INTERCROPPING FODDER GRASSPEA WITH WHEAT AT DIFFERENT FERTILIZER DOSES AND SEED RATES

BY

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This is to certify that the thesis entitled, "Intercropping fodder grasspea with wheat at different fertilizer doses and seed rates." Submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in AGRONOMY embodies the result of a piece of bonafide research work carried out by Md. Enamul Islam, Roll No. 00135, Registration No. 25239/00356 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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Dedicated to

My

Beloved Parents

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INTERCROPPING FODDER GRASSPEA WITH WHEAT AT DIFFERENT FERTILIZER DOSES AND SEED RATES

ABSTRACT

An experiment on the performance of wheat – grasspea intercropping at different fertilizer dose (100 and 120% of recommended dose for wheat) and seed rates of grasspea (100%, 80%, 60%, 40% and 20%) was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December, 2005 to March, 2006. The experiment was laid out in a randomized complete block design with three replications. Significantly higher yields of wheat (3.00 – 3.08 t/ha) were obtained with wheat, wheat 100% + grasspea 20% + fertilizer 100% and wheat 100% + grasspea 100% + fertilizer 120% treatments. Significantly the highest fodder yield (1.47 t/ha) was obtained with the treatment of wheat 100% + grasspea 100% + fertilizer 120%. The best land equivalent ratio (LER), benefit: cost ratio (BCR) and total net return were 1.96, 1.558 and 14466.50 Tk./ha respectively and these were obtained with the treatment of wheat 100% + grasspea 100% + fertilizer 120%. So, fodder grasspea may be intercropped with wheat using the recommended seed rate under120% recommended fertilizer dose of wheat.

LIST OF CONTENTS

LIST OF CONTENTS (Contd.)

LIST OF TABLES

LIST OF TABLES (Contd.)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^{H}	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

Chapter 1
Introduction

21

Chapter 1

INTRODUCTION

Bangladesh is an over populated country. Increasing agricultural production per unit area of land is becoming most important step to cope with the present population growth in Bangladesh. In recent years, multiple cropping has been gaining importance as a means of more crop production in limited land area particularly in the countries with small size farm holdings. This system of farming is in practice in Bangladesh, India, China, Taiwan, Srilanka, Malaysia, Hongkong, Vietnum, Africa and Latin America (Beet, 1977).

By the practice of intercropping system, people can improve their socio-economic condition of their family. Wheat and pulse intercropping reduce the total weed population significantly compared to the wheat monoculture (Alam *et al*. 1997). All the intercropping systems give substantially higher total yield equivalent than that of the sole crop (Nazir *et al*., 1997).

Two socio-economic situations appear to favour its adoption as (i) high population pressure which results in small size farm holding and (ii) surplus of labour and lack of power for tillage. As farm size decreases, and both the labour supply and demand increases, in such condition, the farmer's only alternative is to increase their cropping intensity by practicing multiple cropping systems where they make their maximum use of resources available to them. These resources are both physical and socio-economic. According to Dey and Singh (1981), the most important advantages of such cropping system are;

1) Insurance against total crop failure under aberrant weather conditions or pest epidemics,

2) Increase in total productivity per unit land area, and

3) Equitable and judicious utilization of land resources and faming inputs including labour.

Though the practice of multiple cropping is becoming popular, yet its advantages are not ensured in all circumstances. The profitability, of course, depends on edaphic and biotic conditions and management practices. In last two or three decades, vigorous investigations of multiple cropping had been done in tropical regions. In most cases the practice was found to be profitable. Various preconditions are necessary for the success of multiple cropping. Some favorable important conditions are proper soil textural property, nutrient status of the soil, climatic conditions of the locality, nature of crops and crop combinations (Dalrymple, 1971).

Three types of crop combinations are generally recognized. Some are competitive, some are supplementary and some are complementary to each other. Usually crops belonging to the same family or types are competitive for nutrients moisture, space and others. But crops of different families, such as cereal and legume are usually complementary in nature, that is, they are mutually benefited by natural symbiosis and fixation of nitrogen in soils. Application of phosphorus sometimes enhances the rate of fixation of nitrogen and utilization of other nutrients by crops (Patwary *et al.*, 1985).

The common mixture crops for intercropping comprise of a dwarf and a tall type or a legume and a non- legume. Grasspea is a popular choice of the farmers for mixed cropping with cereals. Intercropping of grasspea with wheat was sustainable over sole crop (Rahman, 1999). The farmers follow different types of intercropping or mixed cropping. The farmers usually use normal dose of fertilizers for the intercropping system.

Practicing intercropping grasspea with wheat, farmers can obtain wheat and pulse at the same time from the same land. Higher equivalent yields are obtained with intercropping. Land equivalent ratio (LER) values greater than unity is obtained with intercropping (Sarno *et al.*, 1998).

The population of our country is very large. More people need more food. Due to the population pressure, the demand for live stock products is also increasing. But there is a great crisis of live stock feeds in the country. Grasspea is an important green fodder crop which is also a good source of animal nutrition.

If grasspea is cultivated with a cereal crop like wheat as an intercrop, farmers may be benefited in two ways; they may get a fodder crop with a cereal crop and at the same time this approach may become helpful in increasing soil fertility by fixing nitrogen.

The fertilizer and seed rate has a considerable influence on growth and development of plant as well as on yield of wheat (Verma and Mallick, 1997). These two factors under intercropping systems also need to be standardized (Nargis *et al.*, 2004). Research works on intercropping grasspea with wheat are limiting under Bangladesh condition. So, present investigation was undertaken to observe the yield and economic advantage from intercropping of wheat and grasspea under different levels of nitrogen fertilizer and seed rates.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief review of research in relation to intercropping of pulse crops with wheat to obtain better yield and/or fodder crops. It is an established fact that intercropping system increases water utilization efficiency, shows higher land equivalent ratio and above all gives higher yield (Mengping and Zhangjinsong, 2004).

Intercropping is an age old practice and it has been recognized as a very common practice throughout the developing tropics (Willey, 1979). It makes better use of sunlight, land and water. It may have some beneficial effects on pest and disease problems. In almost all cases, it gives higher total production; monetary returns and greater resources use efficiently and increase the land productivity by almost 60 percent (IRRI, 1973).

One of the earliest reviews on mixed/intercropping in this subcontinent was that of Aiyer (1975). Andrews (1972) indicated that intercropping provided scope for better utilization of labor, ensures crop productivity, increases farm income and improves nutritional quality of diet for the farm family.

With increased production of wheat and its acreage in Bangladesh crop combination like wheat and potato; Tobacco and wheat; Mustard and wheat; Flax and wheat, legume and wheat, etc. were shown to be encouraging (Hasanuzzaman, 1976).

Krantz *et al.* (1976) observed that mixed/intercropping legume and non-legume covered risk, earned more profit and stabilized production, improved soil fertility, conserved moisture and facilitated efficient labor distribution.

Dalrymple, (1976) indicated that net returns per unit area and return per unit time of work were increased by increasing cropping index even up to 300 following the intercropping technique.

The increased land equivalent ratio (LER) from a series of experiments on mixed cropping or intercropping indicated that the mixed cropping/intercropping increases the productivity per unit area compared to sole crop. Mixed cropping or intercropping system increased benefit : cost ratio which was found to be remarkably significant (Nargis *et al.*, 2004).

Farmers of Bangladesh have been using the technique of mixed and intercropping since many years. Most of the mixed cropping and intercropping are practiced during Rabi season. Some of the important combinations are aus and broadcast aman rice; aus and sesame, lentil and wheat/linseed/mustard/millet, wheat and gram/mustard, etc. (Haque and Hobbs, 1976).

In recent years, many scientists are engaged to improve intercropping system for long time to achieve higher yield benefit. Among different cropping systems, intercropping system was found to be a better practice for increased growth, yield and development. In Bangladesh, pulse crops are generally grown without fertilizer or manures. However, it was found that the yield of pulse could be increased substantially by using fertilizers. Pulses, although fix nitrogen from atmosphere, it was also evident that nitrogen application became helpful to increase the yield, although there were controversies regarding the rates of nitrogen (Patel *et al.*, 1984; Ardesana *et al.*, 1993).

The ratio of seed rate of crops in mixed or intercropping has got direct effect on the production and yield. Fertilizer application in the practice of mixed or intercropping is another important factor that affects the yield and production of the crops. The seed rate ratio or plant population is an important consideration in mixed/intercropping practices. The best combination of seedling ratio for wheat and chickpea was found to be 50 : 100 (Khan, 1983).

Singh (1979) reported that the choice of crops for a mixture should be such that the peak periods of growth of the different crop species did not coincide.

The degree of complementary (temporal as well as spatial) needs to be maximized by way of differences in growth rhythm, duration, light, nutrient supply and water requirements for maximization of intercropping advantages (Singh, 1979; Singh, 1983).

Saxena (1972) reported that crops of varying maturity needed to be chosen so that a quick maturing crop completes its life cycle before the grand period of growth of the other crop starts. Intercropping legumes with non-legumes has been a traditional practice of farmers of tropical and sub-tropical areas where ' low level equilibrium' farming existed and difficulties arose from shortage of available capital, unfavorable price relationships, un-sophisticated markets, uncertain and unevenly distributed rain and a rudimentary infrastructure (Bhatnagar and Davis, 1979).

Many scientists have reported that legume may benefit the associated non-legume crops (Singh, 1981; Waghmare *et al.*, 1982). Inclusion of legumes in the intercropping system was likely to be beneficial as they could fix atmospheric nitrogen into the soil and help in the utilization of soil moisture from deeper soil layers (Bautista, 1988).

Farmers in developing countries have shown keen interest in intercropping practice because of its potentiality for increasing crop production to meet their requirements for food, fibre and fodder from existing area (Bandyopadhyay, 1984).

The intercropping experiment on wheat, gram, lentil and mustard showed that the combinations of wheat with mustard and with gram were quite compatible producing 19 and 11 percent, respectively more yield than those under monocrops (Razzaque, 1980).

The farmers follow different types of intercropping and mixed cropping. The common mixture comprised of a dwarf and tall type of a legume and a non-legume. Grasspea is a popular choice of the farmers for mixed cropping with cereals and oil seeds such as wheat, barley, grain sorghum, mustard, linseed or safflower (Agrikar, 1979).

To determine the profitability of intercropping systems, their cost and return must be analyzed. Agronomically feasible technology may not always be accepted if it is not economically viable. It is claimed that in almost all cases intercropping gave more monetary return than the sole crops (Andrews 1972; Kalra and Gangwar, 1980; Hashem, 1983).

Hoque *et al.* (1978) working on mixed cropping of wheat – lentil and gram - mustard at various seed ratios found that wheat - gram gave the best production per unit area with 50 : 100 or 50 : 50 wheat - gram combination giving more than 50% increase in production. Singh and Katyal (1966) found in India that mixed cropping of wheat + gram produced higher yields than that of either wheat or gram grown alone.

In Madhya pradesh in India a mixture of wheat and gram in proportion of 2:1 was found to give the highest net return than other seed rate ratio (Raheja, 1954). Wheat - chickpea was found to be most efficient with 1 irrigation in respect of land equivalent ratio, relative co-efficient, monetary advantage, relative net return and area time-equivalent ratio (Mondal *et al.*, 1986).

Singh (1981) reported that the intercropping of wheat with chickpea, lentil or lathyrus under adequate moisture conditions did not give higher total grain and dry matter production but was more profitable. Total monetary return is higher than sole crop and LER was greater than monocrop.

Kumari *et al.* (2003) conducted a field experiment on the sandy loam soil to evaluate weed management practices in a wheat based intercropping system. The highest land equivalent ratio was obtained in the wheat + chickpea intercropping. Weeding thrice showed higher land equivalent ratio compared to the other weed management systems.

Nargis *et al.* (2004) evaluated an experiment on mixed cropping of lentil (100%) and wheat (20, 40, 60 or 80%). It was observed that in lentil, 100% lentil + 40% wheat gave the highest number of branches per plant (3.25), whereas 100% lentil + 60% wheat recorded the greatest plant height (35.70 cm). The highest number of seeds per plant (47) and seed yield (1278 kg/ha) of lentil were obtained under line sowing. Sole wheat (broadcast) produced the tallest plants (89.15 cm) and the longest spikes (9.84 cm). The highest land equivalent ratio (1.52), monetary advantage (63%) and benefit : cost ratio (1.84) were recorded for intercropping lentil (100%) and wheat (40%).

Nargis *et al.* (2004) reported that the highest seed yield (2704 kg/ha) was obtained under line sowing of sole wheat. The variation in the number of effective tillers per plant and number of seeds per plant was not significant. In both crops, line sowing was superior over broadcasting. The higher land equivalent ratio indicated that mixed cropping or intercropping increased the productivity per unit area compared to sole cropping of lentil.

Biological efficiency (yield) and economics of wheat-based intercropping were introduced as the intercropping systems of wheat + fenugreek, wheat + lentils, wheat + chickpeas, wheat + linseed, wheat + barley and sole crop wheat in Pakistan. In monetary terms, both the wheat-fenugreek and wheat-lentil intercropping systems proved to be more beneficial than the other cropping systems, including mono cropped wheat (Nazir *et al.*, 1997).

Mixed or intercropping has been reported to has many advantages for the farmers. It increased the total production; acted as insurance against failure of the principal crop and better utilization of inter space in crops. It also reduced the cost of intercultural operation and increased the fertility of the soil (Oleksy and Szmigiel, 2002).

Evans (1960) and Kurate (1966) indicated that intercropping was a useful practice as it often gave higher returns and total production than growing one crop alone.

Malik *et al.* (1998) conducted a field trial with wheat grown alone or intercropped with lentils, gram or rape. Grain yield of wheat was decreased by 371, 420 and 388 kg/ha with intercropping of lentil, gram and rape respectively. However, losses in wheat yield were compensated by increased income from the intercrops. The highest net income with a benefit : cost ratio (BCR) of 2.75 was obtained from wheat - lentil intercropping compared with a BCR of 2.35 for wheat alone.

A field experiment was conducted at West Bengal to study the performance of wheat and lentil. The crops were grown in pure stands or intercropped under different levels of irrigation. Results revealed that mean wheat grain yield was 2.08 t/ha without irrigation, 2.99 t/ha with two irrigation (21 and 65 days after sowing) and 3.40 t/ha with irrigation at 4 critical growth stages. Lentil yield was 0.68 t/ha without irrigation, 1.16 t/ha with two irrigations at branching and flowering, and 0.94 t with 4 irrigations (Ghosh *et al.*, 1997).

Haymes, *et al.* (1994) compared wheat yield under sole cropping which was not severely depressed by intercropping with bean. It was found that wheat yield was significantly higher in alternate and within row spacings than in block spacing. Wheat yields increased with increasing density, and were decreased by increasing bean density. Weed biomass was significantly lower in all intercrop patterns compared with sole cropping. In the block spacing the highest LER was obtained with wheat at 100% of the recommended sowing rate.

Ashok *et al.* (2001) evaluated an experiment at New Delhi. They found that number of tillers per plant of wheat was not significantly affected by wheat based intercropping system.

In an experiment, wheat and gram were grown in pure stands or in 1 : 1, 1 : 2, 2 : 1 or 2 : 2 row ratios and given 0, 25, 50 or 75 kg N/ha. Yields of both crops were highest in pure stands. Wheat equivalent yield was highest in wheat grown alone and in the 2 : 1 wheat : gram intercrop. Land equivalent ratios were always more than one in most intercropping treatments (Singh, *et al*., 1996)

Hosamani *et al*. (1995) published the results of a field experiment with wheat which was intercropped with *Cicer arietinum* (chickpea), safflower or *Brassica juncea* in wheat: oilseeds row ratios of 3 : 1, 4 : 2 or 5 : 1. Mean wheat grain yields at the 3 row ratios were 1.78, 1.50 and 1.91 t/ha, respectively. Wheat/safflower intercrop gave the highest wheat equivalent yield (3.07 t) and the highest net returns.

In a field trials, wheat and *L. culinaris* were grown alone or intercropped in 1 : 1, 1 : 2, 2 : 1 or 2 : 2 row ratios and crops were given 0 - 75 kg N/ha. Wheat and *L. culinaris* yields were highest in their sole crops. However, wheat productivity/row was higher when intercropped than when grown alone. Wheat equivalent yield was highest when *L. culinaris* was grown as a sole crop due to its high sale price. Wheat yield increased with extra nitrogen use up to 50 kg /ha either grown alone or intercropped (Singh, 1996).

In a field study in 1988-90, winter wheat was relay cropped with soybeans. Sole wheat yielded slightly more than intercropped wheat. The land equivalent ratio was 1.18 with the wheat component comprising over 80% of the total. Among the intercropped treatments, soyabean grown in narrow row spacings and those with an indeterminate growth habit had better light interception (Goldmon, 1992).

Ali (1993) conducted a field experiments to determine the optimum fertilizer rate and row ratio of wheat and chickpeas in the late-sown irrigated condition. Of the 3 populations tested (2 : 2, 2 : 1 and 3 : 1 row ratios of wheat: chickpeas), the 2 : 2 row ratios allowed more light interception and transmission to the lower canopy and gave significantly higher yield (4.16 t/ha wheat equivalent) and land equivalent ratio (LER) than the other treatments. Fertilizers rates used were those of the recommended ones (120 kg N + 26.4 kg P + 50 kg K/ha) in both cases.

Hiremath *et al*. (1990) carried out a field trial in the rabi season on black clay soils. Wheat and soyabean were grown alone or intercropped in 12 different row ratios ranging from 1 : 1 to 4 : 3. The highest land equivalent ratio (1.33) was obtained from intercropping wheat and soyabean in a 1 : 2 row ratio, and the highest gross returns from a 3 : 1 row ratio.

Legumes grown as companion crops were found to be beneficial for the principal crop through nitrogen fixation. Moreover, legumes may help in the utilization of soil moisture from deeper soil layers. In intercropping of maize with cowpeas in both dry and rainy season. Cowpea gave the best result with respect to soil improvement and weed control (Bautista, 1988).

Dwivedi *et al*. (1998) found that all intercropping systems had higher total yield and net returns than pure stands. Higher equivalent yields were obtained with intercropping. The land equivalent ratio (LER) values were found to be greater than unity (Sarno *et al*., 1998). It was also reported that practicing wheat and pulse intercropping reduced the total weed population significantly compared to the wheat monoculture (Alam *et al*., 1997).

All the intercropping systems were reported to give substantially higher total yield equivalent than sole crop (Nazir *et al.*, 1997). A field experiment was conducted at New Delhi with wheat base intercropping system. It was observed that intercropping system ensured highest water use efficiency (Atar *et al.*, 1992)

Gupta and Sharma (1984) reported that sorghum in paired rows of 30 + 60 cm did not reduce yield when compared to that from uniform rows of 45 cm and in addition a yield of 2.11 t/ha was obtained from pigeon pea resulting an increase in LER by 1.26.

Sarma *et al.* (1998) conducted a field study in rabi season (winter). Wheat, lentils and peas were grown alone or as 1 : 1 or 2 : 2 intercrops between wheat and each of the other crops. Wheat yield was 3.0 - 3.1 t/ha when grown alone and 0.6 - 0.8 t/ha when intercropped. Wheat-equivalent yield was highest from sole Rajmash, because of the higher economic value of this crop. Wheat-equivalent yield was higher in intercropping systems than in sole wheat, with the best results given by intercropping with Rajmash.

In field trials in 1989-92, wheat and groundnuts were relay cropped or sequentially cropped and given 2 rates each of N and P fertilizer, alone or in combination. Average wheat and groundnut yields were increased by 27.7 and 14.3%, respectively, compared with sequential cropping. Both individual and combined applications of N and P significantly increased yield, and yield stability was greatest with combined application in the relay intercropping system (Qiujie *et al.*, 1999).

Xiao *et al.* (2003) conducted an experiment on intercropping of faba bean (*Vicia faba*) and wheat (*Triticum aestivum*) using different nitrogen sources. They found that without any root barrier, the growth of wheat plants were improved resulting in greater biomass production and N uptake. Biomass production and N uptake of faba bean were lowest in the treatment without a root barrier. This suggested that wheat had greater competitiveness than faba bean and that this competition leaded to a higher percentage of N fixations from atmospheric nitrogen.

In a field experiment during the winter season, wheat was intercropped with French bean. Row ratios were 6 : 3 or 4 : 2 and the crops were given recommended fertilizers (100 kg N + 50 kg P + 50 kg /ha for wheat and 90 kg N + 50 kg P/ha for French bean). French bean grown alone produced the highest wheat equivalent yield of 4.01 t/ha and the highest net returns. The best intercropping treatment producing a wheat equivalent yield of 3.60 t/ha was wheat/French bean intercrop (4:2) (Dahatonde, 1992).

A field trial in winter seasons was carried out with wheat and lentils grown alone or intercropped in a 4 : 2 row ratio. The wheat in pure stand was given 80 kg N + 16 kg P + 16 kg K/ha (100% NPK), while sole lentil received 20 kg N + 16 kg P/ha (100% NP). Intercrops were given 8 different combinations of fertilizers. Wheat grain yield was 3.29 t/ha in pure stand and 2.73 - 3.12 t/ha when intercropped. Lentil seed yield was 1.53 t/ha in pure stand and 0.22 - 0.41 t/ha when intercropped. The highest wheat-equivalent yield and net returns were obtained when wheat with 100% NPK was intercropped with lentils fertilized with 75% NP (Verma *et al.*, 1997).

With increasing N and P application rates (up to 40 kg/ha of each), yields of sole wheat and *Cicer arietinum* grown as either intercrop or mixed crop were increased (Pandey *et al.*, 1992).

Varshney, (1994) conducted an experiment during a rabi season. Chickpeas and wheat were grown as sole crops or intercrop. Both crops only received the recommended NP fertilizer rate. Result showed that the sole wheat gave the highest chickpea equivalent yield. Application of the recommended fertilizer rate to wheat gave higher yields than application to both the crops.

The main advantage of using legumes in intercropping and mixed cropping was found to be the saving of nitrogen fertilizer (Trenbath, 1976). Hashem (1983) indicated that 40 per cent N may be saved in a maize cowpea intercropping system. Islam (1982) estimated that 80 per cent N fetilizer may be saved in a maize + blackgram intercropping. He found highest LER values (1.55) when maize was intercropped with black gram at 44, 444 maize plants/ha, 1, 11, 111 black gram plants/ha with 20 kg N/ha instead of 120 kg N/ha.

In a field trial on sandy loam soil in winter seasons, wheat was grown alone or intercropped with *Lens culinaris* and *Cicer arietinum* in 2 : 2 or 3 : 2 row ratios. Seed yields of all crops were decreased by intercropping. Total plant N content was highest in *L. culinaris* grown alone. Increasing N fertilizer rate (0 - 90 kg N/ha) increased wheat grain yield but did not generally affect legume seed yields (Tomar *et al.*, 1997).

In another investigation of mixed cropping (Bhuiyan, 1981) of gram with wheat under different proportion of normal seed rates, the highest LER of 1.47 was obtained at 100 : 75 seed rate ratio.

Rahman and Shamsuddin (1981) reported yield reduction of component crops in intercrop using 10, 20, 30 and 50 percent of wheat seed rate in wheat-lentil intercropping. They found that excluding 10% wheat seed rate, all reduced lentil yield significantly.

Ahmad *et al.* (1998) conducted a field experiment in Pakistan. Wheat and lentil were grown alone or intercropped in 80 cm X 100 cm strips at wheat : lentil row ratios of 4:3, 5:3, 8:3 or 10:3. Wheat grain yield was highest (4040 kg/ha) with the 10:3 intercrop. This treatment produced lentil seed yield of 424 kg/ha. The 8:3 intercrop produced wheat grain yield of 3760 kg and lentil seed yield of 481 kg and the highest net return, which was only slightly higher than the returns obtained with the 10 : 3 intercrop.

Intercropping of grasspea with wheat was reported to be sustainable over sole crop (Rahman, 1999). Miah (1982) obtained similar results where wheat and gram combination at 50 : 100 or 50 : 50 seed rate ratios gave more than 50% increased production over monoculture.

A field experiment was conducted at West Bengal to study the performance of wheat and lentil. The crops were grown in pure stands or intercropped under different levels of irrigation. Results reveal that mean wheat grain yield was 2.08 t/ha without irrigation, 2.99 t/ha with two irrigation (21 and 65 days after sowing) and 3.40 t/ha with irrigation at 4 critical growth stages. Lentil yield was 0.68 t/ha without irrigation, 1.16 t/ha with two irrigations at branching and flowering, and 0.94 t with 4 irrigations (Ghosh *et al.*, 1997).

Ghanbari *et al.* (2002) reported that significant effect on spike length of wheat was found with intercropping system. They reported that proper fertilization under intercropping system increased spike length of wheat.

Cheng *et al.* (2003) reported that when higher nitrogen was applicated under wheat + blackgram intercropping system, 1000 seed weight was greater than monocropped wheat.

Alam *et al.* (1997) carried out an experiment on the efficiency of intercropping on different upland crops with wheat to reduce weed populations. A wheat monoculture control was compared with wheat intercropped with chickpeas, lentils and peas. No weeding was done in any treatment. Weed populations and biomass production (dry weight) were recorded at 21, 42 and 63 days after sowing (DAS). At 21 DAS, there were no differences in weed population and biomass production among the treatments, but both were significantly reduced by intercropping at 42 and 63 DAS. Wheat + chickpeas, wheat + lentils and wheat + peas reduced the total weed population by 26, 12 and 28% and weed biomass by 31, 13 and 27% respectively, compared to the wheat monoculture. The wheat + lentil intercrop was a comparatively poor to weed suppressant.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodology followed during the experimental period are described.

3.1 Experimental Site

The study was carried out at the research farm of Sher-e-Bangla Agricultural University (SAU) during the period from December, 2005 to March, 2006. The soil of the site was well drained and medium high. Physical and chemical properties of soil, climatic condition (monthly) during the experimental period has been plotted in Appendix I and Appendix II. The average temperature during the experimentation was 20^0 C – 25^0 C.

3.2 Planting materials

The wheat variety Kanchan and grasspea variety BARI Khesheri -2 were used as experimental planting materials. The recommended optimum growing period of the wheat variety was mid-November to mid-March. This variety had bold and white grains and was described to be adaptable to late planting.

BARI Khasheri -2 was a recent grasspea variety which was introduced by BARI in 1996. The seed size of this variety was 40 - 50% larger than the local ones. This variety was described to be resistant to powdery mildew and downy mildew. From sowing to harvesting it was reported to take 125 - 130 days.

3.3 Experimental details

3.3.1 Treatments

Twelve treatments included in the study were as follows:

i. T_1 = Sole wheat (recommended seed rate) under 100% recommended fertilizer dose of wheat.

ii. T_2 = Wheat (recommended seed rate) + 100% Grasspea seed rate under 100% recommended fertilizer dose of wheat.

iii. T_3 = Wheat (recommended seed rate) + 80% Grasspea seed rate under 100% recommended fertilizer dose of wheat.

iv. T_4 = Wheat (recommended seed rate) + 60% Grasspea seed rate under 100% recommended fertilizer dose of wheat.

v. T_5 = Wheat (recommended seed rate) + 40% Grasspea seed rate under 100% recommended fertilizer dose of wheat.

vi. T_6 = Wheat (recommended seed rate) + 20% Grasspea seed rate under 100% recommended fertilizer dose of wheat.

vii. T_7 = Wheat (recommended seed rate) + 100% Grasspea seed rate under 120% recommended fertilizer dose of wheat.

viii. T_8 = Wheat (recommended seed rate) + 80% Grasspea seed rate under 120% recommended fertilizer dose of wheat.

ix. T_9 = Wheat (recommended seed rate) + 60% Grasspea seed rate under 120% recommended fertilizer dose of wheat.

x. T_{10} = Wheat (recommended seed rate) + 40% Grasspea seed rate under 120% recommended fertilizer dose of wheat.

xi. T_{11} = Wheat (recommended seed rate) + 20% Grasspea seed rate under120% recommended fertilizer dose of wheat.

xii. T_{12} = Sole Grasspea (recommended seed rate) under 100% recommended fertilizer dose of grasspea.

3.3.2 Experimental design

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments were randomly assigned in each replication. There were 36 unit plots in the experiment and the size of each unit plot was 2.0 m x 3.0 m.

3.3.3 Land preparation

The land was first ploughed on 15 November, 2005 by disc plough. The land then was harrowed again on 26 and 28 November to bring the soil in a good tilth condition. The final land preparation was done by disc harrow on 27 November, 2005. The land was prepared thoroughly and leveled by a ladder. Weeds and stubbles were removed from the field. The experiment was laid out on 3 December, 2005 according to the design adopted.

3.3.4 Fertilizer application

The fertilizers were applied according to the treatment.

As such there were three levels of fertilizer combinations as follows

i. 100% recommended fertilizer dose of wheat (Treatment, T_1 - T_6).

This level comprised the following combinations

Compost	=	8000 Kg/ha
Urea	=	180 Kg/ha
TSP	=	140 Kg/ha
MP	=	40 Kg/ha
Gypsum	=	110 Kg/ha

ii. 2. 120% recommended Fertilizer dose of wheat (Treatment, T_7 - T_{11}).

This level comprised the following combinations

Compost	=	9600 Kg/ha
Urea	=	216 Kg/ha
TSP	=	168 Kg/ha
MP	=	48 Kg/ha
Gypsum	=	132 Kg/ha

iii. 100% Fertilizer dose of grasspea (Treatment, T_{12}).

This level comprised the following combinations

Urea	=	40 Kg/ha
TSP	=	80 Kg/ha
MP	=	30 Kg/ha
Gypsum	=	110 Kg/ha

Two third ($^2/_3$) amount of urea, whole amount of TSP and MP were applied at the time of final land preparation. Rest amount of urea ($^1/_3$) were applied as top dressing at the time of 1st irrigation.

3.3.5 Sowing of seeds

Seeds were sown on 3rd December, 2005 by hand. Wheat seeds were sown in line and grasspea seeds were sown by broadcasting method. Seeds were then covered properly with soil. The line to line distance for wheat was 20 cm and plant to plant distance was 4 - 5 cm.

3.3.6 Harvesting

Grasspea were uprooted on 10th February, 2006 as a fodder crop and wheat was harvested plot wise at the proper maturity on 24th March, 2006.

3.4 Recording of data

The following data were recorded from the experiment

3.4.1 Wheat

i. Plant height (cm)
ii. Number of spike/plant
iii. Spike length of wheat (cm)
iv. Number of tillers/plant
v. Grain weight/spike (g)
vi. Dry weight (g)
vii. Weight of 1000 seed (g)
viii. Grain yield (t/ha)
ix. Harvest Index (%)

3.4.2 Grasspea

i. Plant height (cm)
ii. No. of branches/plant
iii. Dry weight/plant (g)
iv. Total fresh weight at 67 days after sowing (t/ha)
v. Total dry weight at 67 days after sowing (t/ha)

3.4.3 Weed

i. Total dry weight/ha (Two times)
   a) at 17 days after sowing (DAS) and
   b) at 49 days after sowing (DAS)

3.5 Procedure of recording data

The detail outline of data recording is given below

A. Wheat

a. Plant height (cm)

The height of five plants were measured from the ground level to tip of the plants and then averaged. It was taken at different days after sowing (DAS) separately.

b. Number of spikes/plant

Total number of spikes were counted from five plants and then averaged. It was taken at different days after sowing (DAS) separately.

c. Spike length (cm)

Spike length were counted from five plants and then averaged. This was taken at different days after sowing (DAS) separately.

d. Number of tillers/plant

At different days after sowing (DAS) it was taken from five plants separately and then averaged.

e. Grain weight/spike (g)

At the time of harvest, from thirty plants it was measured by the following formula

$$\text{Grain weight/spike (g)} = \frac{\text{Grain weight (g)}}{\text{Number of spike}}$$

f. Dry weight/plant (g)

Five plants at different days after sowing (52, 59 and 67 DAS) were collected and dried at 70° C for 24 hours. The dried samples were then those weighed and averaged.

g. Weight of 1000 seed (g)

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and the mean weight was expressed in gram.

h. Grain yield (t/ ha)

Wheat was harvested randomly from pre-selected 1 m^2 in land of each plot. Then the seeds were threshed, cleaned and sun dried for seven days. The dried seeds were then weighed and averaged. The seed yield was recorded at 12% moisture level and converted to ton/hectare.

i. Harvest Index (HI)

Harvest Index was taken plot wise as per experimental treatments by the following formula

$$HI = \frac{\text{Grain yield (t/ha)}}{\text{Straw yield (t/ha)} + \text{grain yield (t/ha)}} \times 100$$

B. Grasspea

a. Plant height (cm)

The height of five plants was measured from the ground level to tip of the plants and then averaged. It was taken at different days after sowing (DAS) separately.

b. Number of branches/plant

Total number of branches were counted from five plants and then averaged. It was taken at different days after sowing (DAS) separately.

c. Total fresh weight (t/ha)

At 67 DAS fodder grasspea was uprooted by hand from 1 m^2 area of each plot and the fresh weight was taken and averaged. It was then converted to ton/hectare.

d. Total dry weight (t/ha)

The uprooted fodder grasspea was oven dried at 70° C for 24 hours and weighed again. Then it was converted to ton/hectare.

C. Weed

a. Total dry weight (t/ha)

At two times (17 and 49 DAS) weeds were collected from each plot separately and oven dried and than weighed. Then it was averaged and converted to ton/hectare.

3.6 Productivity performance

Total number of labour used for the different operations were recorded with cost of variable inputs to compute the variable cost of different treatments. The cost and return analysis were done for each treatment on hectare basis. Here, productivity performance was discussed in terms of land equivalent ratio (LER), net income and benefit: cost ratio.

3.6.1 Land equivalent ratio (LER) of wheat and fresh weight of grasspea

In order to compare the difference among the treatments, land equivalent ratio (LER) was calculated. LER value was computed from the grain yield according to the following formula (Shaner *et al.*, 1982).

$$\text{LER} = \frac{\text{Yield of the intercropped wheat}}{\text{Yield of the sole wheat}} + \frac{\text{Fresh weight of intercropped grasspea}}{\text{Fresh weight of the sole grasspea}}$$

LER in its simplest form has been defined as the relative area of the sole crop that would be required to produce the yield achieved by intercropping.

3.6.2 Net income

The net income (Tk/ha) was calculated for each component crop separately as per following formula.

Net income = Total return (Tk/ha) – Total cost of production (Tk/ha)

To calculate net income, rate of different input and output cost was given in the Appendix III.

3.6.3 Benefit : cost ratio (BCR)

In order to compare better performance, benefit : cost ratio (BCR) was calculated. BCR value was computed from the total cost of production and net return according to the following formula.

$$\text{Benefit : cost ratio (BCR)} = \frac{\text{Gross return (Tk/ha)}}{\text{Total cost of production (Tk/ha)}}$$

3.7 Statistical analysis

The data collected on different parameters were statistically analyzed using the MSTAT computer package program developed by Russel (1986). Least Significant Difference (LSD) technique at 5% level of significance was used to compare the mean differences among the treatments (Gomez and Gomez, 1984).

Chapter 4

Results and Discussion

Chapter 4

Results and discussion

The results obtained from present study for different crop characters, yields and other analyses have been presented and discussed in this chapter.

4.1 Wheat

4.1.1 Plant height

Plant height of wheat was significantly affected by the intercropping systems (Table 1). Plant height increased with the advancement of crop age. At 52 DAS, the tallest plant was 61.47 cm, while at maturity it was 90.23 cm. At all the stages, T_1 showed significantly the highest plant height. However, $T_6 - T_9$, $T_6 - T_9$, $T_4 - T_{10}$, $T_3 - T_9$ and $T_6 - T_8$ showed plant height which were not significantly different from that of T_1 at 52, 59, 67, 75 DAS and at harvest, respectively. The lowest plant height at all the stages was shown by T_{11} which however, did not show significant difference in comparison to T_{10} at 75 DAS and also at harvest.

Similar findings were also found by Nargis *et al.* (2004). They reported that plant height of wheat was significantly affected by intercropping under wheat – lentil intercropping system. Highest plant height was shown in sole and also when intercropped at 80% wheat + 100% lentil seed rates.

Table 1. Plant height at different growth stages of wheat intercropped with fodder grasspea under different fertilizer doses

Treatments	Height of wheat plant (cm)				
	52 DAS	59 DAS	67 DAS	75 DAS	At harvest
T_1	61.467	63.83	79.683	87.663	90.230
T_2	49.137	51.65	74.783	82.950	84.813
T_3	54.167	56.43	75.297	85.729	87.097
T_4	55.800	57.38	75.427	86.200	88.297
T_5	56.033	58.21	77.090	86.420	87.353
T_6	61.333	63.72	79.273	86.780	90.150
T_7	62.200	63.69	79.250	86.590	89.740
T_8	61.167	63.48	78.480	86.227	89.340
T_9	60.500	61.87	77.673	85.230	87.680
T_{10}	56.333	58.45	75.920	84.773	86.103
T_{11}	51.010	54.46	71.230	82.470	85.820
LSD(0 .05)	2.565	2.81	3.783	2.427	1.341
CV (%)	3.63	3.42	2.890	2.670	0.900

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.2 Number of tillers/plant

Number of tillers per plant of wheat was not significantly affected by the intercropping system at different days after sowing (Table 2). At 52 DAS the highest number of tillers/plant was recorded to be 4.6 while at harvest it was 6.00 in T_1. At different DAS, T_1 showed highest tiller numbers/plant. At 52 DAS, 59 DAS, 67 DAS, 75 DAS and at the time of harvest, T_6 and T_7 showed the similar result but those were lesser than T_1. Treatment T_3 and Treatment T_{11} showed the lowest number of tillers/plant at all the stages in comparison with T_1. Different fertilizer doses and different seed rates might be responsible for this type of variation.

Similar findings were found by Nargis *et al.* (2004)) and Ashok *et al.* (2001). They found that number of tillers/plant of wheat was not significantly affected by wheat based–intercropping system. Singh, *et al.* (1996) also reported similar result.

Table 2. Number of tillers at different growth stages of wheat intercropped with fodder grasspea under different fertilizer doses

Treatment	No. of tiller of wheat/plant				
	52 DAS	59 DAS	67 DAS	75 DAS	At harvest
T_1	4.600	5.233	5.61	5.78	6.000
T_2	4.333	4.400	4.46	4.56	5.133
T_3	4.400	4.567	4.58	4.92	5.467
T_4	4.467	4.490	4.72	4.96	5.530
T_5	4.532	4.667	4.67	5.12	5.533
T_6	4.534	5.167	5.56	5.67	5.933
T_7	4.533	4.733	5.33	5.58	5.930
T_8	4.530	4.667	5.79	5.20	5.733
T_9	4.467	4.533	4.59	4.86	5.201
T_{10}	4.466	4.530	4.58	4.75	5.267
T_{11}	4.401	4.420	4.45	4.48	5.200
LSD (0.05)	--	--	--	--	--
CV (%)	7.15	7.68	7.95	8.28	8.75

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.3 Number of spikes/plant

From the beginning, significant difference was observed in the number of spikes/plant among the treatments (Table 3). It was observed that at 59 DAS, T_1 showed the highest number of spikes/plant (3.48). However T_6 and T_7 showed the spike numbers/plant which was not significantly different than that of T_1 at 59 DAS (Table 3). Again, T_3 showed the lowest number of spike (2.59) at 59 DAS. T_2, T_5 and $T_8 - T_{11}$ showed the spike numbers/plant which was not significantly different than that of T_3 at 59 DAS. At 67 DAS, 75 DAS and at harvest, there was no significant difference among the treatments in respect of the number of spikes/plant.

However, Singh *et al.* (1996) reported that there was no significant effect of spike number of wheat with intercropping system. They also reported that number of spike depended on the effective tiller in most cases.

Table 3. Number of spike at different growth stages of wheat intercropped with fodder grasspea under different fertilizer doses

Treatment	No. of spike of wheat/plant			
	59 DAS	67 DAS	75 DAS	At harvest
T_1	3.480	4.533	5.467	6.000
T_2	2.640	4.223	4.867	5.133
T_3	2.593	4.320	4.933	5.467
T_4	2.803	4.323	5.133	5.523
T_5	3.090	4.330	5.067	5.533
T_6	3.183	4.467	5.400	5.933
T_7	3.150	4.459	5.267	5.923
T_8	3.107	4.400	5.200	5.733
T_9	2.950	4.333	4.733	5.267
T_{10}	2.797	4.331	4.933	5.210
T_{11}	2.875	4.267	4.500	5.200
LSD (0.05)	0.178	--	--	--
CV (%)	3.780	6.780	7.240	7.560

Here,
$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.4 Spike length

Spike length of wheat was significantly affected by the intercropping systems (Table 4). Spike length increased with the advancement of age. At 67 DAS, the highest spike length was 10.25 cm, while at maturity it was 12.47 cm. At all the stages, T_1 showed significantly the highest spike length. However $T_6 - T_8$ & $T_{10} - T_{11}$, $T_5 - T_8$ and $T_5 - T_8$ showed spike length which were not significantly different from that of T_1 at 67 DAS, 75 DAS and at harvest respectively. The lower spike length was found in T_9 (8.28 cm), T_{10} (10.05 cm) and T_{10} (10.27 cm) at 67 DAS, 75 DAS and at harvest respectively which were also at per. At 75 DAS and at harvest $T_2 - T_4$, T_9 and T_{11} showed spike lengths which were not significantly different from T_{10}.

Ghanbari *et al.* (2002) and Nargis *et al.* (2004) reported significant effect on spike length of wheat by intercropping system. They reported that proper fertilization under intercropping system increased spike length of wheat.

Table 4. Spike length at different growth stages of wheat intercropped with fodder grasspea under different fertilizer doses

Treatment	Spike length of wheat (cm)		
	67 DAS	75 DAS	At harvest
T_1	10.250	12.12	12.47
T_2	9.083	10.68	10.84
T_3	9.460	10.83	11.17
T_4	9.453	10.98	11.50
T_5	9.490	11.69	11.80
T_6	10.050	11.62	12.30
T_7	10.150	11.37	12.18
T_8	9.940	11.20	11.73
T_9	8.287	10.28	10.43
T_{10}	9.087	10.05	10.27
T_{11}	9.070	10.68	11.23
LSD (0.05)	1.114	0.90	0.95
CV (%)	5.120	4.80	4.93

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.5 Dry matter weight/plant

Dry matter weight of wheat was significantly affected by the intercropping systems (Table 5). It increased with the advancement of age and at all the stages, T_1 showed the highest result. At 52 DAS, the highest dry weight per plant was 12.20 g which increased gradually at 59, at 67, at 75 DAS and at harvest having the value 12.847, 22.027 and 32.50 g respectively. However, $T_6 - T_8$, $T_5 - T_8$, T_6, $T_5 - T_8$ and $T_4 - T_9$ showed dry weight/plant which were not significantly different from that of T_1 at 52, 59, 67, 75 DAS and at harvest respectively. The lowest dry matter weight per plant at all the stages was shown by T_{11}. However, $T_2 - T_5$, $T_2 - T_4$ & $T_9 - T_{10}$, $T_2 - T_5$ & $T_7 - T_{10}$, $T_2 - T_4$ & $T_9 - T_{10}$ and $T_2 - T_3$ & T_{10} showed dry weight/plant which were not significantly different from that of T_{11} at 52, 59, 67, 75 DAS and at harvest, respectively.

T_1 and T_6 showed better results. Probably there was no competition due to inclusion of 20% grasspea in wheat under 100% recommended dose of fertilizers of sole wheat and less competition with grasspea. T_7, T_8 gave the similar results under 20% higher fertilization. In this case 20% fertilizer was applied more which probably helped reduce the competition for nutrients.

Table 5. Dry matter weight at different growth stages of wheat intercropped with fodder grasspea under different fertilizer doses

Treatment	Dry weight of wheat/plant (g)				
	52 DAS	59 DAS	67 DAS	75 DAS	At harvest
T_1	12.200	12.847	17.49	22.027	32.50
T_2	8.687	8.917	11.75	16.680	22.01
T_3	9.130	9.830	12.83	16.780	26.73
T_4	9.417	9.880	13.43	18.380	28.83
T_5	10.720	10.927	13.92	18.847	29.45
T_6	11.300	12.793	16.23	21.170	31.47
T_7	11.180	12.663	14.76	19.650	31.62
T_8	10.480	12.593	14.55	19.360	29.91
T_9	8.747	9.120	12.58	17.430	28.92
T_{10}	8.167	8.977	12.11	16.980	24.04
T_{11}	7.387	7.823	10.12	15.150	24.23
LSD (0.05)	0.649	2.202	1.064	1.192	3.83
CV (%)	4.580	4.820	5.130	4.670	5.28

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.6 Grain weight/spike

Grain weight/spike was significantly affected by intercropping system (Fig. 1). At the time of harvest, the highest grain weight/spike was recorded (0.664 g) in T_1. The highest grain weight in sole wheat might be attributed to the lack of competition with grasspea. T_6 also gave the higher result (0.658 g) which was not significantly different from those of T_1, T_2, T_5, T_7, T_8 and T_9. T_{10} gave the lowest grain weight which was not significantly different from those of T_{11} and T_3.

Ashok *et al.* (2001) reported grain yield/spike of wheat intercropped with cowpea which was not significantly different from sole crop.

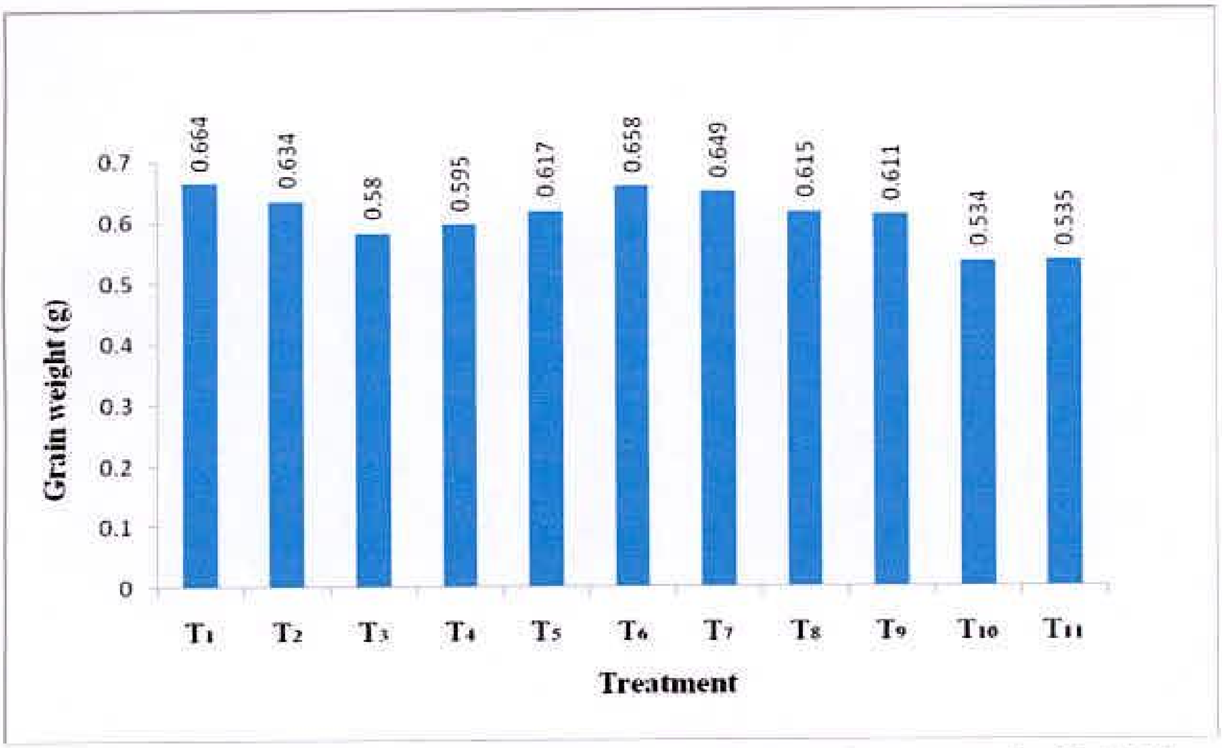

Fig. 1 Grain weight/spike (g) at the time of harvest of wheat intercropped with fodder grasspea under different fertilizer doses (LSD $_{0.05}$ = 0.054)

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.7 Thousand seed weight

Thousand seed weight of wheat was significantly affected by intercropping system (Fig. 2). T_1 produced the heaviest seeds (45.74 g). $T_6 - T_{11}$ gave 1000 seed weight which was not significantly different from that of T_1. T_{11} gave the lowest 1000 seed weight (39.80 g) and $T_2 - T_5$, T_9 and T_{10} gave 1000 seed weight values which were not significantly different from that of T_{11}. The variation in 1000 seed weight among the treatments might be attributed to the competition for resources with the grasspea under intercropping system. However, Nargis *et al.* (2004) reported that 1000 seed weight did not significantly vary with intercropping. Likewise, Cheng *et al.* (2003) reported that higher nitrogen application under wheat + blackgram intercropping system, 1000 seed weight was greater than monocropped wheat.

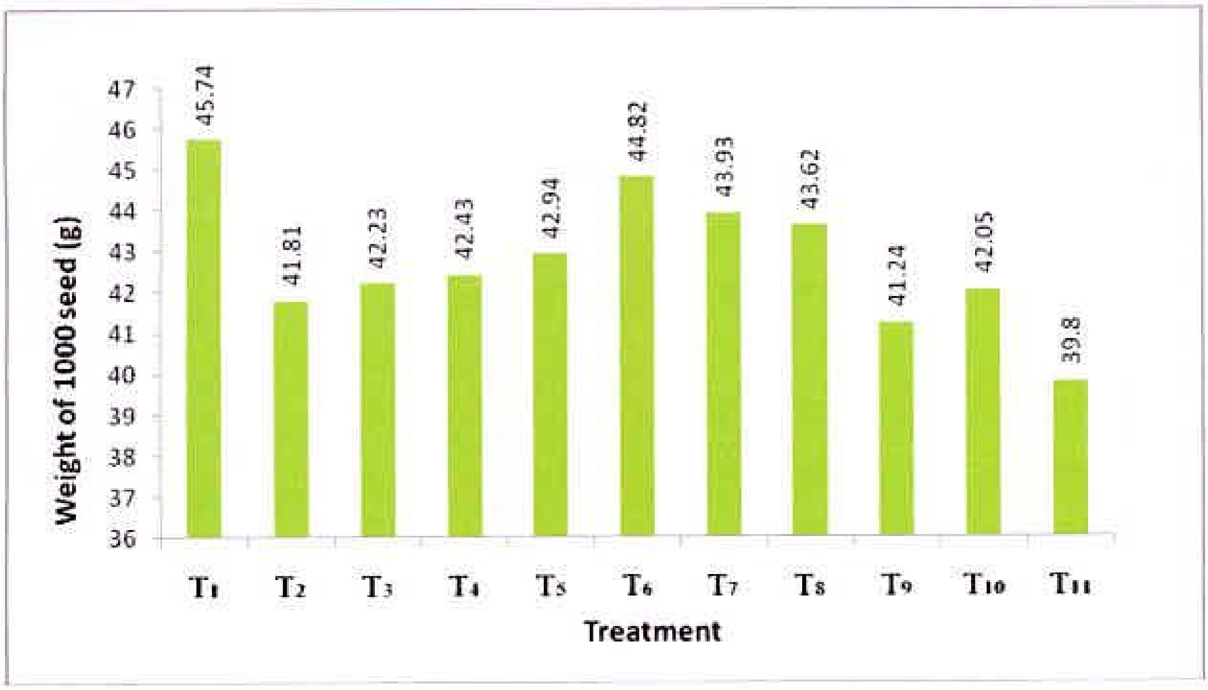

Fig. 2 Weight of 1000 seed of wheat intercropped with fodder grasspea under different fertilizer doses (LSD $_{0.05}$ = 1.66)

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.8 Total grain yield

Grain yield was significantly affected by intercropping system (Fig. 3). T_1 gave the best result (3.08 t/ha). T_6, T_7 and T_8 gave yields (3.01 t/ha, 3.00 t/ha and 2.98 t/ha, respectively) which were not significantly different from that of T_1. T_{11} gave the lowest grain yield (2.27 t/ha). However, T_2 - T_5, T_9 and T_{10} showed yields which, although higher, were not significantly different from that of T_{11}.

Similar result was also obtained by Singh *et al.* (1996). They reported that the combined yield of wheat and lentil under wheat + lentil intercropping system was significantly higher than the sole crop. The application of increased N increased grain yield of wheat which was not significantly higher than that obtained under recommended dose. In this study the yield of wheat under increased application of fertilizer in presence of 20% grasspea did not increase (T_{11}).

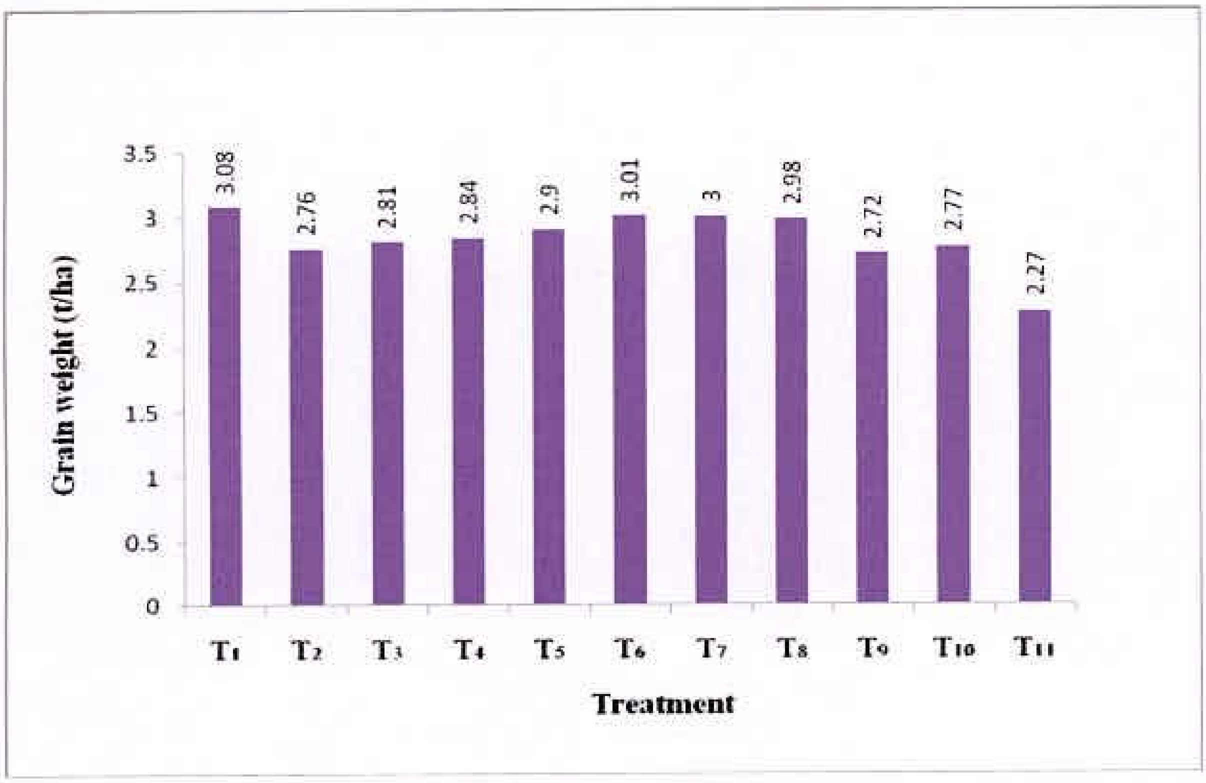

Fig. 3 Grain weight (t/ha) of wheat intercropped with fodder grasspea under different fertilizer doses (LSD $_{0.05}$ = 0.228)

Here,

$T_1 = W_{100} + F_{100}$ (Sole wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.1.9 Harvest Index

Harvest index was significantly affected by intercropping system (Fig. 4). Among the treatments, T_1 gave the best harvest index (41.30), while was statistically similar to those of $T_5 - T_7$. T_{11} gave the lowest harvest index result (33.98). Treatments $T_2 - T_4$ and $T_8 - T_{10}$ were at par showing harvest index values which were not significantly different from that of T_{11}.

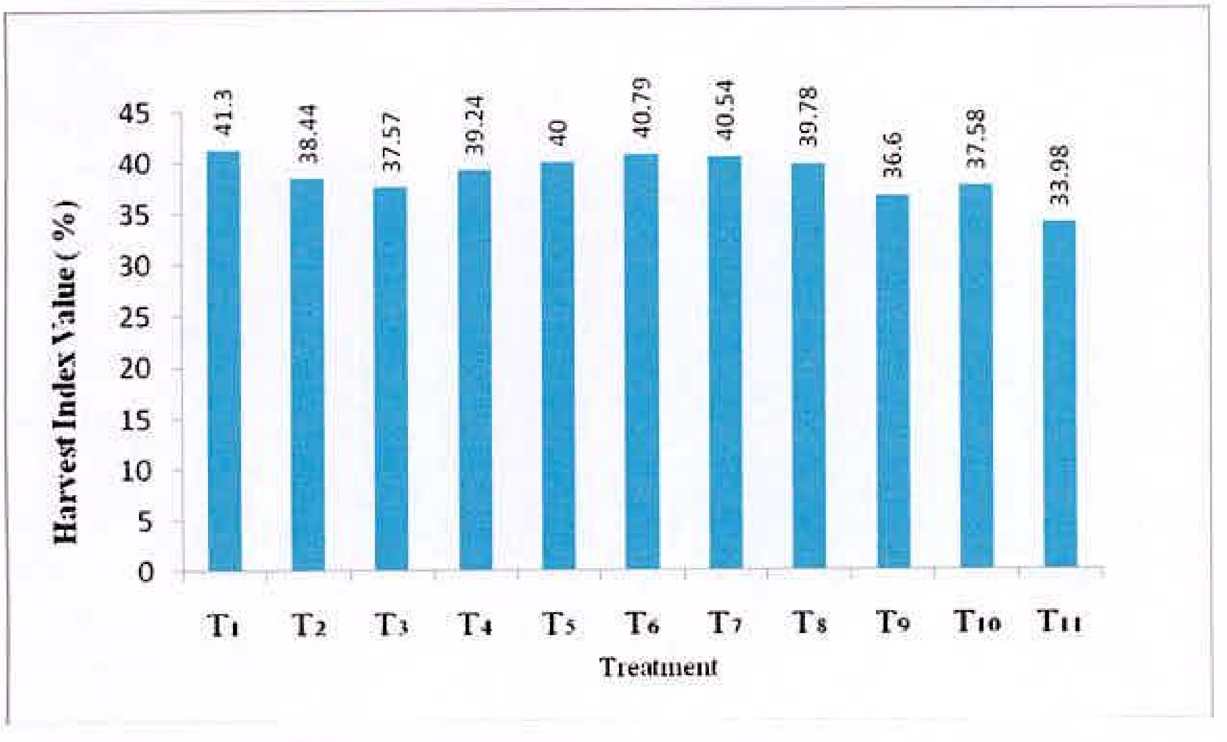

Fig. 4 Harvest Index of wheat intercropped with fodder grasspea under different fertilizer doses (LSD $_{0.05}$ = 1.321)

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.2 Fodder grasspea

4.2.1 Plant height

Plant height of grasspea was significantly affected by the intercropping systems (Table 6). Plant height increased with the advancement of crop age. At 52, 59 and 67 DAS, the taller plants were produced by T_{12} (24.67 cm), T_8 (26.7) and T_8 (40.35 cm), respectively. At 52 DAS, T_7 and T_8 produce similar plants to T_{12}. Likewise at 59 DAS, T_7, T_9 and T_{12} produced plants which were not significantly different from those of T_8. Similar trend was also noticed at 67 DAS. On the other hand, at 52, 59 and 67 DAS, treatments T_6, T_5 and T_6 gave lower plant height (18.97 cm, 22.1 cm and 28.17 cm, respectively). At these stages, T_5 and T_3; T4, T_6 and T_{11}; and T_4, T_5, T_{10} and T_{11}, respectively showed similar plant heights which were not significantly different at the respective stages. Other treatments at all the stages gave intermediate plant height values between higher and lower ones. T_{12} gave the tallest plant; probably there was no competition with wheat. T_7 and T_8 gave the similar result, probably due to higher fertilizer application under more plant population of wheat and grasspea the capability of grasspea to fix atmospheric nitrogen did not decrease.

Table 6. Plant height at different growth stages of grasspea under intercropping grasspea with wheat at different fertilizer doses

Treatment	Plant height of grasspea/plant (cm)		
	52 DAS	59 DAS	67 DAS
T_2	22.83	25.13	37.62
T_3	22.13	23.3	34.78
T_4	21.9	22.07	33.36
T_5	19.53	22.1	28.47
T_6	18.97	22.27	28.17
T_7	24.49	26.43	38.78
T_8	23.33	26.7	40.35
T_9	22.53	25.17	36.43
T_{10}	21.83	24.03	31.95
T_{11}	20.67	23.53	31.91
T_{12}	24.67	26.4	36.78
LS.D (0.05)	3.282	1.729	1.19
CV (%)	8.73	4.23	2.03

Here,
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F= Fertilizer dose)

4.2.2 Number of branches/plant

Number of branches/plant of grasspea was significantly affected by the intercropping systems (Table 7). It increased with the advancement of crop age. At 52 DAS, the highest number was found to be 3.733, while at maturity it was 5.6. Across all the stages, T_{12} showed significantly the highest branch number. However, T_7 and T_8 showed branch numbers, which were not significantly different from that of T_{12} at all stages. The treatment T_6 gave the lowest branch numbers. Other treatments at this stage showed intermediate values in comparison with T_{12} and T_6.

In T_{12}, there was no shading effect of wheat plant as it was a sole grasspea plot. This led to highest branch production. Nargis *et al.* (1996) also gave similar report while conducting an experiment on wheat + lentil intercropping system.

Table 7. Number of branches/plant at different growth stages of grasspea under intercropping with wheat at different fertilizer doses

Treatment	No. of branches/plant		
	52 DAS	59 DAS	67 DAS
T_2	3.28	4.27	4.60
T_3	3.24	4.20	4.60
T_4	3.14	4.18	4.65
T_5	3.06	4.00	3.87
T_6	3.00	3.73	3.60
T_7	3.53	4.40	5.20
T_8	3.40	4.30	5.33
T_9	3.26	4.21	4.67
T_{10}	3.12	4.13	4.60
T_{11}	3.08	4.06	4.20
T_{12}	3.73	5.20	5.60
LSD (0.05)	0.35	0.60	0.74
CV (%)	8.73	4.28	7.12

Here,
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F= Fertilizer dose)

4.2.3 Dry matter weight/plant

Dry matter weight of grasspea was significantly affected by the intercropping systems (Table 8). At all stages it was observed that the highest values of dry weight/plant (0.971, 1.12 and 1.7 g at 52, 59 and 69 DAS, respectively) were found in the treatment T_{12}. At 52, 59 and 67 DAS, T_7 and T_8 showed the values which were not significantly different from that of T_{12}. Again at all stages T_6 showed the lowest value of dry matter/plant. At 52, 59 and 69

DAS, T_5, T_{10}, T_{11} and $T_2 - T_5$, T_9 - T_{11} and $T_2 - T_5$, T_9 - T_{11} showed the values which were not significantly different from that of T_6.

The highest dry matter of T_{12} may be attributed to growth rhythm, duration, light, nutrient supply and water requirements for sole grasspea as there was no competition (Singh, 1979; Singh, 1983).

Table 8. Dry weight/plant at different growth stages of grasspea under intercropping with wheat at different fertilizer doses

Treatment	Dry weight of grasspea/plant (g)		
	52 DAS	59 DAS	67 DAS
T_2	0.727	0.877	1.003
T_3	0.707	0.860	0.960
T_4	0.701	0.818	0.930
T_5	0.584	0.800	0.886
T_6	0.583	0.700	0.780
T_7	0.782	1.040	1.080
T_8	0.732	0.960	1.050
T_9	0.722	0.844	0.986
T_{10}	0.697	0.812	0.926
T_{11}	0.668	0.810	0.916
T_{12}	0.971	1.120	1.700
LSD (0.05)	0.107	0.152	0.143
CV (%)	9.050	9.890	8.960

Here,

$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F= Fertilizer dose)

4.2.4 Total fresh weight

Total fresh weight of grasspea (t/ha) was significantly affected by the intercropping systems (Fig. 5). It should be mentioned here that grasspea was uprooted at 67 DAS as a fodder crop. It was observed that T_{12} gave the highest total fresh weight (1.49 t/ha). This was probably because of more plant population of grasspea and there was no competition with wheat. Treatments T_2, T_3, T_7 - T_9 gave the values which were not also significantly different from that of T_{12}. On the contrary, T_6 showed the lowest dry matter (0.271 t/ha). Treatments T_4, T_5, T_{10} and T_{11} gave the values which were not significantly different from that of T_6. In T_6, grasspea was heavily exposed to competition with wheat under recommended fertilizer dose of wheat. On the other hand, the higher fresh fodder weight obtained in T_{12}, T_7, T_8 and T_2 may be attributed to the greater plant population of grasspea in these treatments.

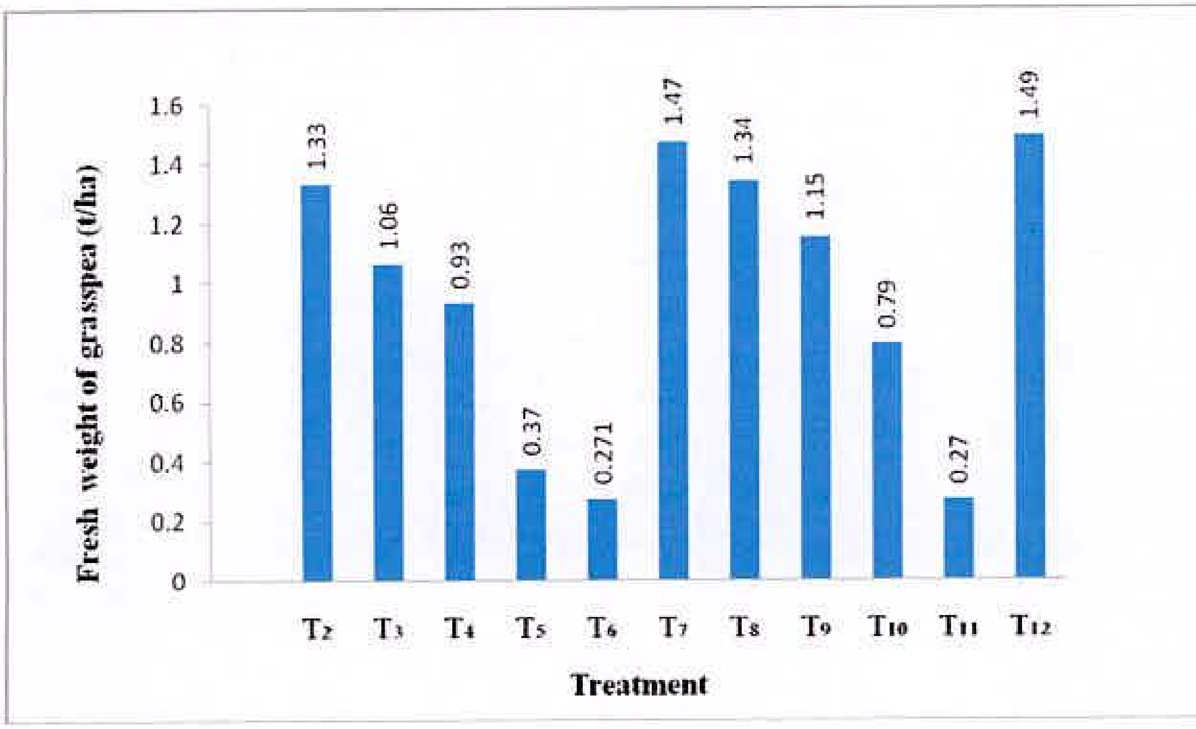

Fig. 5 Fresh weight of fodder grasspea (t/ha) at 67 DAS under intercropping with wheat at different fertilizer doses (LSD $_{0.05}$ = 0.327)

Here,

$T_2 = W_{100} + G_{100} + F_{100}$

$T_3 = W_{100} + G_{80} + F_{100}$

$T_4 = W_{100} + G_{60} + F_{100}$

$T_5 = W_{100} + G_{40} + F_{100}$

$T_6 = W_{100} + G_{20} + F_{100}$

$T_7 = W_{100} + G_{100} + F_{120}$

$T_8 = W_{100} + G_{80} + F_{120}$

$T_9 = W_{100} + G_{60} + F_{120}$

$T_{10} = W_{100} + G_{40} + F_{120}$

$T_{11} = W_{100} + G_{20} + F_{120}$

$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F= Fertilizer dose)

4.2.5 Total dry weight

Total dry weight of Grasspea (t/ha) was significantly affected by the intercropping systems (Fig. 6). The pattern of dry matter accumulation followed that of the fresh matter weight. T_{12} gave the highest total dry weight (0.38 t/ha). T_7 and T_8 gave similar result (0.37 t/ha), which however were not significantly different from that of T_{12}. On the contrary, T_6 gave the lowest dry matter (0.07 t/ha) and T_5, T_{11} showed similar result which were not significantly different from that of T_6. Treatments T_3, T_4, T_9 and T_{10} gave intermediate values between 0.07 – 0.38 t/ha.

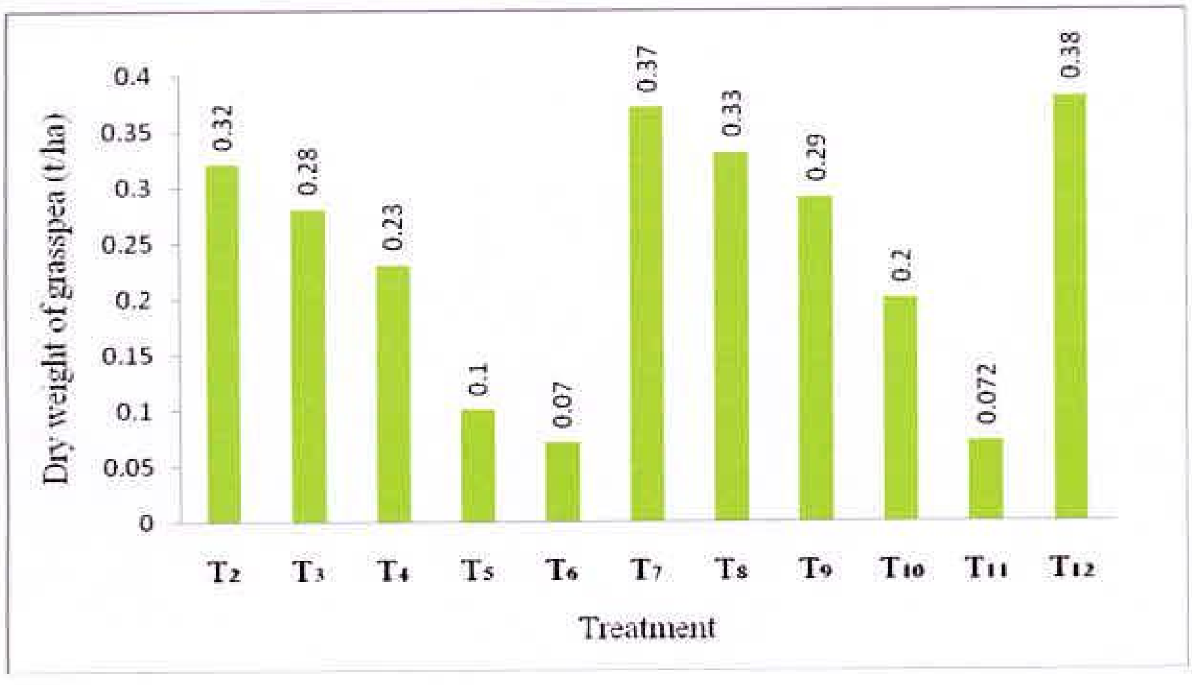

Fig. 6 Dry weight of fodder grasspea (t/ha) at 67 DAS under intercropping at different fertilizer doses ($LSD_{0.05}$ = 0.053)

Here,

$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F= Fertilizer dose)

4.3 Dry weight of weed

Weed infestation was monitored at 17 and 49 DAS. It can be noticed from Table – 9 that weed infestation at 17 DAS was higher than that of 49 DAS. It implies that weeding at the seedling stage might reduce the weed infestation to a great extent. Weed infestation was significantly affected by the intercropping systems. During the experiment, it was observed that increased plant population of wheat decreased weed infestation. Both at 17 and 49 DAS, T_6 showed the most weed population (0.089 t/ha). T_{12} gave similar result (0.088 t/ha) which was not different from that of T_6. T_1 and T_5 showed the results which were not also significantly different from that of T_{12}. Among the treatments, T_7 showed the lowest weed infestation (0.051 t/ha). Again T_8 showed the value which was not significantly different from that of T_7. Treatments $T_2 - T_4$ and $T_9 - T_{11}$ showed the similar results, which were at par and not significantly different from that of T_8.

In this study it was observed that in the sole grasspea (T_{12}) and also in the intercrop treatments having lower population of grasspea, weed dry matter was higher. This was due to the fact that due to lower population of grasspea weed infestation was higher in these treatments. On the contrary, the intercropping treatments having high seed rates produced lower weed dry matter. This was obvious as the combined plant population of wheat and grasspea was much higher which suppressed weed growth. Such finding is in conformation with that of Alam *et al.*, (1997) who reported that practicing wheat and pulse intercropping, the total weed population was reduced significantly. Haymes, *et al.* (1994) also reported that weed biomass was significantly lower in all intercrop patterns compared with sole cropping. Bautista (1988) also reported similar finding.

Table 9. Total dry weight of weed (t/ha) at different days after sowing under wheat–fodder grasspea intercropping at different fertilizer doses

Treatment	Dry weight of weed	
	17 DAS	49 DAS
T_1	0.083	0.055
T_2	0.067	0.063
T_3	0.072	0.071
T_4	0.074	0.072
T_5	0.082	0.079
T_6	0.089	0.086
T_7	0.051	0.047
T_8	0.048	0.049
T_9	0.061	0.058
T_{10}	0.068	0.065
T_{11}	0.077	0.067
T_{12}	0.088	0.080
LSD (0.05)	0.598	0.682
CV (%)	5.068	6.130

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F = Fertilizer dose)

4.4 Productivity performance

The productivity performance of wheat and grasspea under different seed rates and fertilizer doses of intercropping was measured by land equivalent ratio and benefit : cost ratio (BCR). The productivity parameters are presented in Table 10 and Table 11.

4.4.1 Land equivalent ratio

Intercropping offered significant effect on land equivalent ratio (LER). 100% wheat + 100% grasspea under 120% of recommended fertilizer dose of wheat (T_7) was found to be superior in respect of LER (Table 10) on the basis of yield at maturity. However, there was no significant difference among T_2 and T_8 in this respect. T_{11} showed the lowest LER value. Treatments $T_3 - T_6$, T_9 and T_{10} gave the LER values, which were not superior to that of T_7.

The LER value greater than one indicated that there was an yield advantage due to intercropping compared to the sole cropping (Palaniappan, 1988). The highest LER value (1. 96) was obtained in T_7. The LER value of 1.96 meant that by intercropping 3.00 t wheat and 1.47 t fresh weight grasspea was produced from one hectare of land instead of growing them separately in 1.96 hectare of land to achieve the same total yield.

Table 10. Land equivalent ratio (LER) under wheat–fodder grasspea intercropping at different fertilizer doses

Treatment	Land equivalent ratio (LER)
T_1	--
T_2	1.79
T_3	1.62
T_4	1.55
T_5	1.19
T_6	1.16
T_7	1.96
T_8	1.87
T_9	1.65
T_{10}	1.43
T_{11}	0.93
T_{12}	--
LSD (0.05)	0.239
CV (%)	12.46

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F = Fertilizer dose)

Similar findings were found by Mead and Willey (1980) who calculated land equivalent ratio and buckwheat equivalent yield under intercropping. They found that the buckwheat + French bean under intercropping rates recorded higher land equivalent ratio compared to sole cropping.

4.4.2 Net income

Net income provides an appropriate economic assessment of intercropping in terms of increased value per unit land. The highest net income (Tk. 14466.50/ha) was obtained in T_7 (Table 11). The second highest net income at maturity stage (Tk. 14056.50/ha) was found in T_8, which was not statistically different from that of T_7. The negative values of net income were found in T_{12} where grasspea was cultivated as a sole crop for fodder. Treatments T_4 and T_6 gave results which were similar to that of T_1 (Tk.12750.75/ha) but not statistically similar to that of T_7. The treatment T_{11} showed the lowest net income (Tk. 2986.50/ha) where T_{12} gave negative result. Treatments T_2, T_3, T_5, T_9 and T_{10} were also found to have less monetary advantage.

Similar result was found by Singh *et al.* (1992) who stated that the monetary advantage evaluated over sole wheat indicated a positive gain from intercropping system. They tested wheat + grasspea intercropping and found that maximum monetary advantage was recorded from wheat + grasspea in 3:1 row ratio followed by 1:1 row ratio. Sole crops failed to give maximum net return. It appeared that wheat and grasspea were less benefited under sole cropping. Wheat when grown with grasspea gave 24 to 46% higher monetary advantages over sole wheat.

4.4.3 Benefit : cost ratio

It is necessary to mention that higher benefit : cost ratio (BCR) indicate better result. The value of benefit : cost ratio was significantly influenced by intercropping system (Table 11). It was observed that T_7 showed the best result (1.558) among the treatments. T_8 and T_6 also gave better result (1.546 and 1.545) compared to T_1 (1.527) which was not significantly different from T_7. $T_2 - T_5$, T_9 and T_{10} showed the results which were not so good compared to T_7. T_{11} gave the value (1.119) which showed significant difference from T_7 and T_{12} showed the lowest value (0.269)

Similar result was found by Malik *et al.* (1998) stated that the highest net income with a benefit : cost ratio (BCR) of 2.75 was obtained from wheat - lentil intercropping compared with a BCR of 2.35 for wheat alone.

Table 11. Intercropping grasspea with wheat at different fertilizer doses showing total production cost, total return, net income and benefit : cost ratio

Treatment	Total production cost (Tk./ha)	Total return (Tk./ha)	Net income (Tk./ha)	Benefit : cost ratio
T_1	24209.75	36960.50	12750.75	1.527
T_2	25309.75	37110.50	11800.75	1.466
T_3	25089.75	36900.50	11810.75	1.471
T_4	24809.75	36870.50	12060.75	1.486
T_5	24649.75	35910.50	11260.75	1.457
T_6	24429.75	36930.50	12500.75	1.512
T_7	25944.25	40410.75	14466.50	1.558
T_8	25724.25	39780.75	14056.50	1.545
T_9	25504.25	36090.75	10586.50	1.415
T_{10}	25284.25	35610.75	10326.50	1.408
T_{11}	25064.25	28050.75	2986.50	1.119
T_{12}	16600.50	4470.25	-12130.30	0.269
LSD (0.05)	2.113	2.875	3.007	0.093
CV (%)	7.83	9.62	8.41	8.92

Here,

$T_1 = W_{100} + F_{100}$ (Sole Wheat)
$T_2 = W_{100} + G_{100} + F_{100}$
$T_3 = W_{100} + G_{80} + F_{100}$
$T_4 = W_{100} + G_{60} + F_{100}$
$T_5 = W_{100} + G_{40} + F_{100}$
$T_6 = W_{100} + G_{20} + F_{100}$
$T_7 = W_{100} + G_{100} + F_{120}$
$T_8 = W_{100} + G_{80} + F_{120}$
$T_9 = W_{100} + G_{60} + F_{120}$
$T_{10} = W_{100} + G_{40} + F_{120}$
$T_{11} = W_{100} + G_{20} + F_{120}$
$T_{12} = G_{100} + F_{100}$ (Sole Grasspea)

(W = Wheat, G = Grasspea, F = Fertilizer dose)

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMERY AND CONCLUSION

The experiment was conducted at the experimental site of Sher-e-Bangla Agricultural University (SAU) during the period from December, 2005 to March, 2006 to study the intercropping fodder grasspea with wheat at different fertilizer doses and seed rates. Twelve treatments were included in the study. In addition to each of the sole crops, different rates of grasspea seeds (20 – 100%) were tested at two fertilizer doses (100, 120% of the recommended dose of wheat). The experiment was conducted in randomized complete block design (RCBD) with three replications.

The results showed that some of the crop characters such as plant height, number of tillers/plant or branches/plant, dry weight/plant, 1000 seed weight and yield of both wheat and fresh weight of fodder grasspea were significantly affected due to seed rates and fertilizer management.

The best plant height of wheat was shown in sole crop. But in the intercropping treatments, the higher plant height (90.15 and 89.74 cm) of wheat was shown in the treatment of 100% wheat + 20% grasspea at recommended fertilizer rate and 100% wheat + 100% grasspea at 120% of recommended fertilizer dose of wheat at the time of harvest.

Number of tillers/plant of wheat was not significantly affected by intercropping system. But the number of branches/plant of grasspea was significantly affected by intercropping system. At 67 DAS, when it was uprooted as a fodder, the highest number of branches/plant was observed in sole grasspea which was at per with the treatment of 100% wheat + 100% grasspea at 120% recommend fertilizer dose of wheat in this respect.

The highest dry weight/plant and 1000 seed weight of wheat were shown in the treatment of sole wheat. But this was at per with 100% wheat + 100% grasspea at 120% of recommended fertilizer dose of wheat.

Grain yield of wheat was influenced by intercropping compared to the sole crop of wheat. The highest grain yield of wheat (3.08 t/ha) in monoculture was while intercropped with grasspea, the highest yield of wheat (3.01 t/ha) was obtained from the treatment of 100% wheat + 20% grasspea at recommended fertilizer dose of wheat. The treatment, 100% wheat + 100% grasspea, fertilized with 120% of the recommended fertilizer dose of wheat showed the yield (3.00 t/ha) of wheat which was not significantly different from the yield of sole wheat (3.08 t/ha) and also from 100% wheat + 20% grasspea grown under recommended fertilizer dose of wheat. The yield of wheat with the treatments of 100% wheat + 100% grasspea, 100% wheat + 80% grasspea, 100% wheat + 60% grasspea and 100% wheat + 40% grasspea under recommended fertilizer dose of wheat were not so good compared to the yield of sole wheat. Again, wheat yield in the treatments of 100% wheat + 60% grasspea, 100% wheat + 40% grasspea and 100% wheat + 20% grasspea seed rates under 120% of recommended fertilizer dose of wheat were not so good compared to the yield of sole wheat.

The fresh weight of grasspea under 100% wheat + 100% grasspea with 120% fertilizer dose of wheat was 1.47 t/ha which was not significantly different from sole grasspea (1.49 t/ha). The fresh weight of fodder grasspea in the treatment of 100% wheat + 100% grasspea under recommended fertilizer dose of wheat was also better compared to the sole grasspea.

The higher productivity performance of wheat and fodder grasspea intercropping was also obtained (land equivalent ratio (LER), benefit : cost ratio

(BCR) and total net return. The highest LER and CBR value of 1.96 and 1.558 respectively were obtained with the treatment 100% wheat + 100% grasspea at 120% of recommended fertilizer dose of wheat. The highest net return (14466.50 Tk/ha) was also obtained with the same treatment.

Thus the results obtained exhibited that all the intercropping treatments gave encouraging results in respect of yield. Considering wheat as the main crop, intercropping treatment of 100% Wheat + 100% Grass pea fertilized with 120% of the recommended fertilizer dose of wheat emerged out as the promising intercropping system in terms of total return.

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Appendices

APPENDICES

Appendix I Physical characteristics and chemical composition of soil of the experimental plot.

Soil Characteristics	**Analytical results**
Agrological Zone	Madhupur Tract
P^H	5.47 – 5.63
Organic matter	0.82
Total N (%)	0.43
Available phosphorous	22 ppm
Exchangeable K	0.42 meq / 100 g soil

Appendix II Monthly average air temperature, relative humidity, rainfall and sunshine hours during the experimental period (December, 2005 to March, 2006) at Sher - e - Bangla Agricultural University campus.

Month	Year	Monthly average air temperature (^0C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
Dec.	2005	27.19	14.91	21.05	70.05	Trace	212.50
Jan.	2006	25.23	18.20	21.80	74.90	4.0	195.00
Feb.	2006	31.35	19.40	25.33	68.78	3.0	225.50
Mar.	2006	33.20	22.00	27.60	64.13	Trace	220.30

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka – 1212.

Appendix III Rate of different input and output cost

A. Rate of input cost

Sl. No.	Description	Rate
1.	Ploughing with tractor	760.00 Tk./ploughing/ha
2.	Labour	70.00 Tk./labour/day
3.	Fertilizer	
	i. Compost	250.00 Tk./ton
	ii. Urea	6.50 Tk./kg
	iii. TSP	16.00 Tk./kg
	iv. MP	12.00 Tk./kg
	v. Gypsum	10.00 Tk./kg
4.	Seed (for sowing)	
	i. Wheat	22.00 Tk./kg
	ii. Grasspea	40.00 Tk./kg
5.	Insecticide	200.00 Tk./ha
6.	Irrigation	600.00 Tk./irrigation
7.	Interest of total input cost	12.00%
8.	Interest of cost of land	12.00%
9.	Miscellaneous	500.00 Tk./ha

B. Rate of output (benefit)

Sl. No.	Description	Rate
1.	Wheat (grain)	12.00 Tk./kg
2.	Fodder grasspea (fresh weight)	3.00 Tk./kg