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Adaptation of Grass Pea as Sole and Relay Cropping Systems with Transplanted Aman Rice in Sylhet Region of Bangladesh

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Abstract

In Bangladesh, grass pea is generally grown as relay crop in the monsoon rice field but the farmers of Sylhet region are not habituated to grow grass pea as relay crop. Moreover, most of the lands remain fallow during rabi season (winter period) after harvest of monsoon rice due to shortage of soil moisture and lack of irrigation facilities. In this endeavor, for the increasing productivity of crop through the inclusion of grass pea in the rice based cropping system, an experiment was conducted in two locations of Sylhet areas during 2011-12 & 2012-13 for the better adaptation of grass pea through timely sowing and best utilization of existing residual soil moisture. The treatments comprises of T_1: T. aman rice (var. BRRI dhan 33) as sole, T_2: relay of grass pea var. BARI Khesari-1 with T. aman rice; T_3: relay of grass pea var. BARI Khesari-2 with T. aman rice; T_4: BARI Khesari-1 as sole and T_5: BARI Khesari-2 as sole in the present study. The experiment was laid out in a randomized complete block design with three dispersed replications at two different locations. Results revealed that higher rice equivalent yields were recorded at both locations from the two varieties of grass pea as relayed with T. aman rice. The higher economic benefit such as gross return (US$ 1428-1463 ha^{-1}), net return (US$ 880-915 ha^{-1}) and BCR (2.6-2.67) was recorded from relay cropping of grass pea in each location. Through the inclusion of grass pea as relay crop in the rice based cropping system, a vast area of fallow lands of Sylhet region in Bangladesh can be brought under cultivation which also be improved soil health and increased the productivity of crop.

Keywords

Productivity, Relay Cropping, Grass Pea, Rice Equivalent Yield, Economic Benefit, Fallow Land Utilization

1. Introduction

Grass pea (*Lathyrussativus* L.) is one of the hardiest pulses suitable for relay cropping with paddy rice [1]. It has potential among grain legumes for its tolerance to harsh conditions and its adaptability to unfavorable environments with little disease or insect problems. Grass pea has been grown as a cover crop, generally cultivating towards the end of the monsoon rice harvest. This system exploits the ability of grass pea to grow in swampy conditions but also, its drought tolerance, utilizing residual moisture in the paddy fields and growing to maturity during the dry season [2]. Grass pea ranks first among the pulses in respect of area and production in Bangladesh. It covered about 38 per cent of the total cultivated area of pulses and 40 per cent of the total production of pulses in Bangladesh [3]. It requires no major input costs and is easy to cultivate under relay cropping system with paddy rice and also a cheap source of protein and fodder. In addition to nutritional benefits, grass pea has an important role for improving soil fertility by adding around 67 kg ha-1 of nitrogen through biological nitrogen fixation in a single season, thereby conferring yield and protein benefits for the subsequent non-legume crop [4]. Incorporation of leguminous forages in the soil has been reported to increase soil fertility in terms of OM and nitrogen [5].

In Sylhet region, vast areas of lands remain fallow during *Rabi* season in each year because, soil moisture goes down quickly after harvest of T. aman rice and due to lack of irrigation facilities [6]-[7], under the present circumstances, the system of single and double cropping has failed to address the fallow land utilization along with domestic needs of small

growers to sustain their normal livings from their limited land, water and economic resources [8]. In this context, appropriate and more efficient cropping system (inter/relay cropping), which may ensure proper utilization of resources towards increased production per unit area and time on a sustainable basis [9]. Relay cropping is an ancient and traditional agronomic practice has been recognized as a potentially benefitted technology to provide more remuneration to the farmers instead of sole crops [10]. Fallow-T. aus-T. aman rice is the dominant cropping pattern under rainfed condition in this region. The delayed transplantation of aus rice due to dependence on rainfall and usually transplanting is done in early May. This delayed transplantation of aus rice, hampered the timely cultivation of subsequent T. aman rice and resulting delay sowing of *Rabi* crops. So, introduce of short duration rice followed by relay cropping system with grass pea can bring fallow land under cultivation. Henceforth, an experiment was undertaken to inclusion of grass pea in the transplanted aman rice field as a relay crops to ensure higher productivity of pulses, also to assure soil health improvement for sustainable crop production and breaking mono crop culture in Sylhet region of Bangladesh.

2. Materials and Methods

2.1. Experimental Locations

An on-farm study was conducted on grass pea relay cropping with transplanted aman (T. aman) rice in Sylhet district, Bangladesh during *Rabi* season for two consecutive years (2011-2012 & 2012-2013) under agro ecological zone of AEZ 20. The experimental locations based on sandy clay loam soil at farming system research and development (FSRD) site, Jalalpur and multi location testing (MLT) site, Zakigonj. The experimental locations are located at Latitude 24° 53' 48N and Longitude 91° 52' 18E and on an altitude of 10 meters.

2.2. Weather Data

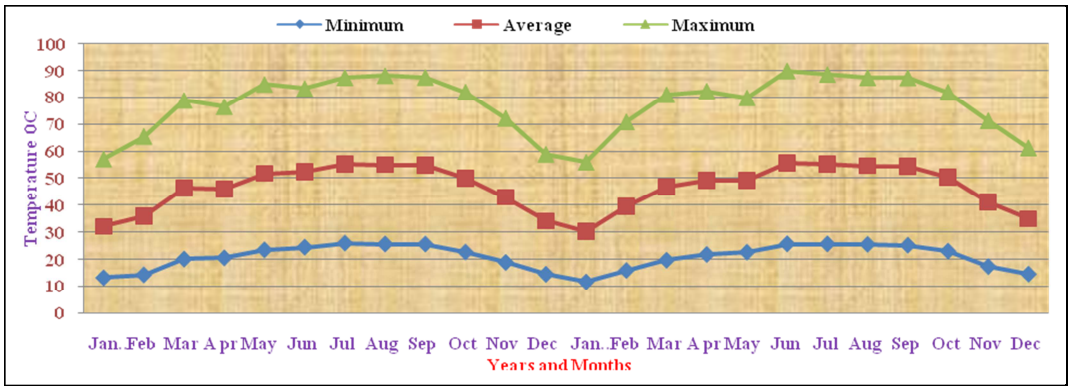


Fig. 1. *Minimum, maximum and mean temperatures (°C) pattern in Sylhet of Bangladesh.*

As indicated in Fig. 2, rainfall of the area is uni-modal, usually occurring during April to October, and total annual rainfall reached to 4217 mm; whereas in December no rain at all and the lowest amount of rainfall occurred in January followed by February. However, in rest of the months total rainfall was ranged from 100 to just below 800 mm. Rainfall increased gradually from the month of May and continued up to September.

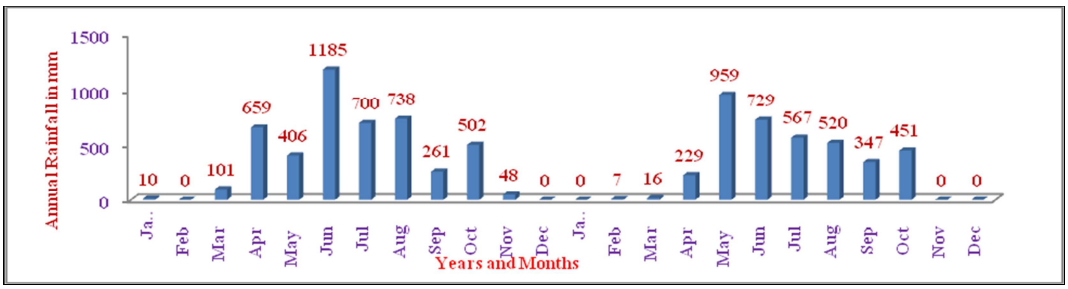


Fig. 2. *Annual rainfall (mm) pattern in Sylhet of Bangladesh.*

2.3. Treatments and Experimental Design

Five combinations of treatments viz. T_1: T. aman rice (var. BRRI dhan33) as sole, T_2: relay of grass pea var. BARI Khesari-1 with T. aman rice; T_3: relay of grass pea var. BARI Khesari-2 with T. aman rice; T_4: BARI Khesari-1 as sole and T_5: BARI Khesari-2 as sole in the present study. The experiment was laid out in a randomized complete block design with three dispersed replications at two different locations.

2.4. Agronomic Managements

The seeds of grass pea varieties (BARI Khesari-1 and BARI Khesari-2) were sown in broadcasting method in the standing paddy crop (T. aman rice) 20 days before harvest and at the time of appropriate moisture level of the soil on 15-20

November in each year. Besides, both varieties were also sown through conventional practices (Tillage) on 05-10 December in both the years. The seed rate of grass pea was 40 kg ha^{-1}. Fertilizers were applied @ 21-17-20 Kg ha^{-1} of N-P and K in the form of Urea, TSP and MoP, respectively. All other agronomic practices were kept uniform for all the treatments except irrigation which was applied before land preparation for grass pea cultivation as sole crop. The crop was harvested on 24-28 March in each year.

2.5. Data Recording

Observations on parameters of the main and component crops (relay crops) were recorded. The yield advantages of different relay cropping systems over mono-cropping of rice were determined in terms of rice equivalent yield (REY), which was computed by converting the yield of relay crops into grain yield of rice based on the existing market price and expressed as US$ (1 US$ = BDT 78) of each relay crop [11]-[12]. All variable costs and cost-benefit analysis with respect to gross and net return was carried out to evaluate the profitability of different treatments of relay cropping system[13].

2.6. Statistical Analysis

The collected data were analyzed statistically following the ANOVA technique with the help of MSTAT-C software. The mean differences among the treatments were adjudged by LSD [14].

3. Results and Discussion

3.1. Yield of T. aman Rice and Grass Pea in Relay Cropping System

Two years results of grass pea and rice grain yields at FSRD site, Jalalpur and MLT site, Zokigonj of Sylhet areas have been shown in Table 1 and 2, respectively.

3.1.1. Location: FSRD Site, Jalalpur

Results of combined analysis of variance across years showed that yield of rice did not significantly affected ($P>0.05$) by rice-grass pea relay cropping systems. In each year, statistically higher seed yields was produced by grass pea as sole cropping system of cultivation. Although this sole cropping system provided maximum amount of seed yield but it had required irrigation before ploughing followed by seed sowing. However it is not general practices in Bangladesh and also very difficult to manage water to irrigate grass pea land in Sylhet region due to drought ecosystem during winter season. Furthermore, this extra irrigation needed additional cost for cultivation of grass pea. Results observed that two varieties of grass pea produced statistically similar seed yields in both sole and relay cropping practices in each year.

The rice equivalent yield (REY) was differed significantly between relay and sole cropping treatments (Table 1). Though the relay cropping system produced comparatively less seed yield of grass pea, but it was an additional yield benefit, which contributed the higher amount of REY in both the years. Reference [15] reported that the inclusion of mustard in between two rices increased the rice equivalent yield (REY) of 21 and 28% with relay and tilled mustard, respectively. The highest REY (6.24, 6.14 tha^{-1}) was recorded in relay of grass pea (var. BARI Khesari-1) with T. aman rice followed by relay of grass pea (var. BARI Khesari-2) with T. aman rice (6.04, 5.91 tha^{-1}). The average REY was also higher in relay of grass pea var. BARI Khesari-1 with T. aman rice and the lowest REY (3.39 tha^{-1}) was found in BARI Khesari-1 as sole. The results are in line with the findings of other workers who reported that relay sowing produced an economic yield of lentil, which was comparable or higher than sole-cropped in all situations[16].

Table 1. *Yield of T. aman rice and grass pea in relay cropping system at FSRD site, Jalalpur, 2011-2013.*

Treatments*	Yield of crops (tha^{-1})		Rice EY** (tha^{-1})	Yield of crops (tha^{-1})		Rice EY (tha^{-1})	Mean Rice EY (tha^{-1})
	T. aman rice	Grass pea		T. aman rice	Grass pea		
	2011-2012			2012-2013			
T_1	3.44	-	3.44	3.54	-	3.54	3.49
T_2	3.38	1.03	6.24	3.42	0.98	6.14	6.19
T_3	3.40	0.95	6.04	3.35	0.92	5.91	5.97
T_4	-	1.27	3.53	-	1.17	3.25	3.39
T_5	-	1.31	3.64	-	1.18	3.28	3.46
LSD (0.05)	0.072	0.178	-	0.101	0.141	-	-
CV (%)	0.94	8.02	-	1.19	6.66	-	-

*T_1: T. aman rice sole, T_2: relay of BARI Khesari-1 with T. aman rice; T_3: relay of BARI Khesari-2 with T. aman rice; T_4: BARI Khesari-1 sole and T_5: BARI Khesari-2 sole; Price of output (US $.$kg^{-1}$): T. aman rice- 0.23 and Grass pea seed-0.64; 1 US $ = Tk. 78

**EY: Rice equivalent yield

3.1.2. Location: MLT Site, Zokigonj

The grain yield of rice was decreased slightly in relay cropping treatments as compared to mono-cropped rice. In between two relay cropping treatments, there was no significant differences in seed yields of two grass pea varieties. But, statistically higher seed yield of grass pea was produced by the varieties in sole cropping practices. It might be due to less competition in soil nutrients along with other natural resources receipt by the sole plot during crop growth.

Table 2. *Yield of T. aman rice and grass pea in relay cropping system at MLT site, Zakigonj, 2011-2013.*

Treatments*	Yield of crops (tha^{-1})		Rice EY** (tha^{-1})	Yield of crops (tha^{-1})		Rice EY (tha^{-1})	Mean Rice EY (tha^{-1})
	T. aman rice	Grass pea		T. aman rice	Grass pea		
	2011-2012			2012-2013			
T_1	3.57	-	3.57	3.51	-	3.51	3.54
T_2	3.47	1.03	6.33	3.43	1.05	6.35	6.34
T_3	3.46	1.00	6.24	3.40	1.03	6.26	6.25
T_4	-	1.21	3.36	-	1.28	3.56	3.46
T_5	-	1.26	3.50	-	1.21	3.36	3.43
LSD (0.05)	0.071	0.167	-	0.124	0.089	-	-
CV (%)	0.96	7.65	-	1.68	3.59	-	-

*T_1: T. amanrice sole, T_2: relay of BARI Khesari-1 with T. aman rice; T_3: relay of BARI Khesari-2 with T. aman rice; T_4: BARI Khesari-1 sole and T_5: BARI Khesari-2 sole; Price of output (US $.kg^{-1}): T. aman rice- 0.23 and Grass pea seed-0.64; 1 US $ = Tk. 78
**EY: Rice equivalent yield

However, the maximum REY (6.34 and 6.35 tha^{-1}) was recorded in relay of grass pea (var. BARI Khesari-1) with T. aman rice followed by relay of grass pea (var. BARI Khesari-2) with T. aman rice (6.24 and 6.26 tha^{-1}). This higher amount of REY might be due to higher unit price of grass pea to that of paddy rice in the market. The lowest REY was found in grass pea as sole cropping practices in both the years. The average maximum REY (6.34 and 6.25 t ha^{-1}) was given by the relay cropping systems of grass pea with monsoon transplanted aman rice and the lowest was in all sole cropping treatments. The introduction of grass pea in relay with monsoon transplanted aman rice increased the REY more than of 70% and 80% from sole T. aman rice and sole grass pea, respectively.

3.2. Cost and Return Analysis

Cost benefit analysis of grass pea relay with T. aman rice at two different locations were presented in Table 3-4.

3.2.1. Location: FSRD Site, Jalalpur

Cost benefit analysis revealed that, the highest gross return (US$ 1428 ha^{-1}) and net return (US$ 880 ha^{-1}) was obtained by relay grass pea (var. BARI Kheshari-1) with T. aman rice, which subsequently provided the highest benefit cost ratio (2.60) that was closely followed by relay of BARI Kheshari-2 with T. aman rice. The lowest gross return (US$ 782 ha^{-1}) and net return (US$ 407 ha^{-1}) as well as the lowest BCR (2.09) were gained from the sole cropping of transplanted aman rice (Table 3).

Table 3. *Cost benefits analysis of relay cropping of grass pea with T. aman rice at FSRD site, Jalalpur, 2011-2013.*

Treatment*	Mean REY** (tha^{-1})	Gross return (US $.$ha^{-1}$)	Total cost (US $.$ha^{-1}$)	Net return (US $.$ha^{-1}$)	BCR
	1	2	3	4 [2-3]	5[2÷3]
T_1	3.49	805	507	298	1.59
T_2	6.19	1428	548	880	2.60
T_3	5.97	1378	548	829	2.51
T_4	3.39	782	375	407	2.09
T_5	3.46	798	375	423	2.13

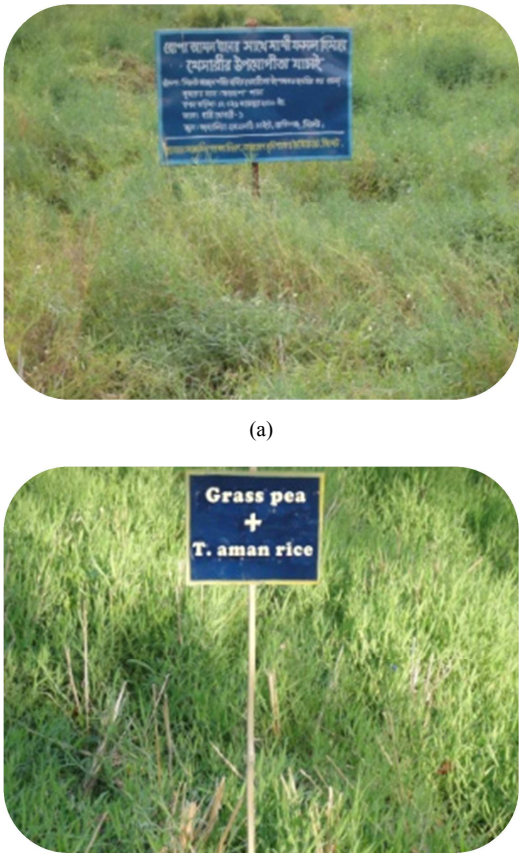
Table 4. *Cost benefits analysis of relay cropping of grass pea with T. aman rice at MLT site, Zakigonj, 2011-2013.*

Treatments*	Mean REY** (tha^{-1})	Gross return (US $.$ha^{-1}$)	Total cost (US $.$ha^{-1}$)	Net return (US $.$ha^{-1}$)	BCR
	1	2	3	4 [2-3]	5[2÷3]
T_1	3.54	817	507	309	1.61
T_2	6.34	1463	548	915	2.67
T_3	6.25	1442	548	894	2.63
T_4	3.46	798	375	423	2.13
T_5	3.43	792	375	417	2.11

*T_1: T. aman rice sole, T_2: relay of BARI Khesari-1 with T. aman rice; T_3: relay of BARI Khesari-2 with T. aman rice; T_4: BARI Khesari-1 sole and T_5: BARI Khesari-2 sole; Price of output (US $.kg^{-1}): T. aman rice- 0.23 and Grass pea seed-0.64; 1 US $ = Tk. 78
**REY: Rice equivalent yield

3.2.2. Location: MLT Site, Zakigonj

From the Table 4, it is revealed that maximum gross return (US$ 1463 ha^{-1}) and net return (US$ 915 ha^{-1}) was found in T_2 (relay of BARI Khesari-1 with T. aman rice) but it was closely followed by T_3 (relay of BARI Khesari-2 with T. aman rice). However, the highest BCR (2.67) was recorded in T_2 that was also followed by T_3, while the lowest gross return (US$ 817 ha^{-1}), net return (US$ 309 ha^{-1}) and BCR (1.61) were provided by transplanted aman rice as sole cropping.



(a)

(b)

Fig. 3. *Grass pea relay cropping with transplanted rice in Zakigonj (a) and Jalalpur (b), Sylhet.*

4. Conclusion

From the dyad years study at two different locations, it was revealed that, the maximum mean rice equivalent yield was recorded in grass pea var. BARI Khesari-1 relayed with T. aman rice followed by grass pea var. BARI Khesari-2 relayed with T. aman rice cultivation in both the locations. Besides, the highest gross return, net return along with highest benefit cost ratio was also achieved. Hence, rice-based grass pea relay cropping system proved to be more remunerative and sustainable than sole cropping systems. So, due to scarcity of water in Sylhet region during rabi season, relay cropping of grass pea with monsoon rice can be a suitable option to achieving higher crop productivity through the utilization of fallow land for the farmers of Sylhet areas in Bangladesh.

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