



## Agro-economic analysis of sustainable cropping patterns in hydric rice fallows of upper Brahmaputra valley, Asom

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### ABSTRACT

Three post rainy season crops, viz. potato (*Solanum tuberosum* L.), pea (*Pisum sativum* L.) and mustard (*Brassica juncea* L.) were evaluated for their economic efficiency for two years (2005-06 to 2006-07) in four hydric rice growing soils under two management levels (farmers' practice and recommended package of practices) in upper Brahmaputra valley of Asom. The farm experimental results recorded tuber yield of 208 q/ha for potato, 9.48 q/ha of grain yield of mustard and 57.5 q/ha of green pod yield of peas under recommended doses with high benefit cost ratio of 2.44 for potato and 2.35 for mustard in *Lahangaon series* (coarse loamy *Aeric Fluvaquents*) as compared to farmer's practice (benefit cost ratio of 1.57 for potato to 1.71 for peas). The performance of potato and peas in rice fallows of Brahmaputra valley was evident in all soils under recommended practices in terms of benefit cost ratio, efficient uptake of NPK and yield.

**Key words:** Agro-economic evaluation, Hydric soils, Rice fallows

Rice-fallow system is not economically viable due to seasonal floods and from year to year depending upon rainfall and available soil moisture (Mishra *et al.* 2004 and Vadivelu *et al.* 2005). In the low-lying areas of Brahmaputra valley, the soils remain wet for long periods; farmers in the region sow the lentil, peas, wheat depending upon the dryness of soil (Razaaque *et al.* 1995) and potato and mustard (Yadav *et al.* 1998). The climatic data revealed that the major constraints for rainfed *rabi* cropping are faster receding residual moisture in fields after rice harvest, soil hardness in the puddled rice fields, lack of short duration varieties of rice that could facilitate timely sowing of *rabi* crops; lack of short-duration drought escaping varieties/seed availability of *rabi* crops; and uncertain *rabi* rainfall. The crops as wheat, potato, cabbage, pea, cowpea, tomato and mustard are recommended for post rainy season by Vadivelu *et al.* (2005). The soils in Brahmaputra valley are mildly acid, coarse textured with stratic layers, deficient in exchangeable Ca, Mg, K, DTPA extractable zinc and available phosphorus (Vadivleu *et al.* 2003 and Bhaskar *et al.* 2010). The economics of rice-potato system in low lands

of Asom were reported as beneficial (Maibangsa *et al.* 2000). The present on farm trials in major soil groups of rice fallows in upper Brahmaputra valley may provide economically viable post rainy season crops from underutilized lands for raising productivity and economic gains to poor farming community in the region.

### MATERIALS AND METHODS

The on farm trials in rice fallows with potato, pea and mustard cropping systems were conducted on four dominant soil series in Jorhat district of Asom namely (Vadivelu *et al.* 2003) (i) *Lahangaon series*, (ii) *Bhogdoi series*, (iii) *Matikhola series* and (iv) *Teok series* (26°49'00"N and 94°14'00" E). The details of soil series is presented in Table 1. The field experiments in randomized block design (RBD) with five replications (Cochran and Cox 1957) were conducted during November 2005 to December 2007 with three crops, viz. potato, pea and mustard under two management levels such as Farmers' practices (FP) and Recommended Package of Practices (RPP). Plot size is 50 m<sup>2</sup> each with a seed rate of 25 q/ha for potato (variety Kufri Megha), 40 kg/ha for peas (Azad 1) and 7 kg/ha for mustard (T 38) due to soil hardness and poor establishment. Post harvested rice fields were ploughed by 3 times and levelled by wooden plank with ridge-furrow spacing of 50 cm and plant to plant spacing of 15 cm. The field for mustard was prepared by ploughing 5 times and by laddering/planking for fine tilth to facilitate the germination of mustard. The recommended dose of N (Urea), P (Single super phosphate) and K (Muriate of potash) was applied @ 60 N: 100 P<sub>2</sub>O<sub>5</sub>:100

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Table 1 Soil – site characteristics of major soil series under study

Soil-site parameters	<i>Lahangaon</i> series	<i>Bhogdoi</i> series	<i>Matikhola</i> series	<i>Teok</i> series
Slope (%)	Very gently (1-3)	Nearly level (0-1)	Nearly level (0-1)	Nearly level (0-1)
Elevation MSL(m)	120	100	90	80
Physiography	Lower piedmont	Gently sloping upland	Very gently sloping plain	Lower flood plain
Sand (%)	54.0	21.03	48.22	42.70
Silt (%)	29.5	45.13	31.28	34.90
Clay (%)	16.5	33.84	20.50	22.40
pH (H <sub>2</sub> O 1: 2.5)	5.5	5.2	5.1	5.0
OC (%)	1.06	0.80	1.26	1.26
CEC	6.0	10.7	12.82	5.28
Base saturation (%)	98.0	55.0	98.00	18.00
Drainage	Poorly drained in rainy season and well drained in winter	Poorly drained in rainy season and well drained in winter, yellow mottled B horizons and sandy-loam Cg horizons	Poorly drained in rainy season and moderately well drained in winter, strong brown mottled B horizons and sandyloam Cg horizons	Poorly drained in rainy season and moderately well drained in winter, strong brown specks on Ap horizons
Soil taxonomy	Coarse loamy, mixed, hyperthermic family of <i>Aeric Fluvaquents</i>	Fine silty, mixed, hyperthermic family of <i>Fluvaquentic Endoaquepts</i>	Fine loamy, mixed, hyperthermic family of <i>Typic Endoaquepts</i>	Coarse silty, mixed, hyperthermic family of <i>Typic Fluvaquents</i>
Water Table	3.5	3.0	(flooding) 1.5	(flooding) 1.00
<i>Soil fertility status kg/ha</i>				
N	264.50	352.80	352.80	423.36
P <sub>2</sub> O <sub>5</sub>	3.23	3.27	3.67	3.09
K <sub>2</sub> O	145.86	165.43	91.37	90.60

K<sub>2</sub>O kg/ha for potato, 20 N: 40 P<sub>2</sub>O<sub>5</sub> 10 K<sub>2</sub>O kg/ha for pea and 60 N : 40 P<sub>2</sub>O<sub>5</sub>;15 K<sub>2</sub>O kg/ha for mustard. Two split doses of N was applied at tuber initiation and bulking stage of potato and flowering initiation and pods/siliquea filling stage in case of pea and mustard, whereas P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O applied as basal dose. No fertilizer, plant protection and intercultural operations were applied in control plot or farmers practice. Crops were sown in 2<sup>nd</sup> week of December. Two intercultural operations have been carried out one at 30 days after sowing and second at 50 days after sowing.

At each site, the yield attributes were recorded and reported. The uptake of NPK for each crop was calculated after determining its concentrations and multiplying with yield. The relative yield was calculated by dividing the difference of yield under recommended practices over farmers' practice with yield under farmers' practice and multiplied by 100. The relative uptake of nutrient (%) was calculated by dividing tuber yield with nutrient uptake and multiplying with 100 (ElSharkawy and Cadavid 2000). The apparent recovery (nutrient uptake under RPP-control/applied fertilizer level), agronomic efficiency (tuber yield under RPP-control/applied fertilizer level); physiological efficiency (total dry matter yield under RPP-control/nutrient uptake under RPP-control) and nutritional consumption efficiency (kg/kg) (physiological efficiency multiplied by apparent recovery) were calculated (Craswell and Godwin 1984 and Mengel and Krikby 1987). Agro-economic analysis was made by calculating potato equivalent yield and benefit-

cost ratio (Gross income/Total cost) as an indicator to summarize the overall value for money (Bashir Khan *et al.* 2011).

## RESULTS AND DISCUSSION

### *Yield attributes*

Soil series wise yield and yield attributes for potato, peas and mustard under two management levels (farmers' practice and recommended packages of practice) were recorded and presented (Table 2). The striking differences in plant height with respect to soil series is observed with maximum plant height of 53.9 cm for potato under RPP in *Lahangaon series* as against farmers' practice with a height of 26.85 cm. The slight difference in height of mustard is recorded in *Lahangaon* (128.6 cm) and *Bhogdai series* (127.90 cm) but distinct variation in *Matikhola* (122.5 cm) and *Teok series* (121.50 cm). Similar trends are recorded for peas with values of 109.5 cm to 105.50 cm under RPP but half of the plant height under farmers' practice recorded.

The number of branches/plant is varied from 35 to 33 for mustard with respect to soil series under RPP with four times reduction in number of branches under farmers' practice. Similar trends for pea and potato are recorded under RPP and farmers' practice. The numbers of branches are low in *Teok/Matikhola* as compared to *Bhogdai/Lahangaon series*. The siliquea numbers are 55 to 49 per plant for mustard, 7 to 8 pods for pea showing slight

Table 2 Yield and yield attributes of *rabi* crops in major soils of Brahmaputra valley (pooled)

Soil series	Crops	Level of management	Plant height (cm)	Branches/ plant	Tuber/pods/ grains/plant (g)	Length of pod/silique (cm)	1000 seed/ tuber weight (g)	Yield (q/ha)	
								Yield	Straw**
<i>Lahangaon</i>	Potato (tuber)	RPP	53.90		217.50*		20885.00	208.00	132.50
		Control	26.85		51.15*		2135.00	58.00	26.70
	Mustard (100seed)	RPP	128.60	35.70	55.85	7.00	4.53	9.48	31.85
		Control	68.10	9.01	16.00	5.20	3.63	4.10	13.80
	Pea (green pod)	RPP	109.50	23.30	7.90	9.30	303.00	57.50	116.60
		Control	62.30	8.70	6.00	6.40	168.00	25.50	54.40
<i>Bhogdoi</i>	Potato	RPP	52.50		181.50*		18410.00	183.00	34.60
		Control	25.75		54.80*		2935.00	62.10	28.25
	Mustard	RPP	127.90	35.90	52.00	6.80	4.00	8.10	27.60
		Control	68.30	8.70	15.70	5.10	3.50	4.10	14.40
	Pea	RPP	108.10	22.40	7.80	9.10	268.00	55.25	111.00
		Control	62.80	9.00	6.15	6.30	195.00	24.30	53.00
<i>Matikhola</i>	Potato	RPP	50.75		110.00*		12275.00	110.00	21.50
		Control	25.10		42.35*		1980.00	48.00	15.35
	Mustard	RPP	122.5	33.60	50.20	6.05	3.80	4.60	16.10
		Control	65.30	8.40	14.70	4.50	2.50	2.50	8.50
	Pea	RPP	107.10	19.05	7.15	8.35	180.00	38.70	81.45
		Control	50.75	7.15	5.35	6.05	98.00	20.70	43.50
<i>Teok</i>	Potato	RPP	49.83		46.00*		9120.00	52.05	9.35
		Control	24.75		40.00*		4005.00	45.45	14.65
	Mustard	RPP	121.50	32.80	48.95	5.90	2.85	0.89	4.00
		Control	64.70	8.30	14.40	4.40	2.50	0.30	1.20
	Pea	RPP	105.50	17.90	7.00	8.20	96.50	33.35	68.30
		Control	50.70	6.75	5.00	5.70	62.50	14.30	31.00

\*Tuber yield, \*\*Straw; Haulm in case of potato, green fodder in case of pea and stover in case of mustard

variations under RPP and farmers' practice whereas tuber weight of potato/plant shows marked differences among soil types (217 g/plant in *Lahangaon* to 46 g/plant in *Teok* series under RPP as against farmers' practice with 51 to 40 g/plant. The tuber weight under RPP is 9 120 g/plant for potato in *Teok* series (4 005 g under farmers practice) to 20 885 g in *Lahangaon* series and 18 410 g in *Bhogdoi* series. The slight differences in test weight of mustard are noticed with values of 2.5 to 4.53 g whereas peas, it varies with 303 g (*Lahangaon* series) to 96.5 g (*Teok* series).

#### Crop yield

The tuber yield of potato varies from 208 q/ha (*Lahangaon* series) to 183 q/ha (*Bhogdoi* series). On similar soils, the pod yield varies from 57.5 and 55.25 q/ha for peas and 9.48 to 8.1 q/ha for mustard due to higher topographic position and well drainage as compared to other soil types in the valley (Table 2). Among crops, the yield of pea is better in *Matikhola* (38.7 q/ha) and *Teok* soil series (33.35 q/ha) despite poor drainage followed by potato (110 and 52.05 q/ha) and mustard (4.90 and 0.89 q/ha). In general, the productivity of *rabi* crops is good in *Lahangaon* series (152.12 q/ha) as compared to *Bhogdoi* (137.7 q/ha), *Matikhola* (87.56 q/ha) and *Teok* series (43.16 q/ha). The haulm yield follows the similar trends potato, peas (fodder)

and (stover) mustard. The stover yield of mustard shows drastic decrease in *Matikhola* (16.1 q/ha under RPP as against 31.85 q/ha in *Lahangaon* series) and 4.0 q/ha in *Teok* series.

The relative yield under RPP shows 258% increase in tuber yield of potato in *Lahangaon* series and straw yield of 396% whereas it is 14.52% of tuber yield in *Teok* series with negative trend of straw yield (-36%). Among soil types, the relative tuber yield is high in *Lahangaon* (289%), but gradually decreases in *Bhogdoi* (242%), *Matikhola* (106%) and negative values in *Teok* series (-2.5%). The results of farm trials strongly support the relevance of soil-site parameters in choosing potato (Vadivelu *et al.* 2005 and Mishra *et al.* 2004). The results further prove that *Lahangaon* and *Bhogdoi* are suitable for potato whereas *Matikhola* and *Teok* series are marginally suitable. The relative yield of mustard and peas is more than 100 in *Lahangaon* and *Teok* series but less than 100 for *Bhogdoi* and *Matikhola* series.

#### Nutrient uptake

The nutrient uptake of potato, peas and mustard under RPP with respect to soil series shows that *Lahangaon* series recorded high uptake of nitrogen on peas (167 kg/ha) and potato (129 kg/ha) with relative increase of 194% (peas) and 102 per cent (potato), with 29.5 kg/ha uptake of

Table 3 Effect of levels of management and soil series on nutrients uptake by *rabi* crops (pooled)

Soil series	Crops	Level of management	Nutrients uptake (kg/ha)			Relative uptake (%)		
			N	P	K	N	P	K
<i>Lahangaon</i>	Potato	RPP	129.0	23.0	145.0	102.2	90.1	90.7
		Control	63.8	12.1	76.0			
	Mustard	RPP	72.7	29.5	196.8	235.0	207.29	1305.7
		Control	21.7	9.6	14.0	0	0	0
	Pea	RPP	167.0	9.7	29.8	1194.5	410.52	319.7
		Control	12.9	1.9	7.1	0	0	0
<i>Bhogdoi</i>	Potato	RPP	120.0	21.0	130.5	75.6	61.5	62.5
		Control	68.3	13.0	80.3	0	0	0
	Mustard	RPP	62.6	25.3	170.5	188.4	163.5	1117.8
		Control	21.7	9.6	14.0	0	0	0
	Pea	RPP	160.0	9.3	28.6	1159.8	57.6	240.4
		Control	12.7	5.9	8.4	0	0	0
<i>Matikhola</i>	Potato	RPP	64.0	13.2	89.6	21.2	37.5	50.5
		Control	52.8	9.6	59.5	0	0	0
	Mustard	RPP	36.0	14.8	99.3	183.4	150.8	1082.1
		Control	12.7	5.9	8.4	0	0	0
	Pea	RPP	112.4	6.3	20.1	912.6	320	286.5
		Control	11.1	1.5	5.2	0	0	0
<i>Teok</i>	Potato	RPP	36.0	8.3	61.0	-28	-8.7	8.1
		Control	50.0	9.1	56.4	0	0	0
	Mustard	RPP	8.1	3.1	24.4	376.4	342.8	2118.1
		Control	1.7	0.7	1.1	0	0	0
	Pea	RPP	96.9	5.6	17.3	1242.1	409.0	343.5
		Control	7.22	1.1	3.9			

phosphorus for mustard and 196.8 kg/ha uptake of potassium (Table 3). The negative trend in uptake of nitrogen and phosphorus in poorly drained *Teok* series indicate serious leaching losses of these elements and advocate for doubling the dosage of NPK under RPP. The optimum doses of N and K for Kufri Jyoti was reported as 220 kg N/ha and 150 kg K<sub>2</sub>O/ha in the alluvial soils of Jalandhar (Grewal *et al.* 1992) while in acid hills of Shimla, the recommended

application rates are 130 kg N/ha and 91 kg K<sub>2</sub>O/ha. According to the results of the experiments presented here, K optimal dose can be further increased, as further positive effects of K were achieved at an application rate of 150 kg K<sub>2</sub>O/ha. Each metric tonne of tubers removes approximately 3.8 kg nitrogen, 0.6 kg phosphorus, and 4.4 kg potassium (Alva *et al.* 2011). In rice-mustard cropping system, application of 100% RDF + FYM @ 5 tonnes/ha and 150%

Table 4 Soil series wise agronomic evaluation of crops

Soil series	Crops	Nutritional consumption efficiency (kg/kg)			Physiological efficiency (kg/kg)	Efficiency of apparent recovery (%)			Agricultural efficiency (kg/kg)
		N	P	K		N	P	K	
<i>Lahangaon</i>	Potato	13.8	0.14	8.8	12.86	1.08	0.11	0.69	57.69
	Mustard	1.10	0.25	2.47	1.35	0.85	0.19	1.82	5.08
	Pea	85.72	0.88	2.55	11.11	7.71	0.08	0.23	53.3
<i>Bhogdoi</i>	Potato	0.89	0.08	0.52	1.04	0.86	0.08	0.50	46.5
	Mustard	0.84	0.19	1.95	1.24	0.68	0.16	1.57	3.77
	Pea	150.39	0.60	4.06	20.32	7.4	0.03	0.20	51.58
<i>Matikhola</i>	Potato	0.68	0.14	1.08	3.62	0.19	0.04	0.30	23.84
	Mustard	0.49	0.11	1.15	1.26	0.39	0.09	0.91	1.98
	Pea	55.76	0.54	1.62	10.82	5.15	0.05	0.15	30
<i>Teok</i>	Potato	1.34	0.05	1.75	5.85	0.23	0.01	0.30	2.54
	Mustard	0.18	0.03	0.52	1.72	0.11	0.02	0.30	0.57
	Pea	57.62	0.64	11.7	12.86	4.48	0.05	0.91	31.75

Table 5 Soil series wise potato equivalent yield (q/ha) and benefit-cost ratio

Soil series	Crops	Level of management	Potato equivalent yield (q/ha)	Benefit-cost ratio
Lahangaon	Potato	RPP	208.00	2.44
		Control	58.00	1.57
	Mustard	RPP	75.84	2.35
		Control	32.80	1.57
	Pea	RPP	172.50	2.03
		Control	76.50	1.57
Bhogdoi	Potato	RPP	183.00	2.43
		Control	62.10	1.72
	Mustard	RPP	64.80	2.27
		Control	32.40	1.71
	Pea	RPP	165.35	2.44
		Control	72.90	1.71
Matikhola	Potato	RPP	110.00	2.10
		Control	48.00	1.58
	Mustard	RPP	36.40	2.00
		Control	20.00	1.58
	Pea	RPP	116.03	2.29
		Control	62.10	1.65
Teok	Potato	RPP	52.05	1.94
		Control	45.45	1.57
	Mustard	RPP	7.08	1.96
		Control	2.40	1.58
	Pea	RPP	100.05	2.24
		Control	42.90	1.58

Note: Potato @ ₹ 300/q, mustard @ ₹ 2400/q, green pea pods @ ₹ 900/q, rice straw, potato haulm, mustard stover and pea fodder @ ₹ 20/q were taken.

RDF were found to be equally effective in terms of yield and nutrient uptake.

#### Agronomic evaluation

Performance indicators for the agronomic evaluation are the grain yield produced per unit N taken up by the plant (kg grain/kg plant N). The data shows that high agronomic efficiency (AE) for potato (57.69 kg/kg) and peas (53.3 kg/kg nutrient) in *Lahangaon* but the efficiency factor for peas shows gradual reduction in *Bhogdai* series (51.58 kg/kg), *Matikhola* series (30 kg/kg) and *Teok* series (31.75 kg/kg). The low agronomic efficiency for mustard is with 5.08 kg/kg in *Lahangaon* and 0.57 kg/kg in *Teok* series (Table 4). The physiological efficiency of peas is good in all types with its values varying from 20.32 kg/kg in *Bhogdai* series to 10.82 kg/kg in *Matikhola*, but low in case of mustard from 1.72 to 1.24 kg/kg. Recovery percent of nitrogen for potato and mustard is more than 1 in *Lahangaon* series whereas 4.48 to 7.71 for peas in all soil types. The recovery per cent for phosphorus and potassium is low except for mustard in *Lahangaon* and *Bhogdai* series. The nutritional consumption efficiency of peas is high in all soil types as

compared to other crops but recorded high in *Bhogdai* series (150 kg/kg of N).

#### Economic evaluation

The potato equivalent yield under RPP is recorded high in *Lahangaon* series (208 q/ha) and *Bhogdai* (183) for potato and high for peas in *Matikhola* (116.03 q/ha) and *Teok* series (100 q/ha). Highest benefit cost ratio (2.44) is recorded with potato in *Lahangaon* series followed by pea (2.35) and mustard (2.03) (Table 5). The results are in agreement with the findings of Maibangsa *et al.* (2000) for maximum rice equivalent yield in rice-potato sequence with high gross returns in rice-fallows of Brahmaputra valley.

The on farm field experimental trials on four dominant soil series of Asom valley with potato, peas and mustard in rice fallows showed adoption of RPP, for *rabi* crops in rice fallows almost doubled the yield and gross income over farmers' practice with significant yield and economic difference in soil sites. The rice-potato system is economically suitable for *Lahangaon* and *Bhogdai* series whereas rice-pea system in *Matikhola* and *Teok* series as compared to the existing rice-mustard system in Brahmaputra valley.

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