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Inclusion of Seed Production in Rice Based Cropping Sequence as a Means for Doubling Farmers' Income

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ABSTRACT: A field experiment was conducted during the year 2020-21 at Laliti village under Dhekargarah Development Block, Jorhat, Assam to study the productivity and profitability of different rice-based cropping systems with medium duration high yielding winter paddy variety TTB 404 (Shraboni) developed by Assam Agricultural University followed by high yielding toria variety TS-38 with special emphasis on seed production towards doubling farmer's income under rainfed, medium land rice ecosystem. Farmers of the area generally practice grain production and thus get low return from sale of their crop. Treatments comprises of three different cropping systems with different crop enterprises. The highest production use efficiency (PUE) (0.23 q/ha/day) and land use efficiency (LUE) (0.61 %) was observed in HYV winter paddy (TTB-404)-HYV of Toria (TS-38) sequence under seed production followed by HYV of winter paddy (TTB-404)- HYV of Toria (TS-38) (PUE- 0.19 q/ha/day & LUE-0.61%) sequence under grain production. However, the highest grain yield in terms of rice grain equivalent yield (84.6 q/ha) was found in HYV of winter paddy (TTB-404)-HYV of Toria (TS-38) sequence under seed production followed by HYV of winter paddy (TTB-404)-HYV of Toria (TS-38) sequence under grain production (70.7 q/ha). The highest gross return, net return and benefit - cost ratio was recorded in winter paddy (TTB-404)-Toria(TS-38) sequence under seed production (Rs. 2,53,860, Rs. 1,63,510 and 2.8) followed by winter paddy (TTB-404)-Toria (TS-38) sequence under grain production(Rs. 70,660.80, Rs. 30,760.80 and 1.8) respectively. Thus, introduction of seed production has increased the farmer's net income from Rs. 30, 760 to 1, 63,510 and contributed towards doubling farmer's income. Inclusion of seed production of HYVs in the cropping sequence is found essential in contributing towards doubling the farmer's income as well as to minimize the gap of quality seed availability.

Keywords: Production use efficiency (PUE), land use efficiency (LUE) HYV Seeds, RGEY, Net Return, Doubling farmers' income.

INTRODUCTION

India is a country where majority of the population are engaged in agriculture, either directly or indirectly. In spite of more than half of the population is dependent on agriculture, almost 20 per cent of the farmers live below the poverty line. As a result, the need to enhance farmers' income has long been felt. In India since 1970s, the continued extension of double cropping system is being promoted to enhanced production (Yang Wen-yuang *et al.*, 1981) which in turn helps in increasing cropping intensity and augmenting farmer's income. Rice-rice system and rice fallows are no longer productive in Southeast Asia. Crop and varietal diversification of the rice based cropping systems with introduction of seed production may improve the productivity and profitability of the systems (Lal *et al.*, 2017). Rice fallows of South Asia accounts for 79% (11.65 m ha) of the total area (15.0 m ha) and rice fallows have a great potential for cultivation of short-duration pulses and oilseed crops. However, very little efforts have been made to efficiently utilize these rice fallows with appropriate technical and developmental back-up. It is expected that nearly 3.0 million hectare area of rice fallows can be brought under cultivation, which can provide about 1.5–2.0 million tones of additional food grain production (MoA. Report of Expert Group on Pulses. Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India, New Delhi; 2013) and help in meeting the increasing demands of pulses and oilseeds as well as doubling farmers income. The growth rates in income of farm households across major states of the country varied from 6.71 per cent to 17.48 per cent. Income doubling time is 8 to 11 years for states like Assam, Bihar, J&K, Jharkhand and West Bengal. However, the lowest real growth rate recorded was less than one per cent in Assam and the highest was 9.81 per cent for Madhya Pradesh (Satyasai and Mehrotra 2016).

In Assam, double cropping is a not a common practice and prevails only in few districts in selected pockets.

Sali (winter) paddy is the main crop of the state and generally grown as monocrop in about 70% of the rice growing areas. Mono-cropping in the farming system decline in farm profit, climate change, and food in security are some of the major concerns that lead to un-sustainability in the agricultural production system (Upadhaya *et al.,* 2022). One of the important factors in increasing crop productivity is the availability of quality seeds. Quality seeds must be made available in sufficient quantity at farmers' doorstep to boost quality production. It is also observed that registered seed growers producing HYV seeds of cereals and oilseeds in Jorhat district is very few although there is a great scope for the seed growers to augment their income level as compare to conventional cropping practices producing food grains only.

High quality improved seed is a pre-requisite to achieve maximum outputs and good returns to farmers. Moreover, it acts as an improved technology in agriculture. Sowing good quality seed leads to lower seed rate, better plant emergence, more uniformity, vigorous early growth, enhanced resistance to pest and disease attack, less weeds, more yield by 5-20%. Indian Seed Industry has played a significant role in seed production of many crops and ensuring the timely availability of seeds to the farmers in order to generate their interest to go for seed production over commercial crop production. Nevertheless, adequate quantity of quality seed at appropriate time and affordable cost needs to be made available to every farmer for bringing about radical change in agricultural scenario in the country and doubling farmers' income (Mandape, 2019).

The Dhekargarah Block under Jorhat district of Assam is mainly dominated by the tribal villages situated on the southern bank of the river Brahmaputra and double cropping is practiced by a handful of farmers. Depending on the season, different crops are being grown on the same field with different cropping sequences. Cropping sequence like winter paddy-*rabi* vegetables-summer vegetables or winter paddy-toria-summer vegetables is commonly found. Although few farmers were practicing double cropping in the locality, the varieties grown were low yielding traditional medium duration farmer rice varieties like *Bas Dhan.* Double cropping has gained its momentum as soon as the concept of doubling farmer's income budded. In the present study rice-based cropping system with high yielding, medium duration variety of winter paddy, TTB 404 (Shraboni) developed by Assam Agricultural University followed by late sown high yielding toria variety TS-38 was undertaken with special emphasis on seed production keeping with a view in contributing towards doubling farmer's income.

MATERIALS AND METHODS

The study was conducted in Laliti Village under Dhekargarah Developmental Blockin Jorhat district, Assam with five numbers of farmer partners in the Longitude-26°47′24.37″N &Latitude - 94°00′17.85″E and they are considered as replications. The field experiment was conducted during *kharif* and *rabi* seasons of 2020-21 in rainfed, medium land rice ecosystem. The textural class of the experimental site was sandy loam with soil pH (5.96), OC (1.03%) and available nitrogen, phosphorus and potassium content was 375.97 kg/ha, 25.46 kg/ha, 71.64 kg/ha respectively. The available S, Zn and B content of the experimental soil was 22.58ppm, 0.62ppm and 0.50 ppm respectively which were sampled before conducting the study. The average rainfall received in the area was 1379.6 mm; mean minimum and maximum temperatures 18.82°C and 28.65°C respectively during the cropping season.

Table1: Basic information about Laliti village.

Parameters	Laliti village	Parameters	Laliti village
Distance from district H.Q (K.M)	22	**Farm mechanization**	
		1. Tractor	2
Total Population	1451	2. Power tiller	4
1. Male	825	3. Irrigation pump	25
2. Female	725	4. Rotavator	2
Tribal population (%)	100	5. Cultivator	2
Population in the age group of 18- 50 years (%)	885	6. Disc Harrow	2
No. of house holds	245	**Major crops grown**	
Average no. of persons/household	6.50	*Kharif*	Winter paddy; Autumn paddy; Summer paddy; Sugarcane; Black gram & Green Gram, *Kharif* vegetables
Occupation		*Rabi*	Toria; Lathyrus; Field pea; Potato; Rabi/Winter Vegetables
1. Agriculture (%)	97.00	Prevailing cropping sequence	1. Winter rice/ Lathyrus (relay) 2.Winter rice/Toria 3.Summer vegetables / Winter rice/winter vegetables 4.Autumn Rice/ kharif pulse 5.Winter rice/ summer rice
2. Service (%)	2.15		
3. Business (%)	0.85		
4. Agril. Laborers (%)	0.00		
Land Holding (ha)			
1. Range	0.75-4.00		
2. Average land holding (ha)	2.15		
Main income source	Agriculture		

Table 2: SWOT analysis of Laliti village.

Strength	Weakness
1. Comparatively larger farm size makes it economical. 2. Large young agricultural work force 3. Existence of good agricultural traditional knowledge and skills among farmers 4. High participation of women in agricultural/animal husbandry/ horticultural/ Sericulture activities 5. Existence of farmer's organizations (FMC/SHG/NGO/ Cooperative society) 6. Shallow water table makes creation of irrigation facility less costly 7. Good network for marketing agricultural produce (Dhekargarah only) 8. Easy accessibility to public institutions, Technical Knowledge, Govt. Assistance 9. Practice of cultivation of green manuring crop (*Sesbania rostrata*) 10. Easy availability of farm labour	1. Age old cultivation practices 2. Lack of skill/ knowledge of the improved farming practices 3. Weariness in adopting new agricultural Technologies 1. Moderate literacy rate create problem in adopting new idea/ technology 2.Various superstition in the society is a hindrance to progress 3. Poor financial capability, difficult in access to credit institution. 4. Lack of coordination among development/extension/ research agencies 5. Lack of support service like seed and planting materials 6. Inadequate irrigation facility, grain storage, cold storage, road and communication, farm electrification etc.
Opportunity	**Threat**
1. Good soil fertility and soil reaction near to neutrality and well drained sandy loam soil suitable for vegetables, pulses and oil seed crop 2. Nearness to markets with good connectivity 3. Possibility of widening the crop species base with high value crops	1. Cultivated land erosion by Brahmaputra river 2. Flood inundation 3. Siltation due to river flood 1. Excessive application of insecticides and pesticides in vegetables 2. No crop rotation makes *rabi* crops susceptible to various disease and pests 3. New generation is not inclined to agriculture

The treatment comprises of 3 (three) treatments *viz*., **T_1:** Seed production of winter paddy (HYV of winter paddy, TTB-404 (Shraboni)) - seed production of Toria (HYV- TS-38), **T_2:** Grain production of winter paddy (HYV- TTB-404 (Shraboni)) - grain production of Toria (HYV- TS-38), **T_3:** Farmers practice (winter paddy local cultivar- *Bas Dhan* - Fallow). The experiment was laid out in randomized block design with five replications considering five participating farmers as replication.

Prior to the start of the experiment extensive benchmark survey (PRA) of the village was conducted to identify the different issues and to recognize the associated strength, weakness, opportunity and threat (SWOT analysis) as perceived by the villagers. Number of participatory tools like- matrix ranking, problem tree analysis, stakeholder analysis, focus group discussion etc. were utilized to record and analyze the information thus gathered. The detail of Participatory Rural Appraisal (PRA) conducted in the Laliti village under Dhekargarah development block is presented in the Table 1 and SWOT analysis in Table 2. The crops included in different sequences were grown with recommended agronomic practices. For preparation of paddy nursery, land was thoroughly puddled and seed beds of 10m length and 1.25m breadth were prepared with 30 cm gap in between the beds. In each seed bed 20-30 kg well decomposed cow dung, 80g urea, 80g SSP and 40g MOP were applied and mixed well with the soil. Well germinated pre treated paddy seeds were sown @ 1 kg per bed. Requirement of seeds for transplanting one hectare of main field is 40 kg. Irrigation water was applied in furrows to maintain saturated condition in the surface soil of the nursery bed and standing water to a depth of 2-3cm were also maintained at least 2-3 days prior to uprooting of the seedlings. Main field was prepared thoroughly by ploughing 4 times followed by harrowing and laddering. Well rotten FYM or compost @ 10t/ha was applied during field preparation. In addition, inorganic fertilizers were applied at rates of N: P_2O_5: K_2O @ 60:20:40 kg/ha in the form of Urea, SSP and MOP. Half of urea and entire quantity of super phosphate and muriate of potash were applied at the time of final puddling. Of the remaining part of urea, half at tillering stage *i.e*. 20-30 days after transplanting and other half at panicle initiation stage was applied. The field was transplanted with 25-31 days old seedlings with a spacing of 20 cm × 15 cm. Two-three seedlings per hill with 4-5cm depth of planting was maintained. Manual weeding with paddy weeder at 20 and 40 days after transplanting and rouging was done.

Table3: Details of different activities and some observation taken during the experiment.

Sr. No.	Parameters	Rice		Toria (TS-38) (Both seed & Grain production)
		TTB-404 (Both seed & Grain production)	*Bas Dhan* (Farmers variety)	
1.	Date of sowing	15.06.20	15.06.2020	05.11.20
2.	Date of transplanting	05.07.20	05.07.2020	-
3.	Date of harvesting	23.10.20	17.10.2020	08.02.2021
4.	Plant ht.(cm)	110.45	97.6	112.85
5.	Effective tiller No	13.27	10.42	-
6.	No of siliqua/ plant	-	-	264.27
7.	Duration (days)	129	123	95
8.	Pest and diseases	Negligible	Negligible	Negligible

For the second crop *i.e.* toria during *rabi* season the field was ploughed 5 times followed by laddering to obtain a fine tilth. Well decomposed FYM @ 2.0 t/ha was applied during field preparation. In addition, N: P_2O_5: K_20 @ 40:35:15 kg/ha was applied as Urea: SSP: MOP @87: 220: 25 kg/ha respectively. Entire quantity of urea, SSP and MOP was applied at the time of final land preparation along with Borax @ 10 kg/ha. Seeds of toria were sown with a seed rate of 10 kg/ha. Details of different activities and some observations are presented in the Table 3. For comparison between crop sequences, the yields of toria were converted into rice grain equivalent yield (RGEY) on prevailing prices (Yadav and Newaj 1990). Land use efficiency (LUE) was calculated by dividing the total duration of crop sequence by 365 and expressed in percentage. Production use efficiency (PUE) value in terms of q/ha/day was obtained by total production in a sequence divided by total duration of crop in that sequence (Tomar and Tiwari 1990). Calculation of economics of paddy and toria was based on the prevailing local market price.

RESULTS AND DISCUSSION

Assessment of performance of cropping sequences under study. Rice based Cropping Sequence *i.e.* Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) under seed production and grain production differed significantly over mono-cropping with local cultivars due to cropping sequence and use of high yielding varieties. Though Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) under grain production(51.6 q/ha) produced highest system productivity over other two sequences but not significantly differed from Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) under seed production which may be due to the adoption of same set of agronomic practices (Table 4). Nath *et al.* (2020) also reported higher net return (Rs 19,490/ha), additional return (Rs. 12,560/ha), benefit cost ratio (2.37) and incremental benefit cost ratio (14.27) were found higher rice-toria sequence as compared to rice alone.

Assessment of Rice Grain Equivalent yield (RGEY). To access the performance of a cropping sequence, crop equivalent yield is an important index. The highest grain yield in terms of rice grain equivalent yield (84.6 q/ha) was obtained in Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under seed production system followed by Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under grain production(70.7 q/ha). The highest RGEY was obtained in Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under seed production (Table 4) due to yield potential and high market value of seeds (Choudhury *et al.,* 2000).

Table 4: Grain yield of individual crops, Rice Grain Equivalent yield of different cropping sequences with respective ventures.

Cropping Sequence	Kharif Season (Winter paddy) crop yield (q/ha)	Rabi Season (Toria) crop yield (q/ha)	Total System Productivity (q/ha)	RGEY (q/ha)
Seed production Winter paddy (TTB-404) – Toria (TS-38)	42.70	8.38	51.10	84.60
Grain production Winter paddy (TTB-404) – Toria (TS-38)	43.16	8.59	51.60	70.70
Farmers Practice Winter paddy (Bas Dhan) -Fallow	31.04	-	31.00	31.00
CD (0.05%)			2.86	3.35

*RGEY = Rice Grain Equivalent yield

Assessment of Biological efficiency of different cropping sequences under study. Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under seed production system obtained the highest production use efficiency (0.23 q/ha/day) followed by Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under grain production (0.19 q/ha/day) which may be higher yield of second crop as well as market price (Table 5). The highest land use efficiency (0.61 %) was in Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under seed production & Winter paddy (HYV- TTB-404)- Toria (HYV- TS-38) sequence under grain production, as these sequences occupied the field for longest period of the year. Deep *et al.* (2018) also reported higher system productivity under different rice based cropping system as compared to mono cropping with rice alone.

Table 5: Biological efficiency of different cropping sequences.

Cropping Sequence	Mean biological efficiency		
	Duration of crop sequence (days)	Production Use Efficiency (q/ha/day)	Land Use Efficiency (%)
Seed production Winter paddy (TTB-404) – Toria (TS-38)	224	0.23	0.61
Grain production Winter paddy (TTB-404) – Toria (TS-38)	224	0.19	0.61
Farmers Practice Winter paddy (Bas Dhan) -Fallow	123	0.09	0.34

Similar results were also reported by Dgagupati *et al.* (2013) in a study on ddiversification of rice (*Oryza sativa*)-based cropping systems for higher productivity, profitability and resource-use efficiency under irrigated ecosystem of Jharkhand and Jat *et al*. (2012) in a study on diversification of rice (*Oryza sativa* L.)-based cropping systems for higher productivity, resource-use efficiency and economic returns in south Gujarat, India.

Economic Assessment of different cropping sequences. Incorporation of higher profit earning enterprise *i.e*. seed production in rice based cropping sequence showed significant difference as compared to the other two sequences in terms of gross cost, gross return, net return and benefit-cost ratios which are presented in Table 6. Winter paddy (HYV- TTB-404) - Toria (HYV- TS-38) sequence under seed production recorded the highest gross return, net return and benefit-cost ratio (Rs. 2, 53,860, Rs. 1, 63,510 and 2.8) followed by winter paddy (HYV- TTB-404) - Toria (HYV- TS-38) sequence under grain production (Rs. 70,660.80, Rs. 30,760.80 and 1.8). Inclusion of seed production and high yielding varieties in the cropping sequence owing to higher net profit which was found essential for doubling the farmers' income as well as to increase the production, productivity of crops and also to minimize the gap of quality seed availability (Ramachandra *et al.,* 2007).

Table 6: Economic assessment of different cropping sequences.

Cropping Sequence	GC (Rs)	GR (Rs/ha)	NR (Rs/ha)	B:C
Seed production Winter paddy (TTB-404) – Toria (TS-38)	90, 348.40	2, 53, 860.00	1,63,510.00	2.8
Grain production Winter paddy (TTB-404) – Toria (TS-38)	39,900.00	70,660.80	30,760.80	1.8
Farmers Practice Winter paddy (Bas Dhan) -Fallow	27,100.00	31,040.00	3,940.00	1.2
CD (0.05)	233.09	6,779.27	6,792.19	0.11

* GC= Gross Cost, GR= Gross Return, NR= Net Return, B: C = GR/GC.

CONCLUSION

Agriculture provides livelihood to more than half of India's population, most of who grow rice as their main crop. The rice production has been increasing but the profit margin needs to be increased further. With the huge potential that the rice market has, seed production can be a source to increasing the income of farmers. From the present study it may be concluded that inclusion of seed production of high yielding varieties (HYVs) in the cropping sequence not only increases the production, productivity of crops but also helps in increasing the farmers income as the higher returns from the seed production leads to higher profit margins and thus can be considered as a source to doubling farmers income.

FUTURE SCOPE

The present study was undertaken in the district of Jorhat, Assam only; such studies may be undertaken in other districts of Assam with different crop combinations with inclusion of seed production for increasing farmers' income towards achieving the goal of doubling farmers' income.

Conflict of Interest. None.

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