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Introduction of fodder legumes into rice-based cropping systems and their use as supplements to straw-based rations for dairy cattle in Bangladesh

A LIVESTOCK PRODUCTION PROGRAMME

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Executive Summary

The vast majority of the livestock population in Bangladesh is located in the rural area and reared by the small holders and are non-descriptive type. Because of the increasing demand for human food production, the land is intensively used for cereal crop production and farmers can not spare land exclusively for growing fodder. Consequently there is tremendous shortage of green forage for ruminant livestock and they are to live only on rice straw which is well known for its nutrient deficiency. This situation has led to the low productivity of livestock in the rural area. Moreover, intensive cropping system is resulting in degeneration of soil fertility as there is little time for regaining soil nutrient status. As a result it has become an urgent need to adopt some technique to improve fodder production situation without changing the existing crop production pattern which will allow supplementing rice straw diets of dairy cows with the produced green fodder to improve milk production of these animals. A further manipulation of this technology towards strategic feeding of cows, a sustainable feeding system may be developed for dairy cows under small holder intensive farming system.

Considering the above views, the general purpose of the project was to promote strategies to improve the seasonal availability of livestock feeds in high potential areas of Bangladesh. The specific purpose of the project was to adopt the technology of legume fodder cultivation through integration into intensive rice-based cropping systems in order to mitigate the alarming shortage of livestock feeds and fodder. The ultimate aim was to develop sustainable and efficient feeding system for dairy cows for improving their productivity under crop/livestock intensive farming system in rural areas of Bangladesh and thus improve the health and economic condition of the rural farmers.

The whole research programme was performed under three components: fodder production, animal feeding and socio-economic activities. The research in each of these components were performed under on-station and on-farm in four years under four activities.

Fodder production in the 1st year of the project was started with three legume fodder, *Sesbania rostrata*, *Lathyrus sativus* and *Crotalaria juncea* were selected for introduction purpose. On-station production was done in the field plots of the Dept. of Agronomy and

Animal Nutrition. For on-farm trial, the village farmers of the project area having 1.02 to 3.04 ha of land and at least 3 cattle, were selected. The seeds of Lathyrus were sown in the standing T. aman rice (dry season rice) and that of Crotalaria in the fallow land after harvesting T. aman rice. Sesbania was not cultivated as there was no season for it. The biomass yield of the fodders were determined.

In the following year, Crotalaria was not tried for production purpose as it did not perform well on-farm, so, only Sesbania and Lathyrus were cultivated. The procedure for cultivation of Lathyrus on-farm was similar as mentioned in the year 1. However, for Sesbania, the seeds were sown first in small plots (seed bed) of the farmers and the cutting were made (two from each plant) out of them and transplanted in the fallow land. In this year, soil samples were collected before and after fodder cultivation in the rice field and analysed in the laboratory for organic matter (OM) and nitrogen (N) in order to examine any change in the level of above nutrients in soil due to fodder cultivation. The yield of rice cultivated following the fodders were also recorded to observe any change in the rice yield due to fodder cultivation.

In 3rd year, the similar trials for fodder production were conducted. This year Lathyrus fodder was cultivated for two duration: short (for up to the next Boro rice) and long (beyond the next rice). Data on soil nutrients and rice yield were also taken like the previous year in the similar way.

In the 4th year, only Sesbania was cultivated both on-station and on-farm. At on-farm, the transplantation of Sesbania fodder from the seed bed was done in two ways: one, by transplanting the whole plant to the rice field, and the other, by transplanting the cuttings to study differences in yield of fodder due to difference in the method of transplantation. Soil nutrient status as well as rice yield were also studied in the same way as above.

Animal feeding trial was performed using both growing and lactating cows both on-station as well as on-farm by feeding the grown fodder as supplement with straw-based rations to observe it's effects on growth or milk production of local cows.

Animal feeding trials were also conducted but only on the lactating cows both on-station and on-farm. This year in on-farm feeding trial, both in case of Sesbania and Lathyrus,

the supplementation of fodder was accompanied by small quantity of home produced rice polish to make the diets more nutritious towards balance of nutrients

After production of fodder only on-station feeding trial experiments were conducted using growing cattle. On-farm trial was not done due to insufficient total quantity of fodder for meeting the animals' requirements for the trial period. However, the grown fodders were fed to the farmers animals by grazing on it in the field

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fodder to animals and gender role in this activity.

The economic study on the fodder production was also started this year. In this year mainly the baseline observation the economic aspects of the research farmers were done.

The socioeconomic study in this year was basically the similar as mentioned above. Socioeconomic study was like that of the previous year but this year special emphasis was given on the effects of fodder production practices on the livelihoods of the rural farmers.

Some other studies on both fodders such as in situ degradation of dry matter and crude protein, as well as rumen parameters like ammonia-N and total Volatile Fatty Acids (VFA) were conducted on-station.

Production data from on-farm showed that Lathyrus grew on average better (12.80 t/ha) than did Crotalaria (3.25 t/ha). Cultivation of Lathyrus under two periods - short duration and long duration showed that although long duration gave higher yield (15.7 t/ha), than that (13.7 t/ha) of short duration the difference was not significant. The on-farm yield was similar to that of on-station (15.8t/ha). Sesbania grown in farmers' field showed that the average plant height (cm) and biomass yield (t/ha) were 119.5 and 28.8, respectively. Middle portion cuttings gave the longest plants (175.3 cm) and the highest biomass yield (32.3 t/ha) compared to top portion cuttings. Sesbania fodder was also cultivated in rice field after harvesting Boro rice following two planting methods : using the cuttings as well as by transplanting whole seedlings. The results showed that the average yield of fodder were ~20 and ~31 t/ha, due to planting of cuttings and by transplantation, respectively. On-farm yield of Lathyrus was similar, but lower for Crotalaria compared to that of on-station.

Field production trial with legume fodders concluded that Sesbania can well be grown in between Boro rice and T. aman rice while Lathyrus can be grown as relay crop with T. aman rice and be continued up to next Boro rice crop. Sesbania can be grown by planting the cuttings of middle portion or the whole plant. However, transplantation of whole seedlings gave higher production of fodder than planting the cuttings.

On-farm feeding trial using growing and lactating cattle at low level (0.5 kg/d) of supplementation of Sesbania fodder with straw-based diet slightly increased milk production and live weight gain, while the higher level (1.5 kg/d) gave 26% increase in milk production. Similar level of supplementation with straw diets under on-station gave lower milk yield compared to that of on-farm yield. More higher supplemental level (3.0 kg/d) increased only 2% more milk (i.e. 28%) than did 1.5 kg/d. On the other hand, feeding Lathyrus supplemented (1.0 kg hay/d) straw-based diet gave average live weight gain of 329 g/d and the milk production was increased by 20% in cattle on-farm, compared to 14% increase under on-station.

It may be summarised from the feeding trial experiments that supplementation of straw-based diet with Sesbania or with Lathyrus (green or hay) increased by 0.3 - 0.4 kg/d live weight gain and 20 - 26% milk production of rural farmers' cattle. Supplementation of either of the fodder moderately increases milk composition.

For efficient feeding system for milk production of rural cows, supplementation of Sesbania green fodder at 1.5 kg/d with 0.5 kg of rice polish and small amount of green grass may be suggested for 26% increase in milk production. The feeding system for rural cows with Lathyrus fodder supplementation may be suggested as 1.5 kg Lathyrus hay and 0.5 kg rice polish and small amount of green grass for about 20% increase in milk production.

Chemical analysis of soil samples showed that organic matter and nitrogen contents before and after Sesbania fodder cultivation increased, on average, from 1.48 and 0.087 to 1.77 and 0.101%, respectively and Lathyrus fodder from 1.65 and 0.101 to 1.75 and 0.103% respectively. Rice yield data before and after fodder cultivation showed that T. aman rice and Boro rice yield increased, on average, by 6.5 to 13% due to Sesbania and Lathyrus fodder cultivation. Cost-return analysis in producing both Sesbania and

Lathyrus fodders showed that yield and economic return on-farm were quite satisfactory and very cost effective compared to others.

Ruminal degradability study showed that DM and CP of Sesbania and Lathyrus were highly degradable, 66.3% and 91.7%, respectively for Sesbania and 67.1% and .....%, respectively for Lathyrus. Concentration of NH3-N and VFA were significantly higher in Sesbania as well as Lathyrus supplemented diets than without supplementation.

The project has contributed to the research goal through application of it's outputs. The integration of fodder production in rice production system has been found successful based on the satisfactory production records of fodders, increased soil nutrient status, increase in milk production and growth of fed cattle, and above all, the positive interest of the participatory and non-participatory farmers in the project area. The integration technique has created interest of the rural farmers to grow fodder in their rice field without affecting their rice production practice. Furthermore, the fodder so produced has allowed the rural farmers to feed their dairy cattle as supplement to straw-based ration and thus milk production of dairy cows were increased. It has helped in formulating feeding systems for small holders dairy production under intensive crop/livestock farming system in Bangladesh using the farmers' home produced animal feed resources to improve their animal's production performance. Finally, the results of the socioeconomic study has contributed to the derivation of economic benefit out of the fodder integration technique by the rural farmers. This was evident from the very low input cost (price of seed only) compared with large return in terms of fodder production and increased rice yield. Moreover, the project has allowed the rural farmers to produce more milk from their cows fed fodder supplemented diets which they consumed or sold and earned extra money and improved their livelihood.

In order to implement the outputs of the project and to continue the fodder production practice the Directorate of Agricultural Extension Services (DAES) and Directorate of Livestock Services (DLS) at field office have been involved in the activity of the project. These organisations agreed to encourage the farmers and to monitor the continuation of the fodder production practice as well as the feeding system being followed by the farmers to feed their animals.

1. BACKGROUND

1.1 Introduction

Bangladesh is a tropical country and its climate is humid tropic. The total area of the country is 134,998 sq. km. Summer, Monsoon and Winter are the major seasons of the country. The average rainfall is 200 cm. The ranges for temperature and relative humidity are 5-41^{0}C and 60-95 per cent, respectively. The country's economy is based on agriculture.

Bangladesh is a country of small and mixed farms where crops, livestock, fishery and homestead forestry are components of the farming systems. Among these components, crop production is the primary one and the others are usually secondary or supportive to it. Out of the country's total land, 60 per cent is utilized for cultivation of different crops, 80 per cent of which is cereal crops (Saadullah, 1992). The major agricultural crops are rice, wheat, jute, potatoes, sweet potatoes, sugar cane, oil seeds and pulses. Modern rice varieties have already occupied more than 22 per cent of the total area and contributed more than 38 per cent of rice production. Three varieties of rice are cultivated by the farmers: rainfed summer variety locally known as Transplanted aman rice, (T. aman rice) flooded summer variety known as Aus rice and irrigated winter variety known as Boro Rice. Because of the high demand for crop production for human consumption, intensive cropping systems are followed by the farmers where land is not usually left fallow.

Recent statistics (1997-98) shows that Bangladesh has got 23.40 million cattle, 0.82 million buffaloes, 34.50 million goats, 1.11 million sheep and 151.20 million chicken and ducks (DLS, 1998). Livestock is the integral part of the farming system of Bangladesh. This sub-sector contributes 6.5 per cent to the GNP, generates 13 per cent to the total foreign exchange earnings and provides full-time employment to about 20 per cent of the rural population (Alam, 1993). The vast majority (82%) of the livestock population is located in the rural area and reared by the small holders (BBS, 1994). Majority of the cattle (Zebu cattle) population in Bangladesh are non-descriptive type, called indigenous which do not belong to any one specific breed. They are small in size. Production capability is much lower than that of high yielding breeds.

Among the different species of livestock, ruminants are the most important for their diversified contribution and occupy 35 per cent of the total population. The number of milking cows in Bangladesh is 3.79 million, which is 18% of all cattle, 35% of all cows and 45% of all adult cows. Of the total milking cows, only 1.09% are reported to be cross-bred (BBS, 1996). The average daily milk yield of local and cross-bread cows are 1.2 and 4.2 kg respectively (Mannan, *et al.*1992).

Usually the farmers of Bangladesh are crop production man but they invariably keep a pair of bullock for ploughing their land. However, this is not the only purpose of rearing livestock by the farmers. They raise livestock also for milk and hard cash. The result of a survey study showed that, 54 per cent of the farmers rear livestock for dual purpose (draught and milk) and 41 per cent for only milk production and 38 per cent for only draught purpose (Akbar *et al.* 1996). However, recently the people are becoming more interested in rearing livestock for milk production as the country is now gradually moving for mechanisation of land cultivation.

In Bangladesh livestock are kept in small holder crop/livestock mixed farming systems, where there exists a form of interdependency between these two components. In the past, land remained fallow for long time in a year between two crops and the livestock, particularly ruminants, were allowed to graze in it. However, in the present time, because of the increasing demand for human food production, the land is intensively used for cereal crop production and neither any grazing land is available for livestock nor can the farmers spare land for growing fodder to feed their livestock. Consequently there is tremendous shortage of green forage for ruminant livestock and they are to live only on rice straw which is well known for its serious deficiency in protein and micronutrients. This situation has led to the low productivity of livestock in the rural area and livestock rearing is proceeding towards an uneconomic component of agriculture. Moreover, intensive cropping system is resulting in degeneration of soil fertility as there is little time for regaining soil nutrient status. Under this situation, it is imperative to identify some methods or approaches to integrate fodder production into cropping systems of the rural farmers and save the livestock component from extinction.

The benefits of integration of fodders, particularly legume fodders, into non-leguminous food cropping systems have been elucidated by a few researchers out side Bangladesh.

Haque (1992) stated that in crop/livestock production system, legumes can be integrated with crops to improve soil fertility and soil structure, thus enhance crop yield and to provide high quality feed for livestock.

This is relatively new area of work in this country and therefore, the scientific information on the research results regarding this aspect is scarce. A limited number of research has been carried out in the recent past, sporadically or if systematically, are all on-station basis. Some works done by Mamun *et al.* (1993) and Bhuiya and Hossain (1993) showed that legume fodders such as Vigna and Sesbania can be grown successfully in the existing rice cropping system without affecting its yield. More recently, Rahman (1995) reported from his intensive on-station studies that both legume and non-legume fodder can be successfully grown in integration with rice-based cropping system and yield of subsequent crop (rice) was improved. There is thus a need to examine the practical application of the approaches of integration of legume fodders into rice-based cropping system in rural area which has not been done in any previous research efforts. In this connection, a survey study was carried out very recently and the results showed that the rural farmers are interested in growing fodders if suitable technologies are provided to them.

Introduction of legume fodder in the rice cropping system may have dual advantage that it increases the supply of high quality green fodder to the ruminant animals and at the same time it may increase soil fertility by adding nitrogen and organic matter for better production the following rice crop. Haque (1992) also reported the use of legumes as intercrops, enhancing both crop yield and providing high quality feed for livestock.

From the above discussion it appears that there is a very large shortage of fodder for ruminant livestock in Bangladesh which is a serious threat to the livestock farming in this country. However, there is possibility of increasing the fodder supply to the animals through the adoption of appropriate technology and thus developing efficient feeding system for improving the productivity of rural cattle. With these views in mind a research programme was undertaken in order to achieve the following objectives:

1.2 Objectives

i. To introduce production of legume fodder into rice-based cropping system without alteration of the existing cropping pattern.
ii. To increase the supply of high quality fodder for livestock, particularly dairy cattle of rural farmers
iii. To improve milk production of rural indigenous dairy cows through supplementation of fodder with rice straw-based diets.
iv. To develop sustainable feeding system with straw-based ration for dairy cows of Bangladesh.
v. To improve soil fertility though legume fodder cultivation for better rice production.
vi. To examine the socioeconomic benefits of legume fodder introduction into cropping system.

2. PROJECT PURPOSE

From the discussion of the foregoing section it is clear that the major constraints for improvement of productivity of livestock in Bangladesh are the shortage of feeds and fodder and lack of sustainable scientific feeding system available to them. It is now imperative to improve the productivity of livestock to sustain livestock farming in Bangladesh. In order to do this the above constraints has to be eliminated or at least mitigated.

The shortage in the supply of green fodder may be mitigated by motivating the rural farmers towards cultivation of fodder for their animals. This is, in its straight form, is not acceptable to the farmers as they are more interested in rice crop production and although most of them realised the importance of feed for livestock, can not spare land for fodder production at the cost of rice production. Therefore, to improve the condition, suitable technology should be transferred to the doorstep of the village farmers so that their traditional practices are not disturbed and it is not costly one, or in other words, socio-economically viable. Under the above situation, it has become an urgent need for adopting some technique to improve fodder production situation without changing the existing crop production pattern. This will allow supplementing rice straw diets of dairy

cows with the produced green fodder in order to improve milk production of these animals. A further maipulation of this technology towards strategic feeding of cows, a sustainable feeding system may be developed for dairy cows under small holder farming system.

There are opportunities to improve the situation of shortage of fodder supply and low productivity of the animals. Integration of fodder legumes with rice-based cropping system may be an appropriate technology for this situation. The benefits of supplementation of straw-based rations for ruminants with green fodders, particularly leguminous fodder, have been reported by several authors (Nielson, 1981; Preston, 1986; Karim *et al.* 1988; Khan *et al.* 1990). A study on the levels of milk production, as affected by different diets based on urea-treated straw, suggested that even high quality rations containing fishmeal responded well when supplemented with green grass (Khan *et al.*, 1990).

Of the green fodders, legumes are of good quality and contain high level of protein and micronutrients. There are a number of leguminous fodders available in the country such as Khesari (*Lathyrus sativus*), cowpea (*Vigna unguiculata*) sunnhemp (*Crotalaria juncea*), *Leucaena leucocephala* and species of Sesbania. Of these, Sesbania is of particular importance because of its special qualities. It is a tree legume used for soil fertility regeneration and also for fire wood. There is now growing interest in the use of Sesbania as a supplement to low quality diets for ruminants. Khan *et al.* (1990) found that supplementation in straw –based diets with Sesbania increased production of milk in local cows. There are two varieties of Sesbania available in the country: *Sesbania aculeata,* which is indigenous, and *Sesbania rostrata*, which is recently introduced exotic one. Studies have shown that *S. rostrata* produces more dry matter and has a higher crude protein content than *S. aculeata* (Akbar, 1993). It is also well eaten by ruminants (Akbar *et al.* 1994). Moreover, it can be propagated vegetatively and can stand waterlogging in the field. The possibilities for integration of this legume into the cropping systems of rural farmers have been reported by several authors. It has been suggested that there are some advantages in using *S. rostrata* as green manure to improve soil fertility and structure in lowland rice production.

There are some home produced grain byproducts available to farmers, they have rice straw. In addition, if they have high quality green fodder like legume fodder, it is possible to develop a sustainable feeding system with these feed items to improve the productivity of indigenous dairy cattle of Bangladesh.

Cultivation of legume fodder by integration in the rice cropping system may also improve soil fertility and as a consequence improves the yield of the following rice grain. In addition, use of legume fodder, if improve soil fertility, may restrict the use of chemical fertiliser and thus may prevent environmental pollution.

Production of grain byproducts at home does not involve extra cost to the farmers, fodder production may not involve much cost. Therefore, formulation of somewhat balanced ration for dairy cows using rice-straw, legume fodder and little concentrate is expected to be cost effective and socio-economically acceptable.

Considering the above views, the general purpose of the project was to promote strategies to improve the seasonal availability of livestock feeds in high potential areas of Bangladesh. The specific purpose of the project was to adopt the technology of production of fodder legumes through integration into intensive rice-based cropping systems in order to mitigate the alarming shortage of livestock feeds and fodder. The ultimate aim was to develop sustainable and efficient feeding system for improving the productivity of dairy cattle under crop/livestock intensive farming system in rural areas of Bangladesh and thus improve the health and economic condition of the rural farmers.

3. RESEARCH ACTIVITIES

Before actual commencement of the main project activities, a survey study was conducted in two target rural areas of 17 and 20 km away from the Mymensingh district town in order to assess the socioeconomic conditions, existing cropping system and livestock management system, awareness of farmers regarding the importance of fodder and its role in livestock feeding and their productivity.

In each area, a total of ten villages, each having ten farmers (five small +five medium) were selected for the study. Therefore, in total 200 farmers were selected (100 small and 100 medium farmers). Data and information were collected from the heads of the farm households using a pre-tested structured questionnaire (Appendix 1) through direct

interview. Based on the results of the survey study the main project activities were started from Middle of 1996.

The activities of the project was adaptive research carried out in Bangladesh under the Dept. of Animal Nutrition, Bangladesh Agricultural University and sponsored by the DFID, U.K. It was a technology transfer research and farming household members (small holders) in rural area was directly involved in the evaluation of technology to improve animal feed supplies, feeding strategies and the performance of livestock in rural area. The whole research programme, with the above mentioned objectives and purpose, was performed under three components: fodder production, animal feeding trial and socio-economic activities. Therefore, it will be worth describing the activities under the subheadings of these components. The activities under on-farm and on-station will be discussed under the above subheadings wherever applicable. The main aim of organising the on-station study was to investigate for the optimum production response by the animals or fodder under controlled conditions. This allowed the comparison of these responses to those under rural farmers' condition. However, on-farm responses, both fodder and animal productions were the target of the programme.

3.1 Fodder Production

The major aim of this research was to introduce fodder production in the rice cropping system. This activity of fodder production was performed both on-station and on-farm. It may be best described the activities under these conditions separately.

3.1.1 On-farm fodder production

3.1.1.1 Activity 1 (1996/97)

Selection of Farmers: Seven medium farmers having 1.02 to 3.04 ha of land and minimum of 3 cattle heads per farm were selected from Rajpur village under Muktagacha Thana of Mymensingh district for the study and considered as prarticipatory research farmers.

Production of *Lathyrus sativus*: Seeds of Lathyrus was sown by all the 7 farmers in November 1996 in the standing T. aman rice field as relay crop at the rate of 40 kg/ha. After harvesting of T. aman crop, the Lathyrus plants were left in the field and started to grow rapidly.

No fertiliser and irrigation were applied and no intercultural operations were done. The crop was harvested in February 1997 and the data on plant height, number of branches per plant and green weight of fodder were recorded from the plant samples collected from 5 places of plots as described in case of Sesbania on-station above.

Production of *crotalaria juncea*: All seven farmers grew Crotalaria in their fallow land after harvesting T. aman rice. The land was prepared and seeds of crotalaria were broadcasted in early December, 1996 at the rate of 40 kg/ha. No fertiliser, irrigation or intercultural operations were done in the crop. The fodder was harvested in January 1996. Data on plant height and biomass yield were recorded.

3.1.1.2 Activity 2 (1997/98)

Cultivation of *S. rostrata*: The same seven farmers, who cultivated Lathyrus fodder in the last year, broadcasted sowed the seeds of Sesbania first in the small plots (seed bed) at the rate of 45 kg/ha during at the end of March, 1997. When the plants grew well two types of cuttings were made from each plant one was top portion cutting, the other was the middle portion. The length of the cuttings were about 50 cm. The cuttings were planted in the fallow plots after harvesting Boro rice in May 1997. No fertilizer or intercultural operations were done. The fodder was harvested in the middle of July 1997. Plant height and green biomass yield was recorded. A considerable amount of top portion of green biomass was used as animal feed and the rest portions were incorporated in the soil.

Cultivation of *L. sativus*: Eleven farmers (four more farmers in addition to seven cultivated Sesbania shown above. Broadcasted the seeds in late October, 1997 in the standing Transplanted aman (T. aman) rice as relay crop at the rate of 100kg/ha. All the farmers divided their plots into two subplots and grew Lathyrus for short-term production for 2.5 months i.e. up to the next Boro rice crop in one subplot. In the other subplot they kept Lathyrus fodder for long-term production for 3.0 months up to its full growth. The idea behind it was whether the farmers can get significantly higher quantity of fodder to compensate the late cultivation of the next rice crop. The fodder grown for short-term production was harvested towards the middle of January 1998. Long-term fodder was harvested in early February, 1998.

Among the 11 farmers who cultivated fodder, the fodder in the plots of one farmer did not grow well. So, data from the 10 farmers' plots were taken at 15 days interval for studying growth rate in terms of plant height, number of branches per plant and green weight.

3.1.1.3 Activity 3 (1998/99)

***Sesbania rostrata*:** Seeds of *Sesbania rostrata* were sown at the rate of 50 kg/ha in the seedbed of 9 farmers of Rajpur and Garaikuti villages. Two types of *Sesbania* cuttings, one from top and another from middle portion of the plant were used for plantation in the farmers field just after harvesting the Boro rice maintaining 50 cm line to line distance and 20 cm plant to plant distance. No other intercultural operations were required. The crop was harvested in July 1998. Data on plant height, and the fresh weight of plant were taken at the time of harvest. A considerable portion of green biomass was used as fodder for the cattle of the farmers and the rest were incorporated in the soil.

***Lathyrus sativus*:** The experiment was conducted during the period from October 1998 to January 1999 in the same area of Muktagacha. Seeds of Lathyrus were broadcasted in October 1998 in the plots of 8 farmers at the seed rate of 100 kg/ha. In all the farmer's plots, relay cropping of Lathyrus were practised in standing T. aman rice field. No fertilizer and irrigation were applied and no intercultural operations were done in the crops. The crop was harvested in January 1999 and data on plant height, number of branches/plant and fresh weight of forage were recorded. Top portion of green biomass was used as fodder for the cattle of the farmers and the rest were incorporated in the soil.

3.1.1.4 Activity 4 (1999/2000)

***S. rostrata*:** Seeds of *Sesbania rostrata* were sown in the seedbed of 9 farmers at the rate of 50 kg/ha. Both top and middle portion cuttings from the plants were transplanted in the field after harvesting Boro rice. No intercultural operations were done. The crop was harvested in July 1998. Data on plant height, and the fresh weight of plant were taken at the time of harvesting. A considerable portion of green biomass was used as fodder for the cattle of the farmers and the rest were incorporated in the soil.

3.1.2 On-station fodder production

3.1.2.1 Activity 1(1996/97)

Three legume fodders, *Sesbania rostrata*, *Lathyrus sativus* and *Crotalaria juncea* were cultivated in the field plots of the Dept. of Agronomy and the Dept. of Animal Nutrition in two seasons, Summer and Winter. Sesbania was grown in Summer and Lathyrus and Crotalaria & were grown in Winter. Seeds of Sesbania were sown in April, 1996, and harvested in August 1996. Lathyrus and Crotalaria were sown in November, 1996 and harvested in January 1997. The Sesbania fodder was grown with application of different levels of phosphorus fertiliseer (0, 25, 50, 75 and 100% of the recommended dose of 270g TSP per 15 sq. metres). This fertiliser application was done to examine the effect of phosphorus on the yield of Sesbania. No fertiliser was applied to Lathyrus and Crotalaria. None of the fodder needed irrigation or intercultural operations. During harvest, the yield of fodder was recorded by taking the weight of green fodder within 1 sq. metre area sampled from 5 different places of the plots. The average of all five samples was taken as the yield expressed in per cectare.

Chemical analysis of fodder: The samples of each of the three fodders were processed and analysed in the Animal Nutrition laboratory for its proximate nutrients according to AOAC (1990).

3.1.2.2 Activity 2(1997/98)

On-station fodder production was done in order to monitor the yield and to conduct animal feeding trial.

***Sesbania rostrata*:** Seeds were sown in the previously prepared land in April, 1997 in the field plots of the Dept. of Animal Nutrition. No irrigation or fertiliser were applied to the land, only thinning of plants was done. The crop was harvested in late July 1997. Data on biomass yield was recorded.

***Lathyrus sativus*:** The fodder was grown in the fields of Animal Nutrition Dept. by sowing seeds in the previously prepared land in November, 1997. No irrigation, fertiliser or intercultural operations were needed. The fodder was harvested in January 1998 and yield was recorded.

3.1.2.3 Activity 3 (1998/99)

On-station production of both fodders, Sesbania as well as Lathyrus were performed in the experimental field plots of the Dept. of Animal Nutrition and Dept.of Agronomy with a view mainly to compare the results of animal feeding trial on-station and also some aspects of production with those of the on-farm.

3.1.2.4 Activity 4 (1999/2000)

On-station production of both fodders, Sesbania as well as Lathyrus were performed in the experimental field plots of the Dept. of Animal Nutrition and Dept.of Agronomy with a view mainly to compare the results of animal feeding trial on-station and also some aspects of production with those of the on-farm.

3.2 Soil nutrient and rice yield study (On-farm)

3.2.1 Activity 2 (1997/98)

Soil nutrient study: Soil samples were collected from five different places of each plot where the above fodders (Sesbania and Lathyrus) were grown in order to monitor the effect of cultivation of legume fodder on the soil fertility. The samples were collected before fodder cultivation and also seven days after harvesting fodder. With the help of metal tool called augar up to approximately 6 inches depth of the soil and from five different places in each plot. Collected soil samples were processed and analysed in the laboratory for the determination of organic matter and nitrogen following the method of Page et al. (1982).

Rice yield study: Yield of rice per unit of land (t/ha) was also recorded in order to examine the effect of cultivating fodder on the following rice yield. This was done by dividing the rice field into two equal subplots – one was used for cultivation fodder and the other half was left fallow up to the cultivation of the next rice crop. Both subplots were treated similarly. After harvesting fodder both the subplots were ploughed and treated equally as the preparation for production of the next rice crop. After harvesting rice crop, grain yield of the two subplots were calculated and compared as the yield before (without) and after (with) fodder cultivation. Any difference in yield was

considered as the effect of contribution of fodder legume. The same method was followed for both types of fodder legumes, *Sesbania rostrata* and *Lathyrus sativus*.

3.2.2 Activity 3 (1998/99)

Soil nutrient status: Soil nitrogen and organic matter levels were determined by analysing the representative samples of the soil of the plots collected before and after growing fodders. The collected soil samples were processed and analysed in the laboratory for the above nutrients as has been described in Activity 2.

Rice yield study: Yield of rice grain per hectare was recorded both with or without cultivation of fodder in order to examine its the effect of legume fodder cultivation on rice yield. The procedure followed was the same as described under Activity 2.

3.2.3 Activity 4 (1999/2000)

Soil nutrient study: Soil nitrogen and organic matter levels were determined by analysing the representative samples of the soil of the plots collected before and after growing fodders. The soil samples were collected with the help of augar, a metal machine used as a probe to collect soil up to the depth of 6 inches from the surface.

Rice grain yield: The whole land was divided into two equal subplots – one was used for cultivation of fodder and the other half was left fallow up to the cultivation of the next rice crop. Both subplots were treated similarly. After harvesting fodder both the subplots were ploughed and treated equally as the preparation for production of the next rice crop. After harvesting rice crop, grain yield of the two subplots were calculated and compared as the yield before (without) and after (with) fodder cultivation. Any difference in yield was considered as the effect of contribution of fodder legume. The same method was followed for both types of fodder legumes, *Sesbania rostrata* and *Lathyrus sativus*.

3.3 Animal feeding trial with legume fodder

Animal feeding trial was conducted in order to find a suitable level of supplementation of the fodder with rice straw based ration for animals and also for recording the effects of supplementation on growth and milk production of the fed animals.

3.3.1 On-station animal feeding trial

3.3.1.1 Activity 1 (1996/97)

***Sesbania rostrata*:** Sixteen indigenous zebu heifers were grouped into four and supplied with 0, 0.50, 0.75 and 1.00 kg/d/ of green Sesbania fodder. Other ingredients of the ration were commons feeds such as rice straw, wheat bran, rice polish and oil cake. The ration without supplementation contained green grass. The trial was continued for 45 days. Data on feed intake, digestibility and growth rate of animals were recorded.

***Lathyrus sativus*:** The similar feeding trial experiment as mentioned for Sesbania above, was also conducted with same groups of animals with different levels (0, 0.05, 1.00 and 1.5 kg/d) of Lathyrus green fodder. The experiment continued for 42 days. Data were taken to study the same parameters as in the case of Sesbania experiment.

***Crotalaria juncea*:** The yield of fodder was not sufficient to conduct the feeding trial experiment.

3.3.1.2 Activity 2 (1997/98)

***Sesbania rostrata*:** As in the case of animal experiment with Sesbania in the last year of the project, the animals, grouping, basal rations were the same. Only difference was that the Sesbania fodder was supplemented at the levels of 0, 0.75, 1.00 and 1.50 kg/d. The data collected and the parameters studied were also the same as in the previous year. The experiment was conducted for 45 days.

***Lathyrus sativus*:** This experiment was conducted during the period from early January to February 1998. By this time some of the heifers came into milk production. So, the Lathyrus feeding trial was done using these lactating cows.

Six lactating dairy cows of same age and stage of lactation were grouped into two each having 3 animals. They were supplied with two straw-based rations containing rice straw, wheat bran and oil cake but differing in roughage content, green grass or Lathyrus hay at the rate of 1.0 kg/d. Daily feed intake was recorded and faeces were collected for seven days to study the digestibility of feeds. Data on daily milk yield of the animals were collected and milk samples were analysed for its composition. All data were pooled and analysed statistically following paired T-test.

3.3.1.3 Activity 3 (1998/99)

***Sesbania rostrata*:** The experiment was conducted at the Bangladesh Agricultural University Animal Nutrition Field Laboratory for a period of 35 days using six lactating indigenous cows of similar age and body condition. They were also at the same lactation stage. The cows were grouped into two each having three animals. Two straw-based rations were formulated using the available feed ingredients but without or with (1.5 kg /d) the inclusion of *Sesbania rostrata* fodder as supplement. Milk production was recorded for each cow every day. Data for feed intake and digestibility of feeds were also recorded. The feeding and management of the animals were same as mentioned in the previous experiments.

***Lathyrus sativus*:** Six lactating cows of similar age and body condition and at similar lactation stage were used in the experiment. They were grouped into two and supplied without or with (1.0 kg/d) the supplentation of Lathyrus hay. The feeding trial was continued for 60 days.

Feeding and management of animals, recording of feed intake, faeces collection, data for milk production were done in the similar way as in Sesbania fodder trial stated above.

3.3.1.4 Activity 4 (1999/2000)

***Sesbania rostrata*:** The experiment was conducted at the Bangladesh Agricultural University Animal Nutrition Field Laboratory for a period of 35 days using six lactating indigenous cows of similar age and body condition. They were also at the same lactation stage. They were grouped into two and supplied with two straw-based rations formulated using the available feed ingredients but without or with (1.5 kg/d) the inclusion of *Sesbania rostrata* fodder as supplement.

3.3.2 On-farm animal feeding trial

3.3.2.1 Activity 1 (1996/97)

Lathyrus sativus: The fodder yield per hectare was satisfactory, however, the total amount of fodder was not sufficient to conduct systematic feeding trial with animals. However, the animals were allowed for grazing in the fodder fields.

Crotalaria juncea: Per hectare yield as well as the total yield of this fodder was much lower in all the farmers' field compared to that of Lathyrus, and therefore, no systematic feeding trial with animals was conducted. However, the animals were allowed for grazing in the fodder fields.

Since the commencement time of the project exceeded the season for on-farm production of Sesbania, the fodder was not grown on-farm.

3.3.2.2 Activity 2 (1997/98)

***Sesbania rostrata*:** The feeding trial was conducted involving four farmers (three of them did not have sufficient fodder to feed animals) at Rajpur village, Muktagacha Thana under Mymensingh District. All of them had both milking cows as well as growing animals. The farmers harvested the edible top portion of the fodder from their fodder plots and fed to the animals for conducting animal feeding trial. Four farmers had sufficient amount of fodder to conduct feeding trial for growth and milk production of the animals. Others could not conduct the trial as they did not have sufficient fodder because of the predators and other reasons.

The animals were maintained under almost similar conditions. They were supplied with *adlibitum* chopped rice straw supplemented with Sesbania green fodder at the rate of 0.5 kg/day per cattle. Weekly live weight gain was recorded with the help of measuring tape. Milk yield was recorded every day.

***Lathyrus sativus*:**

Out of the 11 farmers, three of them did not have either sufficient fodder to conduct feeding trial or did not have lactating cows to feed. Therefore, thirteen lactating dairy cows of eight farmers were fed on chopped straw diet supplemented with Lathyrus hay at 1.0 kg/d. The study was conducted for 28 days. The yield of milk per day by the same cow was recorded for more than a month before starting feeding trial and considered as yield before feeding the fodder. During this time the decrease in milk production over the monitoring period before feeding fodder was recorded and in the similar way the gradual decrease in the production during the experimental period was also recorded and the differences were corrected. This value was compared with that recorded during feeding Sesbania. Data for milk production were pooled and analysed following paired T-test.

3.3.2.3 Activity 3 (1998/99)

***S. rostrata*:** Seven farmers having 8 lactating cows started feeding *S. rostrata* fodder after harvesting the fodder by clipping the edible portion every day and mixing with chopped rice straw. The animals were also supplied with small amount (300g) of rice polish from their own source. The feeding trial was continued for 35 days. Each farmer recorded milk yield of their cows every day. The feeding practice and milk yield recording followed by the farmers were monitored frequently. Milk production of each cow was recorded daily and the method of calculation and comparison of yield with unsupplemented group was done as mentioned earlier.

***L. sativus*:** Seven farmers having the lactating cows started feeding *L. sativus* fodder by harvesting the fodder cutting the edible portion every day and mixing with chopped rice straw. The animals were also supplied with small amount (300g) of rice polish. The feeding trial was continued for 30 days. Each farmer having cows, recorded milk yield every day. Their feeding practice and milk yield recording were monitored frequently.

3.3.2.4 Activity 4 (1999/2000)

***Sesbania rostrata*:** Eight farmers having the lactating cows started feeding *S. rostrata* fodder by harvesting the fodder by clipping the edible portion every day and mixing with chopped rice straw. The animals were also supplied with small amount (300g) of rice polish from their own source. The feeding trial was continued for 35 days. Each farmer recorded milk yield of their cows every day. The feeding practice and milk yield recording followed by the farmers were monitored frequently. The yield of milk per day by the same cow was recorded for more than a month before starting feeding trial and considered as yield before feeding the fodder. During this time the decrease in milk production over the monitoring period before feeding fodder was recorded and in the similar way the gradual decrease in the production during the experimental period was also recorded and the differences were corrected. This value was compared with that recorded during feeding Sebania.

3.4 Economic study

3.4.1 Activity 1 (1996/97)

To adopt any technology, at the farmers levels, the farmers' socio-economic condition has to be studied first. This is because, soicio-economic condition of the farmers affects their farming practices and household economics. Therefore, it is important particularly to know the background information related to socio-economic components of the farmers.

Selection of farmers: The specific objective of this study was to examine the economics of producing legume fodder in the rice field of farmers and to compare that with non-research farmers. For this purpose, in total 15 medium farmers having at least 3 cattle heads were purposely selected from Muktagacha Thana of Mymensingh district and were divided into two groups: research group having 7 farmers and the non-research group having 8 farmers. Data were collected on the source of income, surplus income, ownership of livestock their feed supply and production etc. in the first stage of the socio-economic study. In the second stage different economic activities were monitored and recorded both on-farm and on-station. The data for economic activities included fodder yield, gross income and gross margin of research and non-research farmers and their comparison. Economic returns and yield of the available variety of rice was also recorded at this stage.

Analytical methods applied: Data and information for the economic activities of the on-station study were tabulated and analysed. For on-farm study mainly tabular technique was used to calculate the meaningful results by using arithmetic mean, percentage and ratio.

3.4.2 Activity 2 (1997/98)

Selection of sample farmers: To achieve the socioeconomic objectives, the legume fodders were grown in both on-station and on-farm condition which were fed to cows and heifers reared by the targeted farmers. For conducting this study, 11 farmers were selected as research farmers in Rajpur villages of Muktagacha thana of Mymensingh district. The selection was based on the same criteria as was done for the previous study.

Data collection: Data on fodder production and its feeding were collected from November 1997 to February 1998 both on-farm and on-station. In on-farm condition, data and information were collected from research farmers through direct interview. For on-station trial, data and information were collected from records and accounts maintained for this purpose. For the research farmers, Block Supervisor in the study area and Scientific Officers of the research project recorded necessary data and information related to legume fodder production and its feeding to animal.

Analytical framework: Farm operators or owners of household were taken as the unit of analysis. Collected data were tabulated and reduced to tabular form which included classifications of tables into meaningful results by using arithmetic mean, percentage and ratio. In this study, mainly tabular technique was used for analysing data.

3.4.3 Activity 3 (1998/99)

Data collection: Data and information were collected from sample farmers through direct interview under on-farm condition. On-station data were collected from the records maintained by the scientific officers. Data were collected on the cost of production of legume fodder, its economic return both on-farm and on-station and also economic impact of fodder production under on-farm condition. Data on the women's participation in livestock rearing under on-farm were also collected.

3.4.4 Activity 4 (1999/2000)

Data collection: Data and information were collected from sample farmers through direct interview under on-farm condition in the same way as has been done in the previous years. Data were collected on the cost of production of legume fodder, its economic return both on-farm and on-station and also economic impact of fodder production under on-farm condition. Data on the women's participation in livestock rearing under on-farm were also collected.

During the conduction of the project activities, particularly for on-station, the infra-structural building facilities like animal shed and related things of the Department of Animal Nutrition of Bangladesh Agricultural University has been used. In addition, the

Departments analytical laboratory facilities have also been used extensively for chemical analysis of animal feed, faeces and soil samples. Animal Nutrition field plots as well as Agronomy field plots were used for growing fodder on-station.

The short-term expertise facility from DFID (Prof. Derrick Thomas) has been used in finalisation of the survey report initially prepared after surveying the agricultural and socio-economic condition of the farmers in the project area. Thereafter again the same expertise has been utilised for modification and finalisation of the originally submitted project memorandum. For the second time another expert from DFID (Dr. Wyn Richards, the LLP programme manager) visited during the middle of the project duration and helped in the form of criticism as well as suggestions for smooth running of the project.

There were no major modifications done to the research activities stated in the project memorandum. Only minor changes like the nitrogen balance and parameters on the reproductive performances of the animals on-station has not been recorded as the number of animals on lactation were insufficient to validate the reproductive results. Nitrogen balance study was not considered useful to compare with the on-farm study.

Fodder production practice in the bank of the pond was not found feasible. Instead of NPK, OM and N content of the soil of the fodder field were studied. These two parameters are found to be more easily detectable and well indicative to the general nutrient status of the soil.

The above minor changes in the activity of the research programme has not affected the desired and stated output of the project.

4 Out puts

4.1 Fodder production

Biomass yield (t/h) of Sesbania fodder on-station was quite satisfactory, 19.7 (Table 1 and Table 4). Application of phosphorus fertiliser non-significantly increased yield of Sesbania fodder on-station (Table 1) indicating that the farmers do not need to apply fertiliser to Sesbania fodder plots. On-farm Sesbania fodder was not cultivated.

Production of Lathyrus (t/ha) in the first year was higher (15.75) in on-station (Table 4) compared to that (12.80) in on-farm (Table 2). However, the yield on-farm was also satisfactory. The yield of Crotalaria on-farm (3.25 t/ha) as shown in Table 3, was

significantly lower than that (10.64 t/ha) of on-station (Table 4) indicating that Crotalaria was not as suitable fodder as Lathyrus at the farmers field.

Table 1. Effect of triple super phosphate (TSP) fertiliser on *Sesbania rostrata* fodder production (1996/97)

TSP level (% of recommended dose)	Seed (t ha^{-1})	Green biomass production (t ha^{-1})
0	0.42	19.7
25	0.39	19.5
50	0.42	18.8
75	0.44	18.8
100	0.44	20.2
Average	**0.42**	**19.4**

Table 2. Yield and yield characteristics of *Lathyrus sativus* grown as fodder crop in the farmers' field (1996/97)

No. of farmers	Plant height (cm)	Number of branches/plant	Fresh weight t/ha
1.	39.68	6.80	12.68
2.	44.40	7.72	13.98
3.	39.95	5.95	12.90
4.	37.35	5.80	11.45
5.	42.89	6.42	12.99
Average	**40.85**	**6.54**	**12.80**

Table 3. Yield and yield characteristics of *Crotalaria juncea* grown as fodder crop in the farmers' field (1996/97)

No. of farmers	Plant height at harvesting (cm)	Green weight at harvesting (t/ha)
1.	40.30	3.51
2.	43.60	3.80
3.	33.50	2.80
4.	38.40	3.15
5.	37.00	3.00
Average	**38.56**	**3.25**

Table 4. Yield and nutrient composition of three legume fodders, *Lathyrus sativus*, *Crotataria juncea* and *Sesbania rostrata* (1996/97)

Name of fodder	Biomass yield (t/ha)		DM (g/100g)	Nutrient composition (g/100g DM)				
	On-station	On-farm		CP	EE	Ash	ADF	NDF
Lathyrus	15.75	12.80	17.21	24.52	4.50	7.95	26.06	38.15
Crotalaria	10.64	3.25	16.03	22.71	1.37	7.14	38.06	43.23
Sesbania	19.74	-	20.83	34.94	5.60	10.51	21.65	33.55

In 2nd year, the average production (t/h) of Sesbania fodder on-farm (27.6) as shown in Table 5, was observed to be higher than that of on-station (25.5) . Results also showed that the biomass yield (t/ha) from the middle portion cuttings (32.3) was significantly ($P<0.05$) higher than that from the top portion cuttings (25.7) as shown in Table 5. A positive relationship can be assumed from the values between plant height and the biomass production.

Table 5. Yield and yield characteristics of *Sesbania rostrata* fodder grown in the farmers' rice field after Boro rice (1997/98)

No. of farmers	Plant height (cm)		SE	Biomass yield (t/ha)		SE
	Top portion	Middle portion		Top portion	Middle portion	
1.	103.5	112.5		23.38	25.42	
2.	102.0	108.9		24.67	27.39	
3.	139.3	175.3		25.66	32.30	
4.	99.6	114.4		21.10	25.45	
***Average**	**111.1**	**127.8**	**12.09**	**23.97[a]**	**27.64[b]**	**1.15**

*The average values for the same parameter bearing the superscript differ significantly ($P<0.01$)

The cultivation of Sesbania in the farmers' rice field can be seen in Photo plate 1.

Lathyrus production was performed under two durations: short duration (2.5 months) up to the next Boro rice and the long duration (3.0 months), the period exceeding or beyond the Boro rice. The results showed that the plant height and yield were increased as the duration advanced (Table 6).

(Photo plate 1 here)

Table 6. Yield and yield characteristics of *Lathyrus sativus* fodder grown in the farmers' rice field after T. aman rice (1997/98)

No. of Farmers	Short duration			Long duration		
	Plant height (cm.)	Number of branches per plant	Fresh yield (t/ha)	Plant height (cm.)	Number of branches per plant	Fresh yield (t/ha)
1.	43.17	7.9	15.85	63.63	5.85	18.87
2.	40.32	7.5	17.75	61.20	5.60	20.80
3.	46.60	8.5	13.60	51.00	6.79	15.47
4.	44.26	7.9	14.43	59.67	5.55	17.07
5.	42.63	7.5	7.85	39.67	6.73	8.53
6.	39.47	6.8	8.59	42.78	9.93	9.87
7.	45.12	8.1	18.75	51.13	6.45	20.80
8.	40.03	7.4	12.95	54.87	6.78	14.53
Average	**42.7**	**7.7**	**13.71**	**52.99**	**6.71**	**15.74**

The values in the table indicated that there was a positive relationship between plant height and biomass yield. However, number of branching had no relationship with yield. The total biomass yield for the short and long duration were 13.7 and 15.7 t/ha, respectively. Production of fodder in long duration was non-significantly higher than that in short duration indicating that the farmers do not need to keep the fodder in the field for longer time causing problems with the next rice crop. Lathyrus fodder grown in the farmer's field is also shown in Photo plate 2.

On-station production of fodder, *Sesbania rostrata* and *Lathyrus sativus* in the 3rd year of the project were 25.8 and 9.4 t/ha, respectively. On the other hand, the yield of the fodders on-farm were observed as 27.6 and 11.3 t/ha, respectively (Tables 7 and 8). It is observed from the table 7 that the plant height (cm) of Sesbania fodder varied from 138.40 as the lowest and 181.70 as the highest. The table also showed that the tallest plants were grown from the middle portion cuttings and shortest plants were from the top portion cuttings. Like plant heights yield of fodder, in general, were higher in middle portion cuttings than top portion. The yield (t/ha) value of middle portions cuttings varied from 28.00 to 32.60, whereas that of top portion cuttings varied from 24.57 to 30.05.

Yield results of Lathyrus fodder on-farm as presented in Table 8 showed that plant height (cm) varied from 29.47 to 36.60. The highest number of branches per plant was observed as 7.7 and the lowest was observed as 4.15. There is a positive relationship between plant height and the biomass yield of fodder. Similarly the number of branching had a positive

Table 7. Planting effect of different portions of *Sesbania rostrata* on plant height and biomass production (1998/99)

No. of farmers	Plant height (cm)		SE	Level of signifi-cance	Biomass weight (t/ha)		SE	Level of signifi-cance
	Top portion	Middle			Top portion	Middle		
1.	141.50	176.80			26.50	30.50		
2.	138.40	175.50			24.57	29.40		
3.	141.70	178.20			26.82	30.72		
4.	143.60	179.30			28.79	31.60		
5.	146.30	180.78			30.05	28.50		
6.	141.80	181.70			27.98	30.35		
7.	142.50	180.22			29.50	32.60		
8.	140.20	178.50			27.19	29.05		
9.	142.00	180.00			27.00	28.00		
Average	**142.00[a]**	**179.00[b]**	**0.56**	**	**27.60a**	**30.08[b]**	**0.64**	**

Table 8. Biomass yield and yield characteristics of *Lathyrus sativus* grown as forage crop in farmers' field (1998/99)

No. of farmers	Plant height (cm)	Number of branches/plant	Fresh weight (t/ha)
1.	36.6	7.70	14.30
2.	31.03	5.33	10.42
3.	33.15	6.20	12.35
4.	29.95	4.15	8.22
5.	31.87	4.87	9.43
6.	29.47	6.90	8.36
7.	32.50	6.03	12.00
8.	32.08	7.70	13.00
9.	33.82	6.90	13.18
Average	**32.27**	**6.00**	**11.25**

relationship with biomass yield as the lower number of branches of plant height resulted in lower yield (Table 8).

Production of biomass (t/h) of *Sesbania rostrata* on-station was found as 22.8 in the 4th year. Data on plant height and biomass yield of *Sesbania rostrata* in the filed plots of farmers are shown in Table 9. It is evident from the values that the plantation of seedings gave the taller plants than that given by the cuttings. The average value for the plant heights (cm) of the seedlings (170.0) was non-significantly higher than that of cuttings (127.0). However, biomass yield (t/ha) of the fodder was significantly ($P<0.01$) higher in seedlings (31.30) than that of cuttings (21.59). This comparison shows that plantation of Sesbania seedings results in better production than that of cuttings. However, another point should be considered here that seedlings require more plants for plantation per unit of land whereas two cuttings can be made from one mature plant.

Table 9. Yield and yield characteristics of *Sesbania rostrata* fodder grown in the farmers field after harvesting Boro rice

No. of farmers	Plant height (cm)			SE	Level of signifi-cance	Fresh yield (t/ha)			SE	Level of signifi-cance
	Transplanted by seedlings	Planted by cuttings				Transplanted by seedlings	Planted by cuttings			
		Top portion	Middle portion				Top portion	Middle portion		
1.	195.2	-	-			35.59	-	-		
2.	179.5	-	-			32.47	-	-		
3.	163.8	-	-			30.92	-	-		
4.	141.6	-	-			26.22	-	-		
5.	-	107.9	122.3			-	17.93	21.81		
6.	-	111.7	136.9			-	19.76	23.20		
7.	-	100.2	124.8			-	17.19	20.77		
8.	-	103.4	123.9			-	17.15	20.59		
Average	**170.025**	**105.8**	**126.975**	**37.26**	**NS**	**31.3**	**18.01**	**21.59**	**0.71**	**

Field production trial with legume fodders concluded that *Sesbania rostrata* can well be grown in between Boro rice and T. aman rice while Lathyrus can be grown as relay crop with T. aman rice and be continued up to next Boro rice crop. Sesbania can be grown by planting the cuttings of middle portion of the whole plant or planting the seedlings. The transplantation of whole seedlings gave higher production of fodder than planting the cuttings. However, both methods gave satisfactory fodder yield.

(Photo plate 2 here)

4.2 Nutrient composition of fodder

Sesbania contained the highest amount of CP (34.9%) and although that of Lathyrus (24.5%) was slightly higher than that of Crotalaria (22.7%) as shown in Table 4 above. Fat content of Sesbania as well as Lathyrus was much higher than that of Crotalaria.

4.3 Soil nutrient status

Soil nutrient status was not studied in the first year of the project. In the following years chemical analysis of soil showed that organic matter (OM) and nitrogen (N) contents before Sesbania fodder cultivation were 1.48% and 0.087% respectively. After cultivation the corresponding values were 1.77% and 0.10%, respectively (Table10).

Table 10. Nitrogen (N) and organic matter (OM) status of the soil of land before and after growing *Sesbania rostrata* fodder (1997/98)

No. of farmers	Organic matter (%)		SE	Level of signifi-cance	Nitrogen (%)		SE	Level of signifi-cance
	Before Fodder	After Fodder			Before Fodder	After Fodder		
1.	1.46	1.72			0.086	0.091		
2.	1.43	1.83			0.084	0.112		
3.	1.67	2.00			0.098	0.117		
4.	1.36	1.53			0.080	0.085		
Average	**1.48[a]**	**1.77[b]**	**0.049**	*****	**0.087**	**0.101**	**0.0056**	**NS**

Table 11. Nitrogen (N) and organic matter (OM) status of the soil of land before and after growing *Lathyrus stivus* fodder (1997/98)

No. of farmer	Organic matter (%)		SE	Level of significance	Nitrogen (%)		SE	Level of signifi-cance
	Before Fodder	After Fodder			Before Fodder	After Fodder		
1.	1.33	1.45			0.078	0.085		
2.	1.69	1.84			0.099	0.108		
3.	1.79	1.98			0.102	0.109		
4.	1.61	1.82			0.094	0.105		
5.	1.74	1.94			0.099	0.110		
6.	1.42	1.56			0.084	0.090		
7.	1.62	1.70			0.095	0.098		
8.	1.36	1.63			0.082	0.095		
Average	**1.57[a]**	**1.74[b]**	**0.013**	******	**0.093[a]**	**0.109[b]**	**0.0008**	******

Similarly, in the initial soil, the average OM and N contents were 1.57% and 0.093%, respectively and after cultivation and incorporation of Lathyrus fodder in the soil the nutrients were found to increase as 1.74% and 0.109%, respectively (Table 11).
These values indicated that cultivation of both of the fodders, Sesbania and Lathyrus improved OM and N contents of the soil. The magnitude of increase was higher with Sesbania compared to Lathyrus.
In the third year, chemical analysis of soil production fodder showed that both Sesbania and Lathyrus cultivation increased soil OM and N level. Production of Sesbania increased soil OM and nitrogen from 1.43 and 0.084% respectively, before cultivation, to 1.75 and 0.105%, respectively after cultivation (Table 12). Similarly, OM and N of soil were also increased from 1.72 and 0.100% as the initial to 1.79 and 0.105%, respectively after Lathyrus fodder cultivation (Table 13). When the contribution of both of the fodders to the soil nutrient status was compared, it was found that Sesbania added more OM and N to the soil than did Lathyrus.

Table 12. Nitrogen and organic matter status of the soil due to Sesbania fodder cultivation (1998/99)

No. of farmer	Organic matter (%)		SE	Level of signifi-cance	Nitrogen (%)		SE	Level of signifi-cance
	Before Fodder	After Fodder			Before Fodder	After Fodder		
1.	1.28	1.69			0.075	0.099		
2.	1.50	1.80			0.088	0.109		
3.	1.66	1.97			0.098	0.118		
4.	1.39	1.83			0.082	0.109		
5.	1.28	1.68			0.075	0.100		
6.	1.33	1.67			0.078	0.099		
7.	1.55	1.70			0.091	0.102		
8.	1.39	1.79			0.082	0.108		
9.	1.45	1.62			0.085	0.098		
Average	**1.43[a]**	**1.75[b]**	**0.035**	*	**0.084[a]**	**0.105[b]**	**0.035**	*

Table 13. Nitrogen and organic matter status of the soil due to Lathyrus fodder cultivation (1998/99)

No. of farmer	Organic matter (%)		SE	Level of signifi-cance	Nitrogen (%)		SE	Level of signifi-cance
	Before Fodder	After Fodder			Before Fodder	After Fodder		
1.	2.34	2.39			0.137	0.140		
2.	2.16	2.19			0.127	0.128		
3.	1.42	1.51			0.083	0.088		
4.	1.42	1.51			0.083	0.088		
5.	1.72	1.79			0.100	0.105		
6.	1.51	1.54			0.075	0.078		
7.	1.45	1.51			0.085	0.088		
8.	1.51	1.67			0.088	0.098		
9.	1.58	1.61			0.092	0.094		
Average	**1.72**	**1.79**	**0.014**	**	**0.100**	**0.105**	**0.001**	**

It was also found in the 4th year of the project that the cultivation of *Sesbania rostrata* increased soil OM and nitrogen of the producing land. Before cultivation, the level of OM and N were 1.76 and 0.082% and after fodder cultivation, the values were increased to 2.13 and 0.103%, respectively (Table 14).

It may be summarised from the above findings that cultivation of fodders, *Sesbania rostrata* as well as *Lathyrus sativus*, improves soil fertility in terms of soil OM and N. Among the fodders, the contribution of Sesbania found to be more than that of Lathyrus. These findings are supported by Haque (1992) and Rahman (1995) who reported that legumes and legume fodder improved soil fertility.

Table 14. Nitrogen and organic matter status of the soil of land before and after growing Sesbania fodder (1999/2000).

No. of farmer	Organic matter (%)		SE	Level of signifi-cance	Nitrogen (%)		SE	Level of signifi-cance
	Before Fodder	After Fodder			Before Fodder	After Fodder		
1.	1.78	2.18			0.081	0.111		
2.	1.80	2.14			0.077	0.092		
3.	2.06	2.38			0.098	0.126		
4.	1.80	2.27			0.089	0.109		
5.	1.76	2.06			0.076	0.097		
6.	1.53	1.95			0.071	0.089		
7.	1.75	2.10			0.083	0.100		
8.	1.59	1.97			0.078	0.103		
Average	**1.76**	**2.13**	**0.02**	**	**0.082**	**0.103**	**0.0019**	**

4.4 Rice grain yield

Like soil nutrient study, rice production study also was not done in the first year. Yield of T. aman rice and Boro rice as affected by Sesbania and Lathyrus fodder cultivation are presented in Tables 15 and 16 respectively. The results showed that the average yield (kg/ha) of T. aman rice followed by fallow land and also followed by Sesbania fodder cultivation were 3296.2 and 3696.8, respectively (Table 15). It clearly indicates that cultivation of fodder resulted in increased rice yield. The per cent increase in yield was calculated as 12.2. Similarly, as above, the yield of Boro rice per hectare was increased due to cultivation of Lathyrus fodder (Table 16). The per cent increase in this case was 6.5.

Table 15. Yield of T. aman rice as affected by legume fodder *Sesbania rostrata* cultivation in farmers' field (1997/98)

No. of farmers	Production (kg/ha)		SE	Level of significance
	After Fallow	After Fodder		
1.	3564.3	3969.8		
2.	3251.0	3639.2		
3.	3802.0	4234.0		
4.	3125.7	3519.0		
5.	2988.1	3369.9		
6.	3091.0	3489.6		
7.	3251.0	3656.4		
Average	**3296.2[a]**	**3696.8[b]**	**6.17**	*

Table 16. Yield of Boro rice as affected by legume fodder *Lathyrus sativus* cultivation in farmers' field (1997/98)

No. of farmers	Production (kg/ha)		SE	Level of significance
	After Fallow	After Fodder		
1.	6142.9	6575.8		
2.	5445.0	5814.4		
3.	6098.1	6407.8		
4.	5866.7	6269.7		
5.	4191.0	4635.1		
6.	4609.0	5056.9		
7.	5027.0	5400.2		
8.	4467.2	4870.3		
9.	5586.8	5967.5		
10.	5724.9	6038.4		
11.	5306.9	5680.1		
Average	**5315.0[a]**	**5701.5[b]**	**14.04**	*

Data for the 3rd year study on the production of T. aman rice and Boro rice as affected by Sesbania and Lathyrus fodder cultivation are presented in Tables 17 and 18 respectively. The results showed that the average (of 11 farmers) yield (kg/ha) of T. aman rice was 13% higher in the subplots where Sesbania was cultivated before rice (Table 17). This was probably the contribution of Sesbania to the soil in the form of increased nitrogen as well as OM as can be seen from the increased soil N and OM shown above, due to fodder cultivation. In the similar way the yield of Boro rice was also increased by about 6.5% due to cultivation of fodder Lathyrus (Table 18). The reason for such increase compared with the control plot (without fodder), is similar as in the case with Sesbania.
That the cultivation of legume fodder in the field before production has been found to increase rice yield (Rahman, 1995).

Table 17. Yield of T. aman rice as affected by legume fodder, *Sesbania rostrata* cultivation in farmers' field (1998/99)

No. of farmers	Production (kg/ha)		SE	Level of significance
	After Fallow	After Fodder		
1.	3196.8	3558.8		
2.	3211.7	3617.7		
3.	2838.5	3222.9		
4.	2476.5	2934.8		
5.	3193.1	3648.4		
6.	3566.3	3887.2		
7.	3211.7	3786.6		
8.	2655.6	3077.4		
9.	2655.6	2999.0		
10.	3200.5	3555.1		
11.	3577.5	3887.2		
Average	**3071.2**	**3470.5**	**23.14**	**

In the 4th year of the project, rice yield study also showed that Sesbania fodder cultivation increased T. aman rice production (Table 19). The additional OM and N from the fodder resulted in increased rice yield of 12.3 % over that of control.

Table 18. Yield of Boro rice as affected by legume fodder, *Lathyrus sativus* cultivation in farmers' field (1998/99)

No.of farmers.	Production (kg/ha)		SE	Level of significance
	After Fallow	After Fodder		
1.	5400.2	5784.6		
2.	5131.5	5437.5		
3.	5568.1	5896.6		
4.	4888.9	5202.4		
5.	5900.3	6310.8		
6.	4515.7	4971.0		
7.	5194.9	5478.6		
8.	4470.9	4750.8		
9.	5411.8	5687.6		
10.	5997.3	6325.7		
Average	**5247.9**	**5584.5**	**19.19**	**

Table 19. Yield of T. aman rice as affected by legume fodder (*Sesbania rostrata*) cultivation in farmers' field (1999/2000)

No. of farmers	Production (kg/ha)		SE	Level of significance
	After Fallow	After Fodder		
1.	4009.7	4529.3		
2.	4286.2	4756.2		
3.	3802.0	4301.5		
4.	3871.6	4363.6		
5.	3940.6	4410.6		
6.	4148.0	4638.2		
7.	3871.6	4383.6		
8.	4158.0	4638.3		
Average	**4010.9[a]**	**4502.7[b]**	**6.44**	**

The above results indicates that the cultivation of both of the legume fodders, *Sesbania rostrata* and *Lathyrus sativus* gave rise to increased rice production (T. aman as well as Boro rice) from 6.5% to 13.0%. Among the fodders, the contribution to the rice yield of Sesbania fodder was higher than that of Lathyrus. The reason for such increase compared with the control plot (without fodder) might be that the fodders are leguminous in nature and therefore added more N to the soil and its biomass incorporation increased OM content of the soil. This speculation is supported by the increased soil OM and N due to cultivation of fodders as shown in the Tables above. This view is also supported by Rahman (1995) who also found that the cultivation of legume fodder in the field before production of rice increased rice yield up to 19.0%.

4.5 Productivity of dairy cattle

Animal production study was performed through series of animal feeding experiments (trials) in different years of the project activity both on-station and on-farm. Table 20 shows the on-station feeding trial results of *Sesbania rostrata* as supplement to rice straw based ration in the 1st year. The results indicated that supplementation significantly ($P<0.01$) increased feed and energy intake, and organic matter digestibility. Growth of animals was also improved due to supplementation of straw diet with Sesbania fodder. However, the highest level (1.0 kg/d) improved significantly the growth rate of animals. The results of on-station feeding trial with Lathyrus fodder on growing heifer are shown in Table 21. Like that of Sesbania supplementation, Lathyrus fodder also significantly ($P<0.01$) increased feed and energy intake and feed digestibility. Growth rate was also increased significantly due to fodder supplementation. However, the highest level (1.5 kg/d) of supplementation significantly ($P<0.01$) improved intake, digestibility and growth of heifers compared to those on the unsupplemented diets.

Table 20. Feed intake, digestibility and live weight gain of animals fed on different experimental straw-based rations supplemented without or with *Sesbania rostrata* fodder (1996/97)

Parameters	Rations				SE
	A	B	C	D	
Feed intake:					
Total DM intake (kg/d)	2.94[ab]	2.83[b]	3.08[ac]	3.17[c]	0.052
Digestible OM intake (kg/kg DMI)	1.68[a]	1.73[a]	1.89[b]	1.98[c]	0.043
Digestibility:					
Organic matter digestibility (%)	65.09[a]	69.73[b]	70.36[b]	71.21[b]	1.69
Crude protein digestibility (%)	71.49	73.06	74.35	76.56	2.66
Crude fibre digestibility (%)	63.76	65.64	69.80	69.83	2.74
Live weight gain:					
Average initial live weight (kg)	95.00 ±0.41	100.00 ±0.82	106.00 ±0.71	115.50 ±3.04	
Average final live weight (kg)	104.75 ±0.48	110.25 ±1.49	117.50 ±0.87	129.25 ±2.93	
Daily live weight gain (g/d)	232[a]	244[a]	286[ab]	327[b]	23.97

The values for the same parameter bearing the superscripts differ significantly (P<0.01)
Rations A, B, C & D are having 0, 0.5, 0.75 and 1.0 kg fodder per day, respectively.

In the 1st year, it was not possible to conduct feeding trial experiment on-farm, since the amount of fodder (Lathyrus and Crotalaria) produced in a mass were not sufficient to feed the animals for sufficiently longer period. The animals, instead, were grazing on these fodders.

The results of animal feeding trial on-station in the 2nd year with Sesbania and Lathyrus supplementation are presented in Tables 22 and 23, respectively. Supplementation of rice straw diet with Sesbania green fodder at different levels did not significantly affect feed intake, but the digestibility of nutrients were significantly (P<0.05 & 0.01) incresed. The supplementation resulted in increased growth of the animals. As regards the level of supplementation, 1.5 kg/d gave the highest live weight gain for the animals (Table 22). Supplementation of Lathyrus hay on-station with straw-based diet did not influence the feed intake by heifers significantly, however, it increased the digestible OM intake significantly (P<0.05). The digestibility of organic nutrients were also significantly (P<0.01) increased by Lathyrus supplementation (Table 23).

Table 21. Feed intake, digestibility and growth rate of heifers fed on Lathyrus green fodder supplemented at different levels with straw-based diets (1996/97)

Parameters	Rations				SE	Level of signifi-cance
	A	B	C	D		
Feed intake:						
Dry matter intake (kg/d)	4.12	4.04	4.07	4.09	0.34	NS
Dry matter intake (g/kg w $^{0.75}$/ d)	102.04	102.86	104.79	104.26	2.27	NS
Digestible OM intake (kg/d)	2.29	2.26	2.35	2.43	0.07	NS
Digestibility (%):						
Organic matter	63.02^{a}	64.39^{ab}	66.27^{b}	69.23^{c}	3.45	*
Crude protein	66.51^{a}	70.24^{b}	74.11^{c}	75.84^{c}	2.89	**
Crude fibre	63.32^{a}	64.90^{ab}	66.05^{bc}	68.21^{c}	4.30	*
Live weight gain:						
Initial live weight (kg)	131.3 ±4.6	125.5 ±2.2	122.8 ±3.5	124.0 ±3.1		
Final live weight (kg)	145.8 ±5.2	141.3 ±2.0	140.0 ±4.1	142.5 ±3.5		
Live weight gain (kg/d)	0.296^{a}	0.321^{ab}	0.352^{b}	0.378^{c}	0.053	*
Nutritive value:						
Digestible crude protein (DCP)%	7.12^{a}	8.22^{b}	7.80^{a}	8.37^{b}	0.72	*
Total digestible nutrients (TDN)%	61.46^{a}	62.49^{a}	63.96^{b}	66.45^{c}	3.82	**
Metabolisable energy (MJ/kg DM)	8.91	8.96	9.23	9.52	0.41	NS

The diets A, B, C & D contained 0, 0.5, 1.0 & 1.5 kg fodder/d, respectively.
The values bearing the dissimilar superscript (s) differed significantly at P<0.05 (*) or P<0.01 (**)

Total digestible nutrients (TDN) of feedstuffs was also increased due to supplementation. Supplementation of Lathyrus hay with straw-based diet resulted in significant (P<0.05) increase (~14%) in milk yield of cows compared with those fed unsupplemented diets. Milk composition notably total solids, milk fat, serum solids and milk protein were also slightly increased due to fodder supplementation.

Table 22. Feed intake, digestibility and growth rate of animals fed straw-based rations supplemented with *Sesbania rostrata* at different levels (1997/98)

Parameters	Rations				SE	Level of significance
	A	B	C	D		
Feed intake:						
Dry matter intake (kg/d)	4.84	4.89	4.92	5.03	0.01	*
Dry matter intake (g/kg w^{075}/d	101.73	102.54	102.9	104.67	0.38	NS
Digestible OM intake (kg/d)	2.64	2.75	2.81	2.95	0.01	**
Live weight gain (kg/d**)**	0.293	0.343	0.371	0.436	0.01	**
Digestibility (%):						
Organic matter	62.96	64.70	65.55	67.30	0.27	**
Crude protein	76.46	69.96	73.52	76.10	0.34	**
Crude fibre	61.65	62.52	64.26	65.47	0.35	*
Nutritive value:						
Digestible crude protein (DCP)%	6.62	7.59	8.28	8.98	0.03	**
Total digestible nutrients (TDN) %	59.88	61.73	64.04	64.40	0.28	*
Metabolisable energy MJ/kg DM	8.74	8.99	9.12	9.38	0.04	*

The values are the average of four animals. This rations A, B, C and are having 0.0, 0.75, 1.0 and 1.5 kg Sesbania fodder per day respectively.

On-farm feeding trial showed that the supplementation of Sesbania green fodder with straw diet increased milk yield, on average, 0.23 litres daily (Table 24). When this increased value was expressed in percentage, it gave a value of 13%. This is not a high value but since the level of supplementation was low (only 0.5 kg/d), the increase was also low. Growth rate of cattle of three farmers was also studied with the same rate of supplementation of Sesbania fodder. The results showed that the cattle gained live weight of 0.272 kg/d, with average gain of 11 kg in 40 days (Table 25).

Table 23. Feed intake, nutrient digestibility, nutritive values, yield and composition of milk of cows fed on rations supplemented without or with *Lathyrus sativus* fodder (1997/98)

Parameters	Rations		SE	Level of significance
	A	B		
Dry mater intake (kg/d)	5.06	4.97	0.017	NS
Dry mater intake (g/kg $w^{0.75}$/d)	120.55	118.98	0.400	NS
Digestible OM intake (kg/d)	2.82	2.99	0.020	*
Organic matter digestibility (%)	63.75	68.46	0.250	**
Crude protein digestibility (%)	65.53	76.12	0.320	**
Neutral detergent fibre digestibility (%)	67.27	74.47	0.040	**
Digestible crude protein (%)	6.87	9.50	0.050	**
Total digestible nutrients (%)	60.49	64.93	0.410	*
Metabolisable energy (MJ/kg DM)	8.93	9.61	0.040	**
Milk yield (kg/d)	1.34	1.53	0.020	*
Total solids (%)	12.51	14.17	0.850	NS
Milk fat (%)	3.80	4.55	0.510	NS
Serum solids (%)	8.71	9.62	0.350	NS
Milk protein (%)	4.80	5.03	0.310	NS

* and ** denotes significant at 5% and 1%, respectively.

Supplementation of Lathyrus green fodder with straw diet on-farm significantly ($P<0.01$) increased milk production of cows of the farmers (Table 26). Milk yield of the cows fed on fodder supplemented diets was increased by 20% over the animals fed on unsupplemented diets. This increased in milk yield clearly indicates the positive effect of feeding Lathyrus fodder to lactating cows.

The results of on-station study of 3rd year on the supplementation of Sesbania fodder with straw-based diets (Table27) showed that feed intake did not vary significantly among the group of animals indicating that supplementation did not affect intake of feed by the animals. Rather the animal group receiving Sesbania supplements, showed a tendency to slightly higher feed intake. The similar observation was also reported Akbar *et al*. (1993).

Table 24. Milk yield of cows on-farm as influenced by feeding *Sesbania rostrata* fodder as supplement to straw diet (1997/98)

No. of farmers	No. of cow	Milk yield (kg/d)		SE	Level of significance	Per cent increase
		Before feeding Sesbania	After feeding Sesbania			
1.	1	1.7	1.9			
2.	1	1.5	1.7			
	2	2.0	2.2			
3.	1	2.0	2.2			
	2	2.0	2.3			
	3	1.6	1.9			
4.	1	1.6	1.8			
Average		**1.77**	**2.00**	**0.031**	**	**13.0**

Table 25. Growth of cattle on-farm as affected by feeding *Sesbania rostrata* fodder as supplement to straw diet (1997/98)

No. of Farmers	No. of animals	Initial LW (kg)	Final LW (kg)	Total LW gain (kg)	Daily LW gain (kg)
1.	1	142	153	13	0.289
	2	138	150	12	0.267
2.	1	135	146	11	0.289
3.	1	152	161	9	0.243
	2	148	158	10	0.270
Average		**143.0**	**153.6**	**11**	**0.272**

Among the digestibility values, crude protein (CP) digestibility and digestible CP were significantly ($P<0.05$, $P<0.01$, respectively) increased due to Sesbania supplementation. Total digestible nutrient (TDN), although was higher in the supplemented group, was not statistically significant.

The average yield of milk per day by different groups of animals are presented also in Table 27. From the table it is evident that milk production was significantly ($P<0.05$) increased in animals fed on the diets supplemented with Sesbania fodder.

Table 26. Milk yield of cows on-farm as influenced by feeding *Lathyrus sativus* fodder as supplement to straw diets (1997/98)

No. of farmers	No. of cow	Milk yield (kg/d)		SE	Level of significance	Per cent increase
		Before feeding Lathyrus	After feeding Lathyrus			
1.	1	2.00	2.50			
	2	2.25	2.75			
2.	1	2.25	2.75			
3.	1	2.50	3.00			
	2	2.25	2.50			
	3	2.00	2.25			
4.	1	2.75	3.25			
	2	2.00	2.50			
	3	1.75	2.25			
5.	1	2.00	2.50			
6.	1	1.75	2.00			
7.	1	1.75	2.00			
8.	1	2.00	2.50			
Average		**2.10**	**2.52**	**0.033**	******	**20.3**

The supplementation increased milk yield by 15% over that of control. This finding is in agreement with that of Khan *et al.* (1990) who also reported increased milk yield of local cows due to supplementation of *Sesbania sesban,* a local variety. The reason for increased milk yield due to supplementation could have been that the green leguminous fodder, Sesbania might have supplied higher amount of soluble protein (Table 1) and micronutrients which are deficient in straw-based diets containing non leguminous low protein Dal grass (~9% CP).

Table 27. Feed intake, nutrient digestibility, nutritive value and milk yield of cows fed rations supplemented without or with *S. rostrata* (1998/99)

Parameters	Rations		SE	Level of significance
	A	B		
Intake:				
Dry matter intake (kg/d)	5.02	5.12	0.036	NS
Dry matter intake (g/kg $w^{0.75}$/d)	109.29	109.18	2.93	NS
Digestible OM intake (kg/d)	2.68	2.85	0.082	NS
Milk yield (kg/d)	1.27^{b}	1.45^{a}	0.04	*
Digestibility (%):				
Organic matter	61.46	63.97	1.36	NS
Crude protein	59.92^{b}	65.07^{a}	1.09	*
Crude fibre	62.41	65.04	1.28	NS
Nutritive value:				
Digestible crude protein (DCP)%	5.68^{b}	7.11^{a}	0.12	**
Total digestible nutrients (TDN)%	57.44	60.06	1.19	NS
Metabolisable energy (MJ/kgDM)	8.53	8.90	0.19	NS

The values are the average of three animals. #A = Without Lathyrus, B= With Lathyrus

Like that of Sesbania trial, feed intake or digestible organic matter intake were not significantly affected by Lathyrus supplementation with straw based diets under on-station Table 28. Similarly, crude protein and organic matter digestibility values were not affected but crude fibre digestibility was significantly ($P<0.01$) increased due to Lathyrus supplementation indicating the improvement in the utilisation of straw by the animals. Digestible CP was increased due to supplementation.

Supplementation of Lathyrus hay with straw-based diet resulted in significantly ($P<0.01$) increased milk production of the cows compared to those fed on unsupplemented diet. The reason for increased (~14%) milk yield in the supplemented group over that of control might be explained in the similar way as in the case of sesbania mentioned above. Milk composition, in terms of total solids, fat, serum solids and crude protein of the cows fed on the Lathyrus supplemented diets increased, though not significantly, up to more than 10% compared to that of unsupplemented diets. The increased milk production and slightly in milk composition in the supplemented group might have been due to the significantly ($P<0.01$) increased fibre digestibility and digestible CP content of the supplemented diets.

Table 28. Feed intake, nutrient digestibility, nutritive values, yield and composition of milk of cows fed on the rations supplemented without or with *Lathyrus sativus* (1998/99)

Parameters	Rations		SE	Level of significance
	A	B		
Intake:				
Dry matter intake (kg/d)	5.02	5.01	0.025	NS
Dry matter intake (g/kg $w^{0.75}$/d)	110.0	109.14	1.43	NS
Digestible OM intake (kg/d)	2.84	2.89	0.051	NS
Digestibility (%):				
Organic matter	64.80	65.84	1.27	NS
Crude protein	63.93	67.06	1.40	NS
Crude fibre	63.60^{b}	66.48^{a}	0.20	**
Nutritive value:				
Digestible crude protein (DCP)%	6.27^{b}	7.55^{a}	0.11	**
Total digestible nutrients (TDN)%	60.40	61.81	0.92	NS
Metabolisable energy MJ/kg DM	9.05	9.23	0.13	NS
Milk yield (kg/d)	1.12^{b}	1.28^{a}	0.03	**
Composition of milk:				
Total solid (TS)%	13.21	14.51	1.15	NS
Fat %	3.82	4.60	0.82	NS
Serum solid (SS)%	9.09	9.91	0.35	NS
Crude protein (CP)%	4.96	5.08	0.55	NS

The values are the average of three animals. Group A = Without Lathyrus Group B = With Lathyrus

On-farm study in the 3rd year of the projects showed that milk production of cows increased significantly ($P<0.01$) due to feeding Sesbania as supplement to straw-based diets as can be seen in Table 29. Daily increased amount of milk is, on average, 400 ml, however, the per cent increase was rather high (26%). This increased value was higher than that of on-station study. The reason for such an increase in milk production may well be attributed to the supplemental effect of Sesbania fodder.

Milk production data (3rd year) of the cows of the research farmers fed on Lathyrus supplemented straw-based diets are presented in Table 30. It can be seen from the table that the daily milk yield was increased significantly ($P<0.01$) due to Lathyrus

Table 29. Milk production of the cows of the farmers as affected by feeding *S. rostrata* with straw-based diet (1998/99)

No. of Farmers	No. of cow	Milk yield (kg/day)		SE	Level of significance
		Before feeding Sebania	After feeding Sesbania		
1.	1	1.00	1.30		
2.	1	1.50	2.00		
	2	1.75	2.25		
3.	1	1.75	2.00		
4.	1	1.50	2.00		
	2	2.25	2.60		
5.	1	1.75	2.25		
6.	1	1.50	1.70		
7.	1	1.25	1.75		
Average		**1.58[b]**	**1.98[a]**	**0.096**	**

Table 30. Milk production of the cows of the farmers as affected by feeding *L. sativus* with straw-based diet (1998/99)

No. of Farmers	No. of cow	Milk yield (kg/day		SE	Level of significance
		Before feeding Lathyrus	After feeding Lathyrus		
1.	1	1.00	1.25		
2.	1	1.25	1.50		
3.	1	1.50	1.70		
4.	1	1.25	1.50		
	2	2.00	2.25		
5.	1	1.50	2.00		
6.	1	1.25	1.60		
7.	1	1.00	1.20		
Average		**1.34[b]**	**1.63[a]**	**0.052**	**

supplementation. The per cent increase (daily) in milk yield was about 20%. Which is higher than that of on-station study.

The reason for greater increase in milk yield under on-farm than that under on-station might be that the animals under on-station study was already was on the moderate concentrate diets well before starting experiment. Therefore, milk production was near optimum level and the additional supplementation did only increase moderately. However, in case of on-farm study, the supplemental effect was more pronounced as the case was reverse to that of on-station.

On-station study in the 4th year indicated that the feed intake of animals slightly increased due to supplementation of Sesbania fodder (3.0 kg/d) with straw-based diets (Table 31). The data in the table also showed that milk production of the cows fed on Sesbania supplemented diets gave significantly ($P<0.01$) higher milk yield than those on the unsupplemented diets. The per cent increase in the yield was calculated to be 16.5 %. Laboratory analysis of milk samples from both group of animals showed that milk composition in terms of total solids, fat, serum solids and crude proteins showed variable response due to supplementation of Sesbania green fodder with straw-based diets (Table 31). Suplementation resulted in significant ($P<0.05$) increase in milk fat and milk protein, however, total solids and serum solids were non-significantly increased.

Milk production per day of the cows of the farmers fed on Sesbania green fodder supplemented (3.0 kg/d) diets was found, on average, significantly ($P<0.01$) higher than those fed on unsupplemented diets (Table 32). Per cent increase in milk yield due to fodder supplementation was 28%. The reason for this high milk in comparison with the previous level of increase, might be that the diets supplied to the cows, in this study, composed of rice-straw, Sesbania fodder and 500g rice polish. This combination of feed ingredients was expected to make the balance of nutrients in the diets which has been established fact to improve the productivity of animals.

The above has been considered as the new feeding system for the dairy cows of the rural farmers with straw-based diets.

Table 31. Feed intake, digestibility, yield and composition of milk of cows fed the rations supplemented without or with *Sesbania rostrata* (1999/2000)

Parameters	Rations		SE	Level of significance
	A	B		
Feed intake:				
Dry matter intake (kg/d)	5.09	5.00	0.02	*
Dry matter intake (g/kg w^{075}/d	109.67	106.87	1.17	NS
Digestible OM intake (kg/d)	3.30	3.32	0.02	NS
Digestibility (%):				
Organic matter	64.88	64.88	0.3	*
Crude protein	67.03	72.41	0.92	*
Crude fibre	62.75	64.16	0.33	NS
Nutritive value:				
Digestible crude protein (DCP)%	6.48	8.89	0.12	**
Total digestible nutrients (TDN) %	60.63	62.78	0.27	*
Metabolisable energy MJ/kg DM	9.05	9.26	012	**
Milk yield (kg/d)	0.80	0.93	0.16	NS
Composition of milk:				
Total solid (TS)%	13.57	16.06	1.76	NS
Fat %	5.40	6.20	1.53	NS
Serum solid (SS)%	8.17	9.86	0.89	NS
Milk protein %	5.81	6.19	1.13	NS

The values are the average of three animals. Group A = Without *Sesbania rostrata*
Group B = With *Sesbania rostrata*

On-station *in situ* study on the degradation in the rumen of dry matter (DM) and crude protein (CP) of *Sesbania rostrata* is presented in Table 33. The data in the table showed that both Sesbania and Lathyrus had high soluble materials. The potential degradability of DM were similar but that of CP was higher in Sesbania than that of Lathyrus. The DM and CP degradability values of both Sesbania and Lathyrus fodder at different time intervals are shown in Appendix Table 2.

Table 32. Milk yield of on-farm as influenced by feeding *Sesbania rostata* fodder as supplement to straw-based diet (1999-2000).

No. of farmers	No. of cows	Milk yield (kg/d)		SE	Level of significance	Percent increase
		Before feeding *Sesbania rostrata*	After feeding *Sesbania rostrata*			
1.	1.	1.00	1.25			
2.	1.	1.25	1.50			
3.	1.	1.25	1.50			
	2.	1.50	2.25			
4.	1.	1.25	1.50			
	2.	1.50	2.00			
	3.	2.00	2.50			
5.	1.	1.50	2.00			
6.	1.	1.25	1.50			
7.	1.	1.75	2.25			
8.	1.	2.00	2.75			
	2.	2.25	2.75			
Average		**1.54[a]**	**1.97[b]**	**0.058**	**	**28.0**

Table 33. Degradation characteristics of dry matter (DM) and crude protein (CP) of *Sesbania rostrata* and *Lathyrus sativus* fodders

Parameter	*Sesbania rostrata*	*Lathyrus sativus*
Dry matter (DM):		
Rapidly soluble fraction (a)	23.03	24.94
Slowly degradable fraction (b)	43.05	40.43
Rate constant (c)	0.0575	0.0493
Potential degradability (a + b)	66.08	65.37
Effective degradability (P) at kp= 0.02/h	55.10	53.0
Crude protein (CP):		
Rapidly soluble fraction (a)	51.13	42.84
Slowly degradable fraction (b)	40.08	44.62
Rate constant (c)	0.0659	0.0565
Potential degradability (a + b)	91.22	87.46
Effective degradability (P) at kp= 0.02/h	81.90	75.6

The values were calculated by the exponential equation, $p = a + b (1- e^{-ct})$.

At the end of the incubation period the concentration of ammonia-N and the total VFA production in the rumen of cattle were studied. The concentration of ammonia-N (mg/L)

in the rumen was 168 in Sesbania fodder supplemented animal group compared to 112 in the animals (control) supplied with green grass. The total VFA production (mM) in the rumen at that time was 84 in Sesbania fed animals compared to 67 in the control group. The similar on-station degradation study *in situ* for Lathyrus sativus fodder showed that the ammonia-N (mg/L) and total VFA (mM) concentrations were 154 and 82 in Lathyrus fed animals and 114 and 66 in animals fed rations without Lathyrus (Appendix Table 2).

4.6 Feeding Systems for dairy cows

The results of the feeding trial experiments stated above using the cultivated legume fodder as supplements to straw-based rations for growing cattle as well as lactating cows leads to the recommendations that the supplementation of rice straw-based rations either with Sesbania or Lthyrus fodder increase by 0.3-0.4 kg/d live weight gain and 20-26% milk production of the indigenous dairy cattle of the rural farmers. Supplementation of either of the fodder moderately increases milk composition.

For efficient feeding system for milk production of rural cows, supplementation of Sesbania green fodder at 1.5 kg/d with 0.5 kg of rice polish and small amount of green grass may be suggested for 26% increase in milk production. The feeding system for rural cows with Lathyrus fodder supplementation may be suggested as 1.5 kg Lathyrus hay and 0.5 kg rice polish and small amount of green grass for about 20% increase in milk production.

4.7 Socio-economic benefits

4.7.1 Economic return from fodder production

Table 34 showed that within the project period 1996-97 to 1999-2000, legume fodders, Sesbania and Lathyrus were successfully grown both under on-farm and on-station. Considering short duration and involvement of small cost, only variable costs were taken to estimate gross margin (operational profit) of the respective crop. Table 34 showed that over the four years per hectare operational profits of respective crops were very high. In different year, gross margin (GM) for Sesbania varied from Tk. 19875 to 23675 in on-farm condition and Tk. 12500 to 15475 in on-station condition. In case of Lathyrus, GM was also higher but there was small variation between on-farm and on-station production.

Table 34. Economic return from legume fodder production per hectare (1996-2000)

Particulars	On-farm condition		On-station condition	
	Sesbania	Lathyrus	Sesbania	Lathyrus
		1996-97		
Yield (ton)	-	12.80	-	15.70
Gross Income (GI), Tk.	-	19200	-	23550
Total Variable Cost (TVC), Tk.	-	4750	-	8150
Gross Margin(GM=GI-TVC),Tk	-	14450	-	15400
		1997-98		
Yield (ton)	25.50	13.70	20.00	12.80
Gross Income (GI), Tk.	25500	20550	20000	19200
Total Variable Cost (TVC), Tk.	5625	4500	7500	8000
Gross Margin(GM=GI-TVC),Tk	19875	16050	12500	11200
		1998-99		
Yield (ton)	28.80	11.30	22.50	12.10
Gross Income (GI), Tk.	28800	16950	22500	18150
Total Variable Cost (TVC), Tk.	5125	4250	7250	7500
Gross Margin(GM=GI-TVC),Tk	23675	12700	15250	10650
		1999-2000		
Yield (ton)	25.60	-	22.80	-
Gross Income (GI), Tk.	25600	-	22800	-
Total Variable Cost (TVC), Tk.	5075	-	7325	-
Gross Margin(GM=GI-TVC),Tk	20525	-	15475	-

*Sale price of Sesbania = Tk. 1.00/kg ; Sale price of Lathyrus = Tk. 1.50/kg

It was observed that in on-station condition, production and management were relatively poor and more labour were employed which made the production cost higher compared to on-farm condition (Appendix Table 3). Nevertheless, economic return or GM was

substantially higher in producing legume fodder in research areas than that of rice which was grown in the same land (Appendix Table 5). However, in all respects production of legume fodder was cost effective and highly profitable.

4.7.2 Economic return from increased milk yield on-farm

Additional milk production per cow per month due to feeding Dhaincha fodder varied from 6.0 to 15.0 litres, the average being 12.0 litres (Table 14). The corresponding financial return varied from Tk. 120 to Tk. 300, respectively with the average of Tk. 240. This return value may look small, but if the per cent increase in milk production due to Dhaincha feeding is considered, it is considerably high, the average figure is 25%. Now, since milk production of the individual animal is too low (1.0 to 2.25 L/d), the increased amount of milk is also low. Again, if the farmers have two or three cows per farm, the additional income from milk would be double or triple.

Table 15 shows that supplementing Lathyrus fodder to the ration of cows on-farm resulted in increased milk production to an average of about 21%. The average additional milk yield being 8.4 L/d with financial return per month of Tk. 168. The similar fact may be explained here that the additional financial return from milk per month would have been double or triple if the number of animal per farm would be two or three.

4.7.3 Economic return from increased rice yield on-farm

From 1997-98 to 1999-2000, yield of Boro production followed by Lathyrus varied from 5.30-5.70 t/ha but without producing fodder, yield varied from 5.19-5.32 t/ha (Table 35). In case of T. aman per hectare yield was slightly lower compared to Boro. Again, it is remarkable that the average yield (3.90 t/ha) and income (Tk.14722) of T. aman followed by Sesbania were higher compared to the corresponding yield (3.46 t/ha) and income (Tk.11410) of T. aman where legume fodder was not produced. However, cultivation of legume fodder added organic matter and nitrogen, and increased soil fertility and the average per hectare net incremental benefit derived from Boro and that T. aman were Tk. 3866 and Tk. 3312, respectively which were estimated by deducting three years average GM of year round rice production from those of GM of respective rice production followed by legume fodders.

Table 35. Economic return from milk yield (litres) of cows as influenced by Sesbania feeding on-farm (1998-99)

No. of farmer	No. of animals	Milk yield without feeding fodder (per day)	Milk yield with feeding fodder	Per day increase in milk yield	Per cent increase	Per month additional milk yield	Per month financial return (Tk.) per cow
1.	1	1.00	1.30	0.30	30.0	9.0	180
2.	1	1.50	2.00	0.50	33.3	15.0	300
	2	1.75	2.25	0.50	28.6	15.0	300
3.	1	1.75	2.00	0.25	14.3	7.5	150
4.	1	1.50	2.00	0.50	33.3	15.0	300
	2	2.25	2.60	0.35	15.6	10.5	210
5.	1	1.75	2.25	0.50	28.6	15.0	300
6.	1	1.50	1.70	0.20	13.3	6.0	120
7.	1	1.25	1.75	0.50	31.0	15.0	300
Average		**1.58[a]**	**1.98[b]**	**0.4**	**25.3**	**12.0**	**240**

Table 36. Economic return from milk yield (litres) of cows as influenced by Lathyrus feeding on-farm (1998-99)

No. of farmer	No. of animals	Per day milk yield without feeding fodder	Per day milk yield with feeding fodder	Per day increase in milk yield	Per cent increase	Per month additional milk yield	Per month financial return (Tk.) per cow
1.	1	1.00	1.25	0.25	25.0	7.5	150
2.	1	1.25	1.50	0.25	20.0	7.5	150
3.	1	1.50	1.70	0.20	13.3	6.0	120
4.	1	1.25	1.50	0.25	20.0	7.5	150
	2	2.00	2.25	0.25	12.5	7.5	150
5.	1	1.50	2.00	0.50	33.3	15.0	300
6.	1	1.25	1.60	0.35	28.0	10.5	210
7.	1	1.00	1.20	0.20	20.0	6.0	120
Average		**1.34[a]**	**1.63[b]**	**0.29**	**21.6**	**8.4**	**168**

Table 37. Economic return from rice yield as influenced by production of fodder legumes in on-farm condition (1996-2000).

Unit/ha

Particulars	Production year							
	1997-98	1998-99	1999-00	3 years average (1997-98 to 1999-00)	1997-98	1998-99	1999-00	3 years average (1997-98 to 1999-00)
	Boro rice followed by Lathyrus				Boro rice followed by fallow			
Yield, ton	5.70	5.58	5.30	5.32	5.32	5.25	5.00	5.19
Gross Income (GI), Tk	41610	40734	38690	40345	38836	38375	36500	37904
Total Variable Cost (TVC), Tk	27275	26500	26300	26692	27500	28300	28500	28100
Gross Margin(GM=GI-TVC),Tk	14335	14234	12390	13653	11336	10025	8000	9787
	T. Aman rice followed by Sesbania				T. aman rice followed by fallow			
Yield, ton	3.70	3.50	4.50	3.90	3.30	3.07	4.01	3.46
Gross Income (GI), Tk	27565	26075	33525	29055	24585	22871	29875	25777
Total Variable Cost (TVC), Tk	14000	14300	15000	14333	14100	13800	15200	14367
Gross Margin(GM=GI-TVC),Tk	13565	11775	18525	14722	10485	9071	14675	11410

Experiments were undertaken both on-farm and on-station to investigate the effects of feeding legume fodder on dairy cows. In on-station, cows fed legume fodder yielded approximately 11.0 to 12.2 litres additional milk per cow within a month while it was 13.5 to 18.0 litres in on-farm condition (Appendix Table 1). It was estimated that with the feeding of legume fodder milk production was increased by 20-28% and in terms of value, farmers earned Tk 270-360 for those days only. It may be noted here that the productivity of local cows is small (1-2 kg/d) and therefore the total increase was not remarkable.

Cost-return analysis in producing both Sesbania and Lathyrus fodders showed that yield and economic return on-farm were quite satisfactory and very cost effective.

4.7.4 Improvement of livelihoods of the research farmers

Milk production of the cows in on-farm condition was satisfactory. After feeding legume fodder to dairy cows total milk production per day was increased. Because of this increased milk production the farmers, particularly the children, consumed more milk than before. Moreover, the additional amount of milk gave additional income through selling, and the benefits of which went to the members of the households, particularly to the children and the women. On the other hand, the increased rice production due to fodder cultivation also gave additional household income which also contributed to the improvement of the livelihoods of the family members. Thus the increased milk production and rice production together improved the socioeconomic condition of the participatory farmers. Photo plate 3 and 4 shows feeding legume fodder to dairy cows and milking activities by the research farmers.

4.7.5 Gender role and women participation in livestock rearing

Rural women are mostly under utilized and largely unrecognized although they contribute significantly to agricultural and economic activities. The male-female ratio in rural areas is 103:100 (BBS 1997). In the livestock sector women traditionally participate mainly as family labor in rearing practices. Before introducing legume fodder in the existing cropping systems. Women usually worked in cleaning cowshed, pens and

sometimes in feeding livestock and they spent 110 hours/year/household. But after introducing legumes fodder it was found that the women of the research farmers spent 115 – 117 hours/year/household. This increase in the workload on women did not have negative effect on them, rather it saved additional expenditure for extra labour and the slight increase in workload has compensated more by more household income.

5. Contribution of outputs

The foregoing section discussed about the outputs of the project in a relatively detailed way. Before going to the contribution, it may be worthwhile to have a look at the major outputs achieved out of the whole project so far.

Production of legume fodder, *Sesbania rostrata* and *Lathyrus sativus* in the rice field is the most important output of the project. The rural farmers have accepted the technology of fodder production in the rice field. Another output is that the practice of production of legume fodder increased soil nutrient status and thus increased the production of rice which was grown as the following crop. The next important output is the increased milk yield up to about 25% due to supplementation of straw-based diet of lactating cows with this fodder. With this positive effect of fodder supplementation on milk production, a feeding system has been developed using the farmers' own resources in order to sustain milk production of dairy cows in rural area. Finally, the socioeconomic output is also an important achievement of the project. The fodder production practice is economically cost-effective and the increased rice yield increases the income of the rural farmers which leads finally to improve the livelihood of the rural farmers.

After achieving the outputs the important issue is how these outputs contributed to the project goal. The ultimate goal of the project is to improve the performance of livestock in high potential intensive crop/livestock mixed farming system.

Bangladesh is a densely populated country and as mentioned earlier that the agricultural mixed farm practices are intensive. Therefore, under this system the performance of livestock is apparently poor in terms of productivity and hence the improvement of the performance of livestock is imperative.

Integration of fodder production with the rice cropping system has been successful. The integration technique has created interest of the rural farmers to grow fodder for their

(Photo plate 3 here)

cattle, in their rice field without affecting their rice production practice. This has resulted in the increased supply of high quality leguminous fodder to the ruminant livestock of the rural farmers of Bangladesh who faced a serious problem in supplying green fodder to their animals in order to get full return from them. The survey study conducted before starting the project activity indicated that the rural farmers are aware of the importance of fodder to improve the productivity of the animals. However, they did not have any ways and means to grow fodder without altering their existing cropping pattern. Now they have been shown the technology of growing fodder, they have found by doing themselves that it is possible to grow fodder without disturbing the crop production practice. So, they are now able to supply good quality fodder to their animals for better production than before. This will also allow them to utilise their land more efficiently for producing rice as well as fodder for livestock without alteration of their rice cropping system.

The fodders so produced by the farmers in their rice field has been used as supplement to straw-based diets for their animals. Straw-based diet is well known for its severe deficiency in digestible protein, available energy and micronutrients. All these nutrients are essential for optimum productivity of animals. The supplementation of rice straw diet with high quality legume fodder balances the diet from the nutritional point of view by supplying digestible protein and micronutrients and thus results in efficient utilisation of straw energy. All these contribute to the increased milk production of dairy cows.

The feeding system based on rice straw supplemented with own resources of the farmers such as good quality legume fodder, home produced rice polish and rice straw allows efficient utilisation of rice straw by supplementing and balancing with essential nutrients from legume fodder and rice polish and as a consequence it increases milk production to a significant quantity. The farmers do not need to buy any feed ingredients for formulating diets for feeding their animals. All are from their own resources.

Integration of fodder with rice production also increased soil fertility and consequently increased rice yield which has been evident from the results presented in the above section. This is the additional benefit of the farmers due to application of fodder production technique.

Finally, the results of the socioeconomic study has contributed to the derivation of economic benefit out of the fodder integration technique by the rural farmers. This was evident from the very low input cost (price of seed only) compared with large return in terms of fodder production and increased rice yield. Moreover, the project has allowed the rural farmers to produce more milk from their cows fed fodder supplemented diets which they consumed or sold and earned extra money and improved their livelihood.

The success of the project goals depends on the acceptance and adoption of the technology and the continuous use of the outputs by the intended users. This can be materialised through some target institutions and following some promotion pathways. The identified main target institutions for to implementation of this project outputs are the government Agricultural Extension Services (DAES), Directorate of Livestock Services (DLS), individual farm families associated with the project, Bangladesh Agricultural University Research System (BAURES). Among these DAES and DLS at field office have been involved in the activity of the project. Some of the officers and the field workers of these institutions were invited several times to visit the activities and to attend the discussion meetings held from time to time in the project progress. These organisations agreed to encourage the farmers and to monitor the continuation of the fodder production practice as well as the feeding system being followed by the farmers to feed their animals. Since the direct beneficiaries of the project are the rural crop/livestock mixed farm families the above promotion activities will help getting the benefits from the project outputs.

In addition to the above promotion pathways, some of the outputs were already presented at the workshop, important outputs are being published in local language and will be distributed among the participatory and non-participatory rural farmers as well as to the government extension services such as DAES and DLS and also to the relevant NGOs.

In order to implement the outputs of the project and its continuation by the intended users a further project may be undertaken. A form of linkage may be established in terms of further activities with ICRISAT in India for continuation and further dissemination of the outputs to all corners of Bangladesh rural farmers and also the SAARC countries having the similar agro-climatic conditions.

(Photo plate 4 here)

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Appendix Table

Table 1. Annual production of milk and eggs of research and non-research farmers in the project area (1996-97).

Farmers	Cow			Poultry birds			Total value (Tk.)
	No.	Total milk production (litre)	Value (Tk.)	No.	Value (Tk.)	Total egg production (No.)	
Research Farmers	1.43	281	4324	3.86	197	229	510
Non-research farmers	0.75	143	2186	3.38	175	640	783
All farmers	1.07	207	3184	3.60	139	448	656

Table 2. Contribution of women in livestock rearing (1996-97).

Attributes	Livestock		Poultry birds		Total (hrs/yr)
	Cleaning cowshed and rearing livestock (hrs/yr)	Feed collection processing and milking (hrs/yr)	Cleaning chicken house (hrs/yr)	Feeding and raining chicken (hrs/yr)	
Research farmers	61	14	26	8.71	109.71
Non-research farmers	56.25	45	7	6	114.25
All farmers	58.47	24	15.87	7.26	112.13

Table 3. Live weight gain (kg) and milk production (litres) during the project period both on-station and on-farm.

Parameters	On-station		On-farm	
	Dhaincha	Khesari	Dhaincha	Khesari
		Year 1996/97		
Live weight gain	8.0	8.0	-	-
Milk production	-	-	-	-
		Year 1997/98		
Live weight gain	12.1	-	11.0	-
Milk production	-	11.3	13.5	12.2
		Year 1998/99		
Live weight gain	-	-	-	-
Milk production	12.0	12.2	18.0	13.5
		Year 1999/2000		
Live weight gain	-	-	-	-
Milk production	11.0	-	16.5	11.8

Table 4. Concentration of NH_3-N (mg/L) and VFA (mM) in the rumen liquor and ruminal degradation (%) of legume fodder at different time intervals suspending in nylon bag

Fodder		Ruminal degradation at hours of incubation							NH_3-N	VFA
		0	2	6	12	24	48	72		
Sesbania	DM	27.81	29.13	32.87	45.30	56.70	61.57	66.25	168	84
rostrata	CP	52.45	56.10	63.59	74.28	82.34	88.69	91.69		
Lathyrus	DM	24.94	27.76	31.17	14.14	54.68	59.25	65.17	154	82
sativus	CP	42.84	46.90	54.69	65.90	74.53	84.85	86.69		

Table 5. Cost of production of legume fodder under on-station and on-farm conditions (1998/99)

Fodder	Item of cost	Unit	Amount used	Price/unit (Tk.)	Cost/ha (Tk.)
On-station					
Sesbania:	A. Labour cost				
	(i) Human labour	Mandays	80	50	4000
	(ii) Animal labour	Pair days	30	75	2250
	B. Material cost				
	(i) Seed cost	Kg	50	20	1000
	Total variable cost				7250
Lathyrus:					
	A. Labour cost				
	(i) Human labour	Mandays	70	50	3500
	(ii) Animal labour	Pair days	30	75	2250
	B. Material cost				
	(i) Seed cost	Kg	70	25	1750
	Total variable cost				7500
On-farm					
Sesbania:	A. Labour cost				
	(i) Human labour	Mandays	45	50	2250
	(ii) Animal labour	Pair days	25	75	1875
	B. Material cost				
	(i) Seed cost	Kg	50	20	1000
	Total variable cost				5125
Lathyrus:					
	A. Labour cost				
	(i) Human labour	Mandays	35	50	1750
	(ii) Animal labour	Pair days	-	-	-
	B. Material cost				
	(i) Seed cost	Kg	100	25	2500
	Total variable cost				4250

Table 6. Comparison of economic return in producing Sesbania and Lathyrus under different types of management (1998-99)

Parameters	Farmers management (FM)	Researcher management (RM)	Difference (FM-RM)
Dhaincha:			
Yield (tons)	28.80	22.50	+ 6.3
Gross income (GI), Tk.	28800	22500	+6300
Total variable cost (TVC), Tk.	3250	7250	- 4000
Gross margin (GM=GI-TVC), Tk.	25550	15250	+10300
Khesari:			
Yield (tons)	11.3	12.1	- 800
Gross income (GI), Tk.	16950	18150	1200
Total variable cost (TVC), Tk.	4250	7500	- 3250
Gross margin (GM=GI-TVC), Tk.	12700	10650	+2050

Table 7. Economic return from rice yield as influenced by cultivation of fodder legumes in on-farm condition (1998-99).

Particulars	T. aman rice after Sesbania (S)	T. aman rice after fallow (F)	Difference (S-F)
Yield (ton)	3.50	3.07	0.43
Gross Income (GI), Tk.	26075	22871	3204
Total Variable Cost (TVC), Tk.	14300	13800	500
Gross Margin (GM=GI-TVC), Tk	11775	9071	2704
	Boro rice after Lathyrus (R)	Boro rice after fallow (F)	Difference (R-F)
Yield (ton)	5.58	5.25	0.33
Gross Income (GI), Tk.	40734	38375	2359
Total Variable Cost (TVC), Tk.	26500	28300	-1800
Gross Margin (GM=GI-TVC), Tk	14234	10025	4159

Appendix 5 - Inventory Control Form

NRIL Contract Number: ZC0010
DFID Contract Number: R6610
Project Title: Introduction of fodder legumes into rice-based cropping systems and it's use as supplements to straw-based rations for dairy cows in Bangladesh
Project Leader: Dr. M. Ali Akbar

[List all single equipment items with a purchase value higher than £500 and items with a purchase value lower than £500 but deemed to be of an attractive nature (i.e. cameras, motorcycles, etc.) purchased during the quarter.]

Please fill in ALL the information requested in the table below for each item

Item	Make and Model	Serial No.	Date received	Purchase price	Location	Disposal		
						To	Date	Authorised
Desktop Computer	Gateway		15.9.98	£1730	Bangladesh	Project Leader	15.9.98	
Notebook computer	TOSHIBA 220CS	67042949E	7.1.98	£1244	U.K.	Project Leader	10.1.98	
Motor cycle	HONDA CD80	AHBCD80P-20080	24.4.97	£1180	Bangladesh	Project Leader	24.4.97	
Camera	MINOLTA α5700i	21124050	14.10.98	£190	Hong Kong	Project Leader	14.10.98	
Feed miller	Local made		10.4.98	£960	Bangladesh	Project Leader	10.4.98	