ha^{-1} followed by Groundnut -Rice-Potato (40.32 t ha^{-1}), C_7= Maize -Rice-Cabbage (28.99 t ha^{-1}) and C_8= Okra-Rice-Chili (24.70 t ha^{-1}) was due to higher productivity of potato. Lowest system productivity of 7.86 t ha^{-1} was noticed in Jute -Rice-Lentil system and that was due to lowest productivity of lentil.

Highest system REY of 41.01 t ha^{-1} was recorded in Okra- Rice-Chili system owing to reasonably higher productivity and better market price of okra and chilli followed by Bitter gourd -Rice-Garden pea (30.73 t ha^{-1}), Jute -Rice-Potato (26.67 t ha^{-1}) and Groundnut -Rice-Potato (24.35 t ha^{-1}). Lowest system REY of 12.97 t ha^{-1} was noticed in Jute -Rice-Lentil system, due to lowest system productivity. Saha *et al.,* (2019) stated 211 to 360% higher REY by two to four based cropping system.

Land Utilization Index clearly determined number of days of a given year; land is occupied by the crops. Highest LUI of 85.91% was found under Jute -Rice-Bengal Gram which was closely followed by Maize -Rice-Cabbage (85.64 %) basically due to higher duration of the component crops in the rice based system. Lowest LUI of 74.69 % was registered by Groundnut -Rice-Potato, due to lees

duration of the component crops. The results are in close lines with the outcomes of Islam *et al.,* (2018).

Economics of cropping system: Success or failure of any system or technology or methods finally depends on their economic feasibility. Economics of the cropping system was calculated based on the prevailing market price and presented in Table 3 and 4. It is apparent from the data that Okra-Rice-Chili cropping system provided the highest mean gross return and net return to the tune of ` 4,10,103 $ha^{-1}$ and `2,52,236.20 respectively simply due to higher system productivity in terms of rice equivalent yield (REY) and better selling price of okra and chilli. Lowest gross return of ` 1,99,083 ha^{-1} was realized under Jute -Rice-Lentil cropping system, while lowest net return to the tune of ₹ 102018.20 was found under Maize -Rice-Cabbage even though it has higher rice equivalent yield over Jute -Rice-Bengal Gram, Jute -Rice-Mustard, Jute -Rice-Wheat, Jute -Rice-Lentil and Groundnut -Rice-Potato due to underprivileged market price of Maize and Cabbage.

Mean highest B:C was registered by Groundnut -Rice-Potato system, simply due to lesser cost of cultivation and higher net return followed by Jute -Rice-Potato (1.70), while lowest B: C ratio of 0.82 was noticed in Maize -Rice-Cabbage system due to lowest net return. Bastia *et al.* (2008) reported an improved economic return with cereal-cereal-pulse system.

Table 2: Yields of rabi crops during crop season 2015-16, 2016-17 & 2017-18.

Crop	Variety	Yield (t ha^{-1})			Mean yield over three years (t ha^{-1})	PEY (t ha^{-1})
		2015	2016	2017		
Potato	Kufripukhraj	37.45	33.0	34.87	35.11	35.11
Bengal Gram	Anuradha (B-39-2)	1.17	1.20	1.26	1.21	6.94
Mustard	NPJ-112	1.32	1.35	1.28	1.32	7.03
Wheat	DBW-14	3.85	4.20	4.51	4.19	9.86
Lentil	WBL-77(Moitree)	1.07	0.95	1.13	1.05	5.87
Cabbage	Pride of India	18.82	19.50	19.02	19.11	32
Chilli	Bhagya Lakshmi	3.92	4.05	4.39	4.12	15.09
Garden Pea	Arkel	4.68	5.2	5.73	5.20	29.20

Table 3: System yield, REY, LUI and cost of cultivation of the cropping system under medium upland situation.

Cropping systems	System yield (t ha^{-1})			Mean System yield (t ha^{-1})	System REY (t ha^{-1})	LUI (%)	Total cost of cultivation (` ha^{-1}) of the system			Mean cost of cultivation (` ha^{-1})
	2015-16	2016-17	2017-18				2015-16	2016-17	2017-18	
C_1	43.81	40.01	41.94	41.92	26.67	74.15	132430.20	135232.45	138130.94	135264.53
C_2	7.53	8.21	8.33	8.02	13.47	85.91	93119.70	96548.70	99867.44	96511.95
C_3	7.68	8.36	8.35	8.13	13.51	80.71	92327.70	95921.70	98582.44	95610.61
C_4	10.21	11.21	11.58	11.00	14.84	79.34	98522.45	101723.20	104244.19	101496.61
C_5	7.43	7.96	8.20	7.86	12.97	79.34	92110.45	96049.70	98809.19	95656.45
C_6	42.19	38.29	40.48	40.32	24.35	74.69	102558.60	104929.25	107301.69	104929.85
C_7	28.47	28.99	29.51	28.99	24.44	85.64	121234.70	124751.00	127939.69	124641.80
C_8	24.85	24.04	25.22	24.70	41.01	78.80	153838.20	157706.00	162057.19	157867.13
C_9	16.25	16.69	18.52	17.15	30.73	75.24	119388.70	123179.00	126883.94	123150.55

C_1= Jute -Rice-Potato, C_2= Jute -Rice-Bengal Gram, C_3= Jute -Rice-Mustard, C_4= Jute -Rice-Wheat, C_5= Jute -Rice-Lentil, C_6= Groundnut -Rice-Potato, C_7= Maize -Rice-Cabbage, C_8= Okra- Rice-Chili and C_9= Bitter gourd -Rice-Garden pea.

Table 4: Economic analysis of the cropping system under medium upland situation.

Cropping Systems	Gross return from the system (` ha^{-1})			Mean	Net return from the system (` ha^{-1})			Mean Net return (` ha^{-1})	B: C ratio of the system			Mean
	2015-16	2016-17	2017-18		2015-16	2016-17	2017-18		2015-16	2016-17	2017-18	
C_1	360620	325540	410740	365633	228189.80	190307.55	272609.06	230368.80	1.72	1.41	1.97	1.70
C_2	182720	210940	223350	205670	89600.30	114391.30	123482.56	109158.05	0.96	1.18	1.24	1.13
C_3	187400	217240	219130	207923	95072.30	121318.30	120547.56	112312.72	1.03	1.26	1.22	1.17
C_4	193670	219340	238810	217273	95147.55	117616.80	134565.81	115776.72	0.97	1.16	1.29	1.14
C_5	181930	202340	212980	199083	89819.55	106290.30	114170.81	103426.89	0.98	1.11	1.16	1.08
C_6	322380	279660	373770	325270	219821.40	174730.75	266468.31	220340.15	2.14	1.67	2.48	2.10
C_7	228720	205260	246000	226660	107485.30	80509.00	118060.31	102018.20	0.89	0.65	0.92	0.82
C_8	401630	437210	391470	410103	247791.80	279504.00	229412.81	252236.20	1.61	1.77	1.42	1.60
C_9	265200	277660	338430	293763	145811.30	154481.00	211546.06	170612.79	1.22	1.25	1.67	1.38

C_1= Jute -Rice-Potato, C_2= Jute -Rice-Bengal Gram, C_3= Jute -Rice-Mustard, C_4= Jute -Rice-Wheat, C_5= Jute -Rice-Lentil, C_6= Groundnut -Rice-Potato, C_7= Maize -Rice-Cabbage, C_8= Okra- Rice-Chili and C_9= Bitter gourd -Rice-Garden pea.

CONCLUSION

It was concluded from the three year experimentation that, inclusion of vegetable crops like okra, chilli, bitter gourd and garden pea in the rice based cropping system augmented system productivity in terms of rice equivalent yield and selection of short duration varieties of the component crops could helped in maintaining proper sowing window and sustainability of the systems. Economic analysis said that Groundnut - Rice-Potato is the most remunerative system of this region for medium land situation, provided that groundnut should be sown within 15th of February as pre kharif crop and short duration rice verities (90-100 days) should be selected.

FUTURE SCOPE

There is a possibility to include more number of short duration high remunerative vegetable crops in the existing cropping system for better system productivity. Therefore, an investigation may be carried out for boosting the system yield and profit with short duration vegetable crops.

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Conflict of interest. None.

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