Introduction of forage legumes into crop production systems in Mymensingh

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Abstract: An experiment was conducted to investigate the appropriate legume fodder and probable integration method to introduce in the farmers existing cropping system without disturbing their cropping pattern and compare the economic return with existing cropping system. A total of fifteen farmers at Harty and Ajmotpur villages in Mymensingh sadar, Mymensingh district were selected for integrated rice-forage production. Based on the farmers' preferences three legume fodders: Khesari (*Lathyrus sativus*), Dhaincha (*Sesbania rostrata*) and Matikalai (*Phaseolus mungo*) were selected to cultivate in farmers rice field the following treatment combinations: T_1 = Transplant Aman rice - Mustard - Boro rice (Control, Traditionally followed by farmers), T_2 = T. Aman rice + Khesari fodder (Relay) - Boro rice - Dhaincha fodder, T_3 = T. Aman rice - Khesari fodder - Boro rice + Dhaincha (Mixed crop), T_4 = T. Aman rice + Matikalai fodder (Relay) - Boro rice – Dhaincha, T_5 = T. Aman rice - Matikalai fodder - Boro rice + Dhaincha (Mixed crop). The study was continued for one year. Grain yield of transplant Aman rice was non-significantly ($P<0.05$) different from the control cropping system due to relay cropping treatments of khesari fodder. However grain yield of Boro rice (6.59 t ha^{-1}) was significantly ($P<0.01$) higher in T_2 cropping system than the other cropping systems including control. On the other hand, straw yield of transplant Aman rice was non-significantly different due to relay cropping treatments compared to its control cropping system but significantly ($P<0.01$) higher straw yield of Boro rice was observed in control (T_1), T_2 and T_4 cropping systems than those of T_3 and T_5 cropping systems. It is revealed that the T_2 cropping system produced significantly ($P<0.01$) highest dhaincha fodder yield than those of T_3, T_4 and T_5. The yield of khesari fodder differed significantly ($P<0.01$) among treatments due to relay cropping with rice and highest yield (12.30 t ha^{-1}) was obtained in T_3 cropping system, however, the yield of matikalai fodder (11.34 t ha^{-1}) was significantly ($P<0.01$) higher in T_5 cropping system than that of T_4 (8.71 t ha^{-1}) cropping system. The highest gross return (Tk. 380872 ha^{-1}) was obtained from the T_2 treatment; while the lowest gross return (Tk. 314563 ha^{-1}) was obtained from T_1 treatment. Similarly the net economic return of different cropping system of rice with different fodders also showed the same trend as exhibited by total gross return. The highest benefit cost ratio (2.41) was obtained from T_2 against the minimum (1.82) was obtained from the traditional cropping system (T_1) practiced by the farmers.
Key words: Introduction, forage legume, crop production system, Mymensingh.

Introduction

Rice (*Oryza sativa* L.) is the stable food crop for more than half of the world's population. In Asia alone, more than 2 million people obtain 60 to 70 percent of their calorie intake from rice and its derived products (FAO, 2003). Rice is grown in 10.42 million hectares of land with a production of 28.91 million tons (BBS, 2009). Among the three distinct seasons aman rice covers the largest area of 5.05 million hectares with a production of 9.662 million tons of rice (BBS, 2009). Bangladesh is a densely populated country, where population density and per capita cultivable lands are 964 persons/sq.km and 0.05 ha, respectively (BBS, 2011). Every year cultivable lands are utilized for housing, office building, roads and others construction work for blooming populations. Day by day, the population per unit area increases but cultivable land decreases which is alarming for growing economy of the country. In this endeavor, researchers, extentionist and farmers are trying to increase cropping intensity through the highest utilization of lands to fulfill the growing demand of increasing population. On the other hand, the total number of present livestock do not meet the demand of protein requirement in Bangladesh. About 88% of the population is suffering from protein deficiency. Children and women, in general and lactating mother in particular (94.4%), are the worst sufferers (Kabir *et al*., 2005). On the other hand, soil fertility in Bangladesh is deteriorating day by day because of intensive food crop cultivation, introduction of high yielding crop varieties, use of less amount of organic matter, abundant application of chemical fertilizers and improper soil and crop management practices (Hossain *et al*., 1995; Balyan and Idnani, 2000; BARC, 2005). Rice-rice or rice-wheat is the main cropping pattern of Bangladesh (Timsina *et al*., 2002; BARC, 2005). The cereal based cropping pattern causes huge depletion of plant nutrients from the soil every year (Islam, 2001).

Under the above situation, inclusion of legumes in the existing cropping pattern as intercrop or mixed crop or relay crop may replenish organic matter content in the soil because legume can add N_2 from the environment through symbiosis by *ribozium* bacteria in their nodules and improves soil nitrogen (Akbar *et al*., 2000). In addition, farmers can get important protein rich fodder for their livestock for improved feeding as well as increase milk and meat production. Therefore, considering the above facts, the present study was designed to investigate the appropriate legume fodder and probable integration method to introduce in the farmers existing cropping system without disturbing their cropping pattern and compare the economic return with existing cropping system.

Materials and Methods

Selection of site, farmers and forage: Harty and Ajmotpur villages in Mymensingh sadar, Mymensingh district was selected for the present study due to the farmers were more interested to produce forage for their livestock and also have the milking cows. A total of fifteen farmers were selected for integrated rice-forage production. Based on the farmers' preferences three legume fodders: Khesari (*Lathyrus sativus*), Dhaincha (*Sesbania rostrata*) and Matikalai (*Phaseolus mungo*) were selected to cultivate in farmers rice field for integrated rice-forage production in the existing cropping pattern during July, 2010 to June 2011.

Treatment of the Experiment: The traditional practice of cropping pattern in a year followed by farmers was considered as control. Other treatment combinations were described as: T_1 = T. Aman rice - Mustard - Boro rice (Control, Traditionally followed by farmers), T_2 = T. Aman rice + Khesari fodder (Relay) - Boro rice - Dhaincha fodder, T_3 = T. Aman rice - Khesari fodder - Boro rice + Dhaincha (Mixed crop), T_4 = T. Aman rice + Matikalai fodder (Relay) - Boro rice – Dhaincha, T_5 = T. Aman rice - Matikalai fodder - Boro rice + Dhaincha (Mixed crop).

Cultivation of Transplant *Aman* rice: BR-11, a modern rice variety, was used in the farmer's field as the test crop (main crop). The seedlings of transplant *Aman* rice were raised in wet nursery bed. Sprouted rice seeds were sown in a well-prepared raised nursery bed. Fertilizer was applied in the nursery bed according to the traditional recommendation of farmers. Irrigation, insect and pest management were done as and when necessary. The experimental plots were irrigated, ploughed and cross ploughed followed by laddering for good puddle condition. At final land preparation the experimental plots were fertilized with full dose of P_2O_5, K_2O, S and Zn in the form of triple super phosphate, muriate of potash, gypsum and zinc sulphate. The fertilizers were applied at the rate 70-55-30-7-4 kg ha^{-1} of N-P_2O_5-K_2O-S-Zn, respectively. N fertilizer was applied in the form of urea in three equal installments at 20, 35 and 55 days after transplanting (DAT). Thirty day old seedlings were uprooted carefully from the nursery bed and were transplanted at the rate of two or three seedlings $hill^{-1}$ in the unit plot on 30 July 2010 with a spacing of 25 cm x 15 cm. To control weeds three times hand weeding and hand mulching were done at 20, 35 and 55 DAT. The experimental field was irrigated properly as and when necessary according to the growth stages.

Cultivation of Boro rice: BR-28, a modern rice variety, was used in the farmer's field as the test crop (main crop). The seedlings of transplant Boro rice were raised in wet nursery bed. Sprouted rice seeds were sown in a well-prepared raised nursery bed. Fertilizer was applied in the nursery bed according to the traditional recommendation of farmers. Irrigation, insect and pest management were done as and when necessary. The experimental plots were irrigated, ploughed and cross ploughed followed by laddering for good puddle condition. At final land preparation the experimental plots were fertilized with full dose of P_2O_5, K_2O, S and Zn in the form of triple super phosphate, muriate of potash, gypsum and zinc sulphate. The fertilizers were applied at the rate 103-60-40-10-4 kg ha^{-1} of N-P_2O_5-K_2O-S-Zn, respectively. N fertilizer was applied in the form of urea in three equal installments at 20, 35 and 55 days after transplanting (DAT). Thirty day old seedlings were uprooted carefully from the nursery bed and were transplanted at the rate of three or four seedlings $hill^{-1}$ in the unit plot on 3 March 2011 with a spacing of 25 cm x 15 cm. To control weeds three times hand weeding and hand mulching were done at 20, 35 and 55 DAT. The experimental field was irrigated properly as and when necessary according to the growth stages.

Cultivation of Kheshari (*Lathyrus sativus*) fodder as relay crop: Total ten farmers of each having land and milking cows were selected for establishing khesari (*Lathyrus sativus*) fodder plots in their transplant Aman (T. Aman) rice fields. The lands were used as demonstration plots. Khesari fodder seeds were supplied to the farmers for sowing in the field plots. The seeds were sown in first week of November' 2010 at the seed rate of 80 kg/ha with standing T. Aman rice crop 15 days before harvesting. After harvesting of T. Aman rice, khesari fodders were left in the field and they grew rapidly. Physical growth of the fodder was also observed through regular field visits. The fodders were kept in the field up to the next Boro rice cultivation. No fertilizer, no irrigation nor intercultural operations were given/done to the fodder plots. Finally, the kheshari fodder was harvested at the end of February' 2011 and data on green weight of fodder of two areas were recorded. This cultivation system was considered as relay cropping system of khesari with T. aman rice. On the other hand, Khesari seeds were also sown in farmer's field at the same seed rate just after harvesting T. aman rice and considered as single crop between T. Aman and Boro rice cropping. The fodders were kept in the field up to the next Boro rice cultivation and harvested in first week of March, 2011. The data on green biomass weight of fodder of two areas were recorded.

Cultivation of Dhaincha (*Sesbania rostrata*) fodder as intercrop and mixed crop: Seeds of Dhaincha (*Sesbania rostrata*) were sown at the rate of 40 kg/ha in the seedbed of ten farmers during at the end of March, 2011. When the plants grew well, two types of cuttings were made from each plant one was top portion cutting and another from middle portion of the plant. The cuttings were used for plantation in the farmers' field just after harvesting the Boro rice maintaining 50 cm line to line distance and 25 cm plant to plant distance in end of May, 2011 which was considered as intercrop-between crop. No intercultural operations were required. The crop was harvested as fodder in middle of August 2011 and data on green biomass weight of fodder of two areas were recorded. On the other hand, in the mixed cropping, the cuttings of dhaincha were used for plantation in the farmers' field after two month of Boro rice plantation in two row interval and 25 cm plant to plant distance in end of April, 2011. The fodder was harvested at 50 cm top portion as fodder in July 2011 for livestock feeding and data on green biomass weight of fodder of two areas were recorded.

Cultivation of Matikalai (*Phaseolus mungo*) fodder as relay crop: Total ten farmers having land and milking cows were selected for establishing Matikalai (*Phaseolus mungo*) fodder plots in their transplant Aman (T. Aman) rice fields. The lands were used as demonstration plots. Matikalai fodder seeds were supplied to the farmers for sowing in the field plots. The seeds were sown in first week of November' 2010 at the seed rate of 90 kg/ha with standing T. Aman rice crop 15 days before harvesting. After harvesting of T. Aman rice, matikalai fodders were left in the field and they started to grow rapidly. Physical growth of the fodder was also observed through regular field visits. The fodders were kept in the field up to the next Boro rice cultivation. No fertilizer, no irrigation nor intercultural operations were given/done to the fodder plots. Finally, the matikalai fodder was harvested at the end of February' 2011 and data on green weight of fodder of two areas were recorded. This cultivation system was considered as relay cropping system of matikalai with T. aman rice. On the other hand, Matikalai seeds were also sown in farmer's field at the same seed rate just after harvesting T. aman rice and considered as single crop between T. Aman and Boro rice cropping. The fodders were kept in the field up to the next Boro rice cultivation and harvested in first week of March, 2011. The data on green biomass weight of fodder of two areas were recorded.

Data collection and Statistical analysis: Data were recorded on grain and straw yields of main crop, Green biomass yield of Fodder crop and stick yield. The collected data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package SAS. The mean differences among the treatments were ranked as per Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results

Grain yield and straw yield of rice: The grain and straw yield of different rice in different cropping systems are shown in Table 1. Grain yield of transplant Aman rice was non-significantly ($P<0.05$) different from the control cropping system due to relay cropping treatments of khesari fodder. The highest grain yield was found (4.86 t ha^{-1}) in T_1 (control) cropping pattern and lowest (4.50 t ha^{-1}) was in T_5 cropping pattern. However, the grain yield of Boro rice (6.59 t ha^{-1}) was significantly ($P<0.01$) higher in T_2 cropping system than the other cropping systems including control in the farmers field. On the other hand, straw yield of transplant Aman rice was non-significantly different due to relay cropping treatments compared to its control cropping system. The highest straw yield of T. Aman (5.68 t ha^{-1}) was obtained in T_1 (control) cropping system and lowest (5.38 t ha^{-1}) was at T_5 cropping system. On the contrary, significantly ($P<0.01$) higher straw yield of Boro rice was observed in control (T_1), T_2 and T_4 cropping systems than those of T_3 and T_5 cropping systems.

Table 1. Yield (t ha^{-1}) of different crops in different cropping systems at Mymensingh area

Cropping systems	T.Aman rice		Boro rice		Dhaincha		Matikalai	Khesari	Mustard
	Grain yield	Straw yield	Grain yield	Straw yield	Fodder yield	Stick yield	Fodder yield	Fodder yield	grain yield
T. Aman - Mustard - Boro rice	4.86±.08	5.68±.09	6.02^b±.03	6.80^a±.07	--	--	--	--	1.19
T. Aman+ Khesari (R)- Boro - Dhaincha	4.84±.07	5.62±.06	6.59^a±.04	6.85^a±.04	26.15^a±.19	1.12^a±.02	--	11.06±.14	--
T. Aman-Khesari - Boro+ Dhaincha (M)	4.78±.07	5.66±.12	5.32^c±.14	5.74^b±.08	24.14^b±.09	0.81^b±.01	-	12.30±.12	--
T. Aman +Matikalai(R)- Boro -Dhaincha	4.51±.09	5.48±.05	6.35^a±.05	6.83^a±.03	26.05^a±.15	1.07^a±.02	8.71^b±.22	--	--
T. Aman -Matikalai - Boro+Dhaincha (M)	4.50±.09	5.38±.05	5.26^c±.12	5.72^b±.05	23.97^b±.06	0.79^b±.01	11.34^a±.05	--	--
Level of significance	NS	NS	**	**	**	**	**	**	

R=Relay cropping; M=Mixed cropping; I=Intercropping-between crop; ** = Significance level at 1% level.

Table 2. Net Economic Returns (NET) and benefit cost ratio (BCR) of different cropping systems (Tk/ha)

Cropping system	Gross return (Tk)	Total variable costs (Tk)	Net Economic Return (Tk)	Benefit Cost Ratio
T. Aman - Mustard - Boro rice	314563	172619	141944	1.82
T. Aman+ Khesari (R)- Boro - Dhaincha	380872	157724	223148	2.41
T. Aman-Khesari - Boro+ Dhaincha (M)	342100	159124	182976	2.14
T. Aman +Matikalai (R)- Boro -Dhaincha	359793	162494	197299	2.21
T. Aman -Matikalai - Boro+Dhaincha (M)	339076	158954	180122	2.13

R=Relay cropping; M=Mixed cropping; I=Intercropping-between crop; Tk = Bangladeshi Taka;

Fodder and stick yield of Dhaincha (*Sesbania rostrata*): Fodder and stick yield varied significantly ($P<0.01$) due to different types of intercropping of *Sesbania* with rice (Table 1). It is revealed that the T_2 (26.15 t/ha) produced significantly ($P<0.01$) highest dhaincha (*Sesbania rostrata*) fodder yield than those of T_3, T_4 and T_5. Likewise, the stick yield of dhaincha showed the similar trend of results in the regions. The stick yield of dhaincha was significantly ($P<0.01$) higher in T_2 cropping system than T_3, T_4 and T_5 cropping systems.

Yield of khesari (*Lathyrus sativus*) and Matikalai (*Phaseolus mungo*) fodders: The yield of khesari fodder differed significantly ($P<0.01$) among treatments due to relay cropping with rice (Table 1). The highest khesari fodder yield (12.30 t ha^{-1}) was obtained in T_3 cropping system and lowest (11.06 t ha^{-1}) was in T_2 cropping system. On the other hand, the yield of matikalai fodder was significantly ($P<0.01$) higher in T_5 (11.34 t ha^{-1}) cropping system than that of T_4 (8.71 t ha^{-1}) cropping system.

Total variable cost: The total variable cost of different intercropping of transplant Aman rice and Boro rice with Khesari, Matikalai and Dhaincha, respectively has been studied and presented in Table 2. Cost of Seedlings, fertilizer, land preparation, weeding, irrigation, labour, pesticide, harvesting, threshing and packaging cost, etc. were calculated for total variable cost. The lowest total variable cost (Tk. 1,57,724 ha-1) was found from the T_2 treatment, however, the highest total variable cost (Tk. 172619 ha-1) was observed in the T_1 cropping system.

Gross and net economic returns: Gross return from different rice, mustard and different fodder yields of different cropping systems has been shown in Table 2. The highest gross return was obtained from the T_2 (Tk. 380872 ha^{-1}) treatment; where the lowest gross return (Tk. 314563 ha^{-1}) was obtained from T. T_1 treatment. The net economic return of different cropping system of rice with different fodders at both regions also showed the similar trend as exhibited by total gross return (Table 2).

Benefit cost ratio: The benefit cost ratio varied from 1.82 to 2.41 due to different cropping systems of transplant Aman and Boro rice with different fodders (Table 2). The highest benefit cost ratio (2.41) was obtained from T_2 against the minimum (1.82) was obtained from the traditional cropping system (T_1) practiced by the farmers.

Discussion

Relay cropping did not decrease grain yield of T. aman rice as compared to traditional cropping system. However, the grain yield of Boro rice was significantly higher (T_2 & T_4) in different combinations of cropping system compared to that of the traditional system except the production reduced where the *Sesbania* used as mixed crop for fodder cultivation with boro rice in T_3 and T_5 treatments as shown in Table 1. This is probably due to fixing of nitrogen in the soil by nitrogen fixing bacteria of previous legume fodder cultivation (Khesari fodder). The similar results were observed by Hegde (1992) who reported that the inclusion of legume crops in rice based cropping system increased the production of subsequent rice crop. Prasad *et al*. (2011) and Anwar *et al*. (2010) also reported that legumes have direct benefit of nitrogen fixation through root nodules and enhance soil fertility which could be used for companion as well as subsequent crops. However, the probable reasons for reduction of boro rice grain yields (T3 & T5) with *Sesbania* mixed cropping system might be due the shading effects of closer planting of *Sesbania* and for the competition for light, space, moisture and nutrient with rice. Reduction in grain yield of rice due to intercropping was also reported by Chandra *et al*., (1992), Saeed *et al*., (1999) and Joshi (2002). The yield of straw varied significantly due to mixed cropping of *Sesbania* with boro rice (Table 1). Shading of *Sesbania* plant resulted less number of total tillers hill^{-1} resulted low straw yield. The obtained result is in conformity with the findings of Biswas *et al.* (1991) and Alam (1995). However, it is revealed that single crop of *Sesbania* treatment produced highest fodder yield than *Sesbania* mixed with the rice field. The adverse effect on fodder yield of the crop due to mixed cropping system with rice occurred mainly due to competition among companion crops for light, space, nutrients and water etc. The more number of plant population was grown, the more competition for light, space, nutrient, humidity and moisture etc. increased and thus yield differences occur. The probable causes for getting higher stick yield in single cropping system of *Sesbania* might be due to more vigorus growth and higher branching of *Sesbania* at sole spacing. The yield of khesari fodder was significantly increased in single cropping system compared to relay cropping system with T. aman rice. The probable cause of low khesari fodder production in relay cropping system might be low germination rate of khesari seed which is affected by the length of residual straw after cutting the rice. The yield of matikalai fodder in relay cropping system also seriously affected for low germination rate of seed by the length of residual straw after cutting the rice.

The highest total variable cost was observed in traditional cropping system T_1 (T. Aman - Mustard - Boro rice) than other cropping systems. The probable cause might be due to high price in fertilizer and irrigation cost involved for mustard cultivation in the traditional cropping system than other treatment combinations.

A gross and net return provides an economic assessment of different cropping patterns in terms of increased value per unit area of land. The highest gross return of grain, straw yield and stick yield of dhaincha from the T_2 cropping system was probably due to the fact that dhaincha fodder with their stick and boro rice gave maximum income due to increased dhaincha fodder yield and higher production rate for boro rice as compared to other treatments. However, the T_4 cropping system gave lower gross return from T_2 treatment due to the reason is that matikalai fodder and boro rice in this cropping system gave less rate of production. The present result was in agreement with the report of Sher *et al.* (2013) who stated that the legume based cropping system increased the productivity of next crop as well as gave higher gross return. The net return of different cropping system of rice with different fodders at different arrangements also showed the similar trend as exhibited by total gross return as shown in Table 2. The result of the present study is in partial conformity with the findings of Prajitno (2001) and Dhimmar (2003) where they obtained higher net return in rice based intercropping systems with different crops.

In order to reach a conclusion as to the desirability of either, rice monocrop or as included in integration with legume, the cost benefit analysis was done using benefit cost ratio as a decision criterion. In this experiment all costs and benefits of changing from rice monocrop to rice–legume integration were identified, quantified and converted to monetary values using conventional and implicit market values. The maximum benefit cost ratio in the treatment T. Aman+ Khesari - Boro - Dhaincha (T_2) might be due to high yield of individual component crop of this cropping system and total high market price than the other cropping systems. These results agree to those of Singh *et al*. (1997) and Asfaw *et al*. (2012) who reported that inclusion of legumes in multiple cropping systems offer many advantages to the farmers. Although the mustard oil seed is high priced component in traditional (T_1) cropping system but their production rate is low and resulted in lower benefit cost ratio. Similar results were obtained by Shah *et al*. (1999) and Padhi (1993) who reported that although price of oilseed crops are higher but their yields are not equivalent to other crops of cropping systems.

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