# PERFORMANCE OF WHEAT – GRASSPEA MIXED CROPPING UNDER DIFFERENT SEED RATE RATIOS

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This is to certify that the thesis entitled, **"PERFORMANCE OF WHEAT – GRASSPEA MIXED CROPPING UNDER DIFFERENT SEED RATE RATIOS"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY** embodies the result of a piece of bona fide research work carried out by **MST. YASMIN SULTANA**, Registration No. **27458/00661** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information availed of during the course of this investigation has duly been acknowledged.

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**Professor**
**Supervisor**

Dated:
Place: Dhaka, Bangladesh

*Dedicated to*
*My*
*Beloved Parents*
*And*
*Esteemed Teachers*

## PERFORMANCE OF WHEAT-GRASSPEA MIXED CROPPING UNDER DIFFERENT SEED RATE RATIOS

### ABSTRACT

An experiment was conducted on the performance of wheat (W) - grasspea (G) mixed cropping under different seed rate ratios (% of the recommended seed rates of W and G respectively ; $W_{100}$, $G_{100}$, $W_{90}$ + $G_{10}$, $W_{80}$ + $G_{20}$, $W_{70}$ + $G_{30}$, $W_{60}$ + $G_{40}$, $W_{50}$ +$G_{50}$, $W_{40}$ + $G_{60}$, $W_{30}$ + $G_{70}$, $W_{20}$+$G_{80}$, $W_{10}$ + $G_{90}$ and $W_{100}$ + $G_{100}$) at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2006 to March 2007. The experiment was laid out in a randomized complete block design with 3 replications. The result showed that highest grain yield of wheat and grasspea were obtained from the respective sole crop. Among the mixed cropping treatments, wheat yield was maximum with seeding ratio of $W_{90}G_{10}$ closely followed by $W_{80}G_{20}$ but yield was slightly reduced (2%). Grasspea yield was also highest from sole crop but the yield was reduced considerably from 29 to 93% due to mixed cropping. But mixed cropping treatments gave encouraging results in terms of crop productivity, monetary and land equivalent ratio (LER). The highest LER (1.17), wheat equivalent yield (3.48 t $ha^{-1}$), combined yield (3.33 t $ha^{-1}$), gross return (Tk. 88620 $ha^{-1}$), net return (Tk. 46270 $ha^{-1}$), benefit- cost ratio (2.09) and monetary advantages (Tk. 12685.94 $ha^{-1}$) were obtained from seed rate ratio of $W_{70}$ + $G_{30}$.

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| **Abbreviation** | | **Full meaning** |
|---|---|---|
| AEZ | = | Agro – ecological zone |
| BARI | = | Bangladesh Agricultural Research Institute |
| cm | = | Centimeter |
| $^{0}$C | = | Degree celcius |
| CV | = | Co – efficient of Variation |
| cv. | = | Cultivar |
| DAS | = | Days after sowing |
| *et al.* | = | and others *(et alibi)* |
| etc | = | et cetera |
| e.g. | = | For example |
| FAO | = | Food and Agriculture Organization |
| g | = | gram (s) |
| kg | = | Kilogram |
| ha | = | Hectare |
| hr | = | Hour |
| i.e. | = | That is |
| IRRI | = | International Rice Research Institute |
| ICRISAT | = | International Crop Research Institute in Semi Arid Tropics |
| LER | = | Land Equivalent Ratio |
| LSD | = | Least Significant Difference |
| kg ha$^{-1}$ | = | Kilogram per hectare |
| L | = | Litre |
| m | = | Meter |
| mm | = | Millimeter |
| MP | = | Muriate of Potash |
| m$^{2}$ | = | Square meter |
| m $^{-2}$ | = | Per square meter |
| MT | = | Metric Ton |
| mL | = | Mililitre |
| P$^{H}$ | = | Hydrogen ion conc. |
| ppm | = | Parts per million |
| RH | = | Relative Humidity |
| RCBD | = | Randomized Complete Block Design |
| t ha$^{-1}$ | = | Ton per hectare |
| TSP | = | Triple Super Phosphate |
| viz. | = | Namely |
| WRC | = | Wheat Research Centre. |
| @ | = | At the rate of |
| % | = | Percent |

# CHAPTER 1

# INTRODUCTION

Wheat (*Triticum aestivum L*) is the most important cereal crop of the world which belongs to the grass family gramineae. Wheat ranks first in respect of total production in the world. Around 50% of world cereal production is covered by wheat. About one third population of the world live on wheat (Hunshell and Malik,1983). In Bangladesh, it is second important cereal crop next to rice constituting 15.2 percent of the staple cereal food of this country. Total land acreage of wheat in Bangladesh was about 556.00 thousand hectares and the total production was 1050.2 thousand m tons with an average yield is of 1.89 t $ha^{-1}$ in 2004 -2005 (BBS, 2005).

The geographical and agro climatic condition of Bangladesh is favourable for wheat cultivation. It is well adapted to our climate and can play a vital role in reducing our food shortage. It contains about 12.1% protein, 69.60% carbohydrate, 1.72% fat, 27.60% minerals and a good source of vitamin B complex (Anon, 1997). The crop is grown under different environmental condition ranging from humid to arid, sub tropical to temperate zone (Saari, 1998).

The present average yield of wheat in Bangladesh is very low compared to other wheat growing countries. In Holland, UK, France and Norway the average yields were 7.1, 5.9, 5.6 and 4.1 t $ha^{-1}$ respectively during 1986 (FAO, 2005). Again, the yield of wheat in the farmer's field of Bangladesh is much lower than that of the research farm. The causes of lower yield of wheat in Bangladesh due to low temperature during reproductive stage. Also may be due to various factors such as lack of quality seed and good variety, improper seeding and poor knowledge about management practices such as spacing, seed rate, irrigation, imbalanced fertilization and other cultural operations. So the yield of wheat can be augmented with the use of improved varieties and suitable agronomic practices that help us to obtain maximum output from the soil.

Bangladesh is a over populated country and the food production of the country is not increasing to keep pace with that of population growth. Bangladesh is running in shortage of food and this is becoming a chronic problem for the increasing population. So, wheat production needs to be increased.

Pulse crops belong to grain legumes. Bangladesh grows various types pulse crops. Among them grasspea, lentil, mungbean, blackgram, field pea, cowpea are important. These crops provide valuable protein in our human diet. Its protein is rich in lysine which is deficient in rice. About 947,000 acres area of land in Bangladesh is covered by pulse crops with the annual production of 316,000 thousands m tons in 2004-05 (BBS, 2005). According to FAO (1999) recommendation, a minimum intake of pulse per capita should be 8o gm $day^{-1}$, where as it is 12 gm $day^{-1}$ person in Bangladesh. This is because of fact that national production of the pulse is not adequate to meet our demand.

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.

Grasspea is popularly known as khesari (*Lathyrus sativus L)* and is the most widely grown pulse crop. It is produced both for human consumption and animal fodder. It is the most important pulse crop in Bangladesh and ranks first in terms of total acreage and production and contributes about 30% to total pulse production. It occupies about 261.0 thousand hectares of land and produces about 232.5 thousand m tons in 2004-2005 (BBS, 2005) and average yield is 890 kg $ha^{-1}$. This crop is unique as because it can be grow well under adverse situations and requires minimum inputs to give reasonable yield. It can with stand water logging better than other legumes and at the same time can tolerate drought condition. Since it is a legume, it adds nitrogen to the soil. It is less susceptible to insect, pest and disease. It is also easy to grow, cheapest, an excellent source of fodder and contains over 28% protein in the grain (FAO, 1984).

Intercropping / mixed cropping is one of the ways to increase the productivity in a unit area of land. In Bangladesh there is a great possibility to practice intercropping. It is also one of the important techniques to intensify production by growing simultaneously two or more crops in the same piece of land (Beet, 1977).

Intercropping is also considered as a well recognized practice for better land use system along with substantial yield advantages compared to sole cropping. These advantages may be especially important because they are achieved not by means of costly inputs but also by the simple expedient of growing crops together (Willey, 1979).

Intercropping is an excellent crop production tool. It increases total production and reduced chemical use, reduced the risk of total crop failure and stabilizes production. Intercropping is proved to be as excellent production system to increase total yield, higher monetary return, greater resource utilization and fulfill the diversified need of the farmers (Singh *et al.*, 1986). There are four types of multiple cropping such as intercropping, mixed cropping, strip cropping and relay cropping.

Intercropping with leguminous crops is beneficial as it helps to improve the soil fertility in addition to the increase of productivity. Generally legumes in association with non-legumes not only helps utilize the nitrogen being fixed in the current growing season, but also keep residual nutrient build up of the soil (Sharma and Choubey, 1991). However, suitable crop combination as planting geometry enhances the productivity and return in the intercropping system. Wheat - Grasspea mixed cropping gives higher cash returns and total production per hectare than growing wheat crop alone (Evans, 1960).

The poor farmers of our country may be benefited from mixed cropping practices. Farmers can obtain wheat and grasspea at the same time from the same land. Farmers get higher equivalent yield, LER, monetary advantages from mixed cropping than sole crop of wheat -grasspea mixed cropping systems. It gives farmer more income than sole crop.

If grasspea is cultivated with a cereal crop like wheat as a mixed crop, farmer may be benefited in three ways; they may get wheat or grasspea grain and at the same time they may get green fodder from grasspea. This approach may become helpful in increasing soil fertility by fixing nitrogen.

Now a days wheat is sensitive to rise of temperature at flowering stage which resulted sterility of the spikes and ultimately considerably reduced grain yield. In this situation grasspea could be grown as mixed crop with wheat which may compensate yield of the total crop. With this point in mind, an experiment was conducted with the following objectives;

- to know the performance of wheat grasspea mixed cropping systems under different seed ratios
- to increase in total productivity per unit land area through mixed cropping and
- to evaluate utilization of land resources and farming inputs.

# CHAPTER 2
# REVIEW OF LITERATURE

Mixed or intercropping has many advantages for the farmers. It increases total production, acts as insurance against failure of the principal crop and better utilization of interspaces in crops. It reduces the cost of intercultural operation and increase the fertility of the soil. It gives higher land equivalent ratio and higher equivalent yield. Some of the research works relating to this are reviewed in this chapter.

Raheja (1954) reported that 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 seeding ratios.

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

Ram *et al.* (1963) reported that intercropping was found to be helpful in soil moisture conservations, proper utilization of labors and natural resources and solving the unemployment problems of the developing countries.

Lupton and Anthonio (1965) reported that mixed cropping usually leaded to higher total production per unit area than a single crop.
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.

Agboola and Fayemi (1971) reported that through a number of studies, it was revealed that intercropping covered the risk of crop failure, earned more profit, stabilized production, increased soil fertility and conserved soil moisture. It also increased the total yield and returns in terms of unit land area.

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.

Andrews (1972) reported that intercropping was found to be helpful to improve nutritional quality of diet, allowed better control of weeds, decreased the incidence of insect pests, increased land equivalent ratio, reduced soil erosion and helped in the better use of sunlight and water.

Andrews (1972) reported that the higher was the LER, the more was the agronomic benefit from intercropping. The LER might be increased up to 2.00 by adopting intercropping.

Andrews (1972) concluded that while 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.

Mirchandi and Mishra (1957) tried intercropping of wheat and chickpea under different row arrangements and reported that 1:1 row proportion gave significantly higher yields of wheat and chickpea. Similar results were also reported by Gautam and Singh (1961).

IRRI (1973) conducted an experiment and observed that it made better use of sunlight, land and water. It might have some beneficial effects on pest and disease problems. In almost all cases, it gave higher total production; monetary returns and greater resources use efficiently and increase the land productivity by almost 60 percent.

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.

Hoque and Hobbs (1976) conducted a study and reported that in the countries with high populations, intercropping was practiced through crop intensification. For successfulness, it was essential to find suitable companion crops

Hasanuzzaman (1976) concluded that 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

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.

Trenbath (1976) reported that the main advantage of using legumes in intercropping and mixed cropping was found to be the saving of nitrogen fertilizer.

De *et al* (1978) showed that productivity per unit area was increased considerably when maize; sorghum or pearl millet was intercropped with green gram and soybean.

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

Willey (1979) pointed out that the productivity of an intercropping system could be improved through minimizing the interspecific competition between the companion crops. Also stated that intercropping was an age old practice and it has been recognized as a very common practice through out the developing countries

The farmers followed 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 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).

Bhatnagar and Davis (1979) conducted an experiment and found that intercropping legumes with non-legumes had 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.

Razzaque (1980) conducted an experiment on wheat, gram, lentil and mustard and 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.

Mead and Willey (1980) calculated land equivalent ratio and buckwheat equivalent yield under intercropping. The buckwheat + french bean (1:1) recorded higher land equivalent ratio compared to sole cropping. This higher value of LER indicated greater biological efficiency of the intercropping system.

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 was higher than sole crop and LER was greater than monocrop.

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.

Martin and Snaydon (1982) conducted two field experiments with barley and field bean which were grown in pure stands, alternate row mixtures and within row mixtures. In both experiments the land equivalent ratio was consistently greater than 1.00.

Waghmare *et al*. (1982) reported that legume might benefit the associated non-legume crops.

Sharma *et al.* (1982) stated that LER measures the crop productivity of a unit area covered by a crop mixture vis-à-vis that of the sole component.

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 $ha^{-1}$ instead of 120 kg N $ha^{-1}$.

Anjaneyulu *et al.* (1982) examined the performance of pearl millet + mungbean intercropping system. They found that double row planting of pearl millet enhanced mungbean yield by 13% and 16% during 1976 and 1977 respectively over paired row planting of pearl millet.

Hunshell and Malik (1983) reported that intercropping maintained superiority to sole cropping in term of monretary grain. He also added that intercropping of maize + black gram gave higher yield but was statistically at par with sole cropping system.

Khan (1983) reported that the ratio of seed rate of crops in mixed or intercropping system had 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 was an important consideration in mixed intercropping$^{-1}$ practices. The best combination of seedling ratio for wheat and chickpea was found to be 50: 100.

Singh (1983) reported that 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 and Singh (1983) conducted an experiment and found that highest land equivalent ratio (1.27) was recorded in wheat and gram intercropping system followed by wheat + pea (1.19) and wheat + lentil (1.10).

Bandopadhyay (1984) conducted an experiment and found that farmers in developing countries were shown to have keen interest in intercropping practice because of its potentiality for increasing crop yield to meet their requirements for food, fibre and fodder from existing area.

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 $ha^{-1}$ was obtained from pigeon pea resulting an increase in LER by 1.26.

Umrani *et al.* (1984) in an experiment of intercropping of greengram, cowpea and pigeonpea with sorghum under three different planting patterns observed that at below normal rainfall condition paired systems of planting increased the production of sorghum by about 24%, whereas, under good rainfall situation, planting patterns did not show any difference.

Natarjan and Willey (1985) reported that most of the literature explained theoretically the yield advantages of intercropping due to better and over all use of resources by the companion crop.

Natarajan and Willey (1985) and Fawusi *et al.* (1982) pointed out that the LER value was influenced by many factors like density, competitive abilities, morphology, growth duration and management etc.

Manson *et al.* (1986) stated that intercropping did not always increase the total yield. Sometimes it reduced the yield too. Cassava yields were reduced by 2.3 to 4.7 tons $ha^{-1}$ when intercropped with cowpea or peanut.

Hashem and Maniruzaman (1986) carried out an experiment on intercropping maize with cowpea at varying levels of plant population. Maize yield (2.9 t $ha^{-1}$) from 100% maize + 50% cowpea was second as compared to sole maize crop (6.0 t $ha^{-1}$). Additionally of cowpea grain yield was obtained from that intercropping combination. The same combination also gave highest gross return, net return, benefit cost ratio (3.0) and LER (1.25).

Mondal *et al*. (1986) conducted a field experiment and found that Wheat - chickpea was found to be most efficient with1 irrigation in respect of land equivalent ratio, relative co-efficient, monetary advantage, relative net return and area time-equivalent ratio.

Sobhan (1986) reported that the highest land equivalent ratio (LER) under intercropping treatment was received when sunhemp was grown at row spacing of 60 cm with three rows of mungbean in row spacing of 15 cm.

He also reported that mixed cropping of sunnhemp and mungbean gave the highest gross income, net return and benefit cost ratio (2:83:1).

Nikma, *et al.* (1987) studied the production potential of safflower and chickpea intercropping under rainfed condition. They observed that when chickpea (75%) and safflower (25%) were grown in a 3:1 ratio, the intercropping gave the maximum monetary return (Rs. 8,265 $ha^{-1}$) and hence produced extra-monetary returns of Rs. 2,766 and Rs. 1,209 $ha^{-1}$ over the sole chickpea

Bautista (1988) reported that inclusion of legumes in the intercropping system was likely to be beneficial as they could fix atmospheric nitrogen into the soil and helped in the utilization of soil moisture from deeper soil layers.

Palaniappan (1988) described that if the LER was equal to or less than one, it was considered to have no advantage of intercropping over monoculture in term of production. But if LER was more than one under intercropping was considered to have agronomic advantage over monoculture practice.

Hiremath *et al*. (1989) reported that wheat yield was highest when intercropped in a 1:3 safflower + wheat row ratio, but safflower (90 cm rows) yield was highest when grown alone. LER and net returns were highest when safflower and wheat were intercropped in a 1:3 row ratio.

Hiremath *et al.* (1989) conducted an experiment that reported that wheat grain yield was not affected by intercropping with soybean at 1:1 to 4:3 row ratios; however, soybean seed yield was reduced from 0.58 t $ha^{-1}$ when grown alone to 0.062 - 0.31 when intercropped. The highest land equivalent ratio (1.33) was obtained from intercropping wheat and soybeans in a 1:2 row ratio and the highest gross return from 3:1 row ratio.

Hiremath *et al.* *(*1990) found that intercropping in 3:1 wheat: mustard ratio gave the highest wheat yield and land equivalent ratios and intercropping in a 2:2 ratio gave the highest mustard yield. However, gross returns were not significantly different between treatments of 2:1 and 3:1 row ratios.

Hiremath *et al.* (1990) said that the highest land equivalent ratio of 1.36 was obtained from the 1:2 row ratio of wheat: linseed, but the highest gross return and benefit: cost ratios were produced from the 3:1 row ratio.

Raghuwanshi *et al.* (1991) found that intercropping sorghum and soybean in 1:1 alternate rows gave the highest net return of Rs. 4508.50 $ha^{-1}$ and LER in the Kharif season. Intercropping wheat and linseed in a 4:2 row ratio gave the highest net return of Rs. 4748.50 $ha^{-1}$ in the rabi (winter) season.

Jha *et al.* (1991) said that the superiority of LER might be ensured with the optimum utilization of solar radiation, time and soil moisture with more efficiently.

Sinde *et al.* (1991) reported the higher equivalent yield along with higher biomass and efficient use of growth resources under intercropping than those of sole cropping.

Dutta *et al*. (1991) found that wheat yield was 2.21 t $ha^{-1}$ in a pure stand, but when intercropped with pea it ranged from 1015 t $ha^{-1}$ in 2:1 row ratio to 1.84 t $ha^{-1}$ in 4:1 row ratio. Rape was found to be the highest yielding intercrop than the pea and 2:1 ratio of wheat-rape intercropping gave the highest land equivalent ratio and wheat equivalent yield.

Atar *et al*. (1992) conducted a field experiment at New Delhi with wheat based intercropping system. It was observed that intercropping system ensured highest water use efficiency.

Dahatonde *et al.* (1992) conducted an experiment on the performance of wheat + bush bean (French bean) intercropping system. Under wheat-bush bean row ratios of 6:3 or 3:2 were tested with recommended fertilizer rates. Bush bean grown alone produced the highest equivalent yield of 4.01 t $ha^{-1}$ and the highest net returns. The next best wheat equivalent yield of 3.60 t $ha^{-1}$ was shown by wheat/bush bean row ratio of 3:2 receiving recommended fertilizer rates.

Pandey *et al.* (1992) reported that 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

Hossain *et al.* (1992) conducted an experiment on the intercropping of coriander and linseed in wheat and reported that intercropping of wheat + coriander and wheat + linseed planted in uniform rows gave higher monetary advantage compared to sole wheat.

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

Hossain *et al.* (1992) said that wheat yield was not significantly affected by intercropping with coriander and linseed in single, double or triple rows but linseed and coriander yields were decreased under intercropping than when grown under sole cropping. Land equivalent ratio and monetary return were also increased by intercropping of coriander and linseed with wheat when grown in single rows.

Rafey and Prasad (1992) reported that frenchbean either alone or in combination with buckwheat (1:1) recorded significantly higher gross and net returns over remaining treatments. The sole crop of frenchbean was most profitable, followed by intercropping of buckwheat + french bean in

1:1 ratio on economic point of view. The higher values of LER revealed the greater biological efficiency of the intercropping systems.

Islam *et al.* (1992) reported that intercropping was an essential practice to reduce the risk of dependence upon a single crop.

Hossain *et al.* (1992) studied that wheat was intercropped with *Cicer arietenum*, safflower or *Brassica juncea* cv. Sita with row ratios of 3:1, 4:2 or 5:1. Mean wheat grain yields at the used 3 row ratios were 1.78, 1.50 and 1.91 t $ha^{-1}$ respectively. Wheat - safflower intercropping gave the highest wheat equivalent yield (3.07 t $ha^{-1}$) and net returns.

Goldman (1992) in a field study 1988 - 90, where 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, soybean was grown in narrow row spacing and those with an indeterminate growth habit had better light interception

Shafi *et al*. (1993) stated that wheat grain yield was 2.47 t $ha^{-1}$ in the pure stand and 1.62, 1.81 and 2.14 t $ha^{-1}$ when intercropped in 2, 3 or 4 row strips, respectively with safflower. Safflower seed yield was 0.34 t $ha^{-1}$ in the pure stand and 0.03 - 0.08 t $ha^{-1}$ when intercropped. Cost - benefit ratio was highest from the intercrop using strips of 3 rows of the each crop.

Jam *et al.* (1993) conducted an intercropping experiment and observed that gram + linseed (1:1), gram + wheat (2:1) or gram + linseed (3:1) gave the best result in terms of gram equivalent yield, land equivalent ratio and benefit - cost ratio.

Ardeshna *et al*. (1993) stated that in recent years, many scientists were 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.

Ali (1993) reported that among 2:2, 2:1 and 3:1 row ratios of wheat-chickpeas, 2:2 row ratios allowed more light interception and transmission to the lower canopy and gave significantly higher yield

(4016 kg $ha^{-1}$) of wheat and land equivalent ratio (LER) than the other treatments.

Nazir *et al*. (1994) conducted an experiment and found that in monetary term, both the wheat - fenugreek and wheat - lentil intercropping systems proved to be more beneficial than the other cropping systems including monocropped wheat.

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 spacing 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.

Banik (1994) carried out an experiment to evaluate wheat and legume intercropping under 1:1 and 2:1 row ratios and found that the wheat $peas^{-1}$ intercropping (1:1) gave the highest wheat yield equivalent of 3.02 t $ha^{-1}$ followed by the wheat - lentil intercropping (2.91) which also gave the highest best monetary returns.

Varshney (1994) conducted an experiment during rabi season. Chickpea 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.

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 $ha^{-1}$, respectively. Wheat $safflower^{-1}$ intercrop gave the highest wheat equivalent yield (3.07 t) and the highest net returns.

Ahmad *et al. (*1995) reported that intercropping with lentil, garlic and Egyptian clover improved water use efficiency by 47.5-100% compared with sole wheat. N, P and K use efficiencies were also increased by 25.5 - 73.7, 17.8 -72.4 and 1.0 - 69.7% respectively due to intercropping. Wheat - garlic intercrop produced the highest mean wheat grain yield.

Reddy *et al.* (1995) conducted an intercropping experiment with sunflower and groundnut. They examined four treatments in 2 plant densities (75 or 100%) combinations for each crop. They found that groundnut pod and sunflower seed yield were not significantly affected by plant density treatments.

Quayyum and Maniruzzaman (1995) also obtained greater yield under maize + blackgram intercropping system than the pure maize yield.

Singh and Sarawgi (1995) conducted an experiment on the effect of row ratio, nitrogen & irrigation on wheat - chickpea intercropping system with row ratios of 2:1 or 2:2. The best intercrop treatment was where the crops were grown using the row ratio of 2:1 with receiving 100 kg N $ha^{-1}$.

Singh et al. (1996) conducted an experiment whose 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-1. 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.

Ghosh *et al*. (1997) conducted a field experiment 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 wheat grain yield was 2.08 t $ha^{-1}$ without irrigation, 2.99 t $ha^{-1}$ with two irrigations (21 and 65 days after sowing) and 3.40 t $ha^{-1}$ with irrigation at four critical growth stages. Lentil yield was 0.68 t $ha^{-1}$ without irrigation, 1.16 t $ha^{-1}$with two irrigations at branching and flowering, and 0.94 t with 4 irrigations at critical stages.

Verma *et al*. (1997) conducted a field trial in winter seasons that 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 $ha^{-1}$ (100% NP). Intercrops were given 8 different combinations of fertilizers. Wheat grain yield was 3.29 t $ha^{-1}$ in pure stand and 2.73 - 3.12 t $ha^{-1}$ when intercropped. Lentil seed yield was 1.53 t $ha^{-1}$ in pure stand and 0.22 - 0.41 t $ha^{-1}$ 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.

Kulmi and Soni (1997) conducted a field experiment on wheat + sunflower intercropping under 2:1, 2:2, 4:1 or 2:2 row ratios. The crops were also grown under a mixed cropping system of 1:1. 2:1 or 4:1 ratios. Wheat equivalent yield was highest (3.29 t $ha^{-1}$) when wheat and sunflower were intercropped in 4:1 seed rate ratio. This treatment also gave the highest net profit and land equivalent ratio (1.15).

Alam *et al.* (1997) conducted an experiment and stated that wheat + chickpea, 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. Wheat + lentil intercrop was a comparatively poor weed suppressant.

Tomar *et al.* (1997) conducted a field trial on sandy loam soil in winter seasons where 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 $ha^{-1}$) increased wheat grain yield but did not generally affect legume seed yields.

Markunder *et al.* (1997) found that the mixed cropping or intercropping of wheat with lentil increased the productivity per unit area compared to sole cropping of wheat or lentil.

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. It was also reported that practicing wheat and pulse intercropping reduced the total weed population significantly compared to the wheat monoculture.

Sarma and Sarma (1998) carried out an experiment on the performance of different wheat based intercropping systems under irrigated condition. They found that wheat equivalent yield was highest from Rajmash. Because of the higher economic value of this crop wheat equivalent yield was higher in intercropping system than in sole wheat. Net returns were also highest from sole Rajmash followed by the 2:2 row ratio of wheat - Rajmash intercropping.

Ahmed and Saeed (1998) conducted an experiment on wheat and lentil intercropping at row ratios of 4: 3, 5:3, 8:3 or 10:3. Wheat grain yield was highest (4040 kg $ha^{-1}$) with the 10:3 row ratios. This treatment produced lentil seed yield of 4241 kg $ha^{-1}$. The second highest yield was obtained form 8:3 ratio whereas wheat was 3760 kg and lentil was 481 kg.

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.

Ahmed *et al*. (1998) conducted a field experiment in Pakistan. Wheat and lentil were grown alone or intercropped in 80 cm X 100 cm strips or wheat: lentil row ratios of 4:3, 5:3, 8:3 or 10:3. Wheat grain yield was highest (4040 kg $ha^{-1}$) with the 10:3 intercrop. This treatment produced lentil seed yield of 424 kg $ha^{-1}$. 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.

Bora (1999) showed that wheat + rapeseed was the best combination for obtaining the maximum yield at 1:1 row ratio out of 1:2, 1:3, 3:1 and 2:1 row ratios.

Qiujie *et al*. (1999) stated that in field trials in 1989-92, wheat and groundnuts were relay cropped or sequentially cropped and were 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.

Rahman (1999) stated that intercropping of grass pea and yellow sarson with wheat was sustainable over sole wheat. The association of wheat with grass pea under either 3:1 or 1:1 was more sustainable, which accounted for better value with respect to biological parameters and was economically more remunerative.

Sarkar (1999) conducted an experiment and found that intercropping maize with cowpea and wheat was evaluated during the rabi seasons of 1988-89 and 1989-90 and demonstrated that intercropping of maize with cowpea produced the highest total maize equivalent yield of 4294 kg $ha^{-1}$. This was 33% higher than the yield of sole crop of maize. The combined maize + cowpea yield gave the highest net return of Tk. 11759 $ha^{-1}$ and highest LER of 1.26 indicating that the mixture was 26 % more efficient in terms of land utilization than a sole crop of maize. This also gave the highest net income of Tk. 1.80 spent.

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

Pratibha *et al.* (2000) studied the growth parameters of sunflower intercropped with pea, linseed, niger and gram under 1:1 and 1:2 row planting geometry during the winter season. Results showed that thickness and height of sunflower plants were almost identical under both planting geometry of the intercropping and sole cropping. The growth parameters were inferior under intercropping particularly with 1:2 row planting geometry than those of the sole crops. Among the intercrops, peas caused more competitive effects on growth of sunflower than linseed, niger and gram.

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.

Ghanbari and Lee (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.

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.

Xiao *et al*. (2003) conducted an experiment on intercropping of fababean (*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.

Cheng *et al.* (2003) reported that when higher nitrogen was applied under wheat + blackgram intercropping system, l000 seed weight was greater than monocropped wheat.

Nargis and krishna. (2003) stated that weed was significantly controlled by wheat + sunflower and wheat + linseed at 3:1 and 3:1 row ratios respectively.

Mengping and Zhangjinsong (2004) observed that intercropping of pulse crops with wheat was found to be useful to obtain better yield and/ or fodder crops. It was established that intercropping system increased water utilization efficiency, showed higher land equivalent ratio and above all gave higher yield.

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 $ha^{-1}$) 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 ratios (1.84) were recorded for intercropping lentil (100%) and wheat (40%).

Nargis *et al*. (2004) reported that the highest seed yield (2704 kg $ha^{-1}$) 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.

Nargis *et al*. (2004) reported increased land equivalent ratio (LER) from a series of experiments on mixed cropping or intercropping and indicated that the mixed cropping intercropping $^{-1}$ increased 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.

Ahlawat et al. (2005) conducted an experiment and found that chickpea yield was adversely affected by intercropping with Indian mustard, barley and linseed. Chickpea yield increased as the proportion of chickpea in the mixture increased from 2:1 to 4: 1. Sole Indian mustard productivity, as measured in chickpea - equivalent yield (CEY) was highest, followed by chickpea + Indian mustard (2:1). Chickpea + linseed and sole chickpea recorded similar CEY.

Howlader (2006) reported that intercropping of wheat with Bush bean increased the no. of leaves Plant$^{-1}$ when wheat: Bush bean (4:1 row ratios arrangements) over sole crop of wheat. Again he found that wheat + bush bean was the best combination for obtaining the maximum number of grain plant $^{-1}$ at 3:1 row ratio.

Howlader (2006) studied an experiment and found that intercropping of wheat and bush bean at different row ratios. Here, highest grain yield of wheat at sole wheat and highest fresh pod yield of bush bean at sole bush bean. Also found that highest seed yield of bush bean at sole bush bean. But highest combined yield at harvesting stage was 3.204 t ha$^{-1}$ obtained from intercropping treatments at wheat: bush bean (4:1 row ratio).

Howlader (2006) conducted an experiment and stated that the row ratio of wheat and bush bean at 3:2 gave the highest plant of bush bean and highest no of branches plant$^{-1}$ and no. of pods plant$^{-1}$ obtained from sole bush bean, highest number of seeds plant$^{-1}$ 44.39 obtained from wheat: bush bean at 3: 1 row ratio.

Howlader (2006) reported that highest land equivalent ratio of 1.094 was obtained from the 4:1 row ratio of wheat: bush bean at maturity stage but 1.440 was obtained from the 3:2 row ratio of wheat: bush bean at vegetative stage. He found that highest wheat equivalent yield was 5.095 t $ha^{-1}$ at maturity stage and 4.734 t $ha^{-1}$ at vegetative stage was from obtained from the 3: 2 row ratio of wheat bush bean.

Ghosh *et al.* (2006) conducted an experiment and reported that inclusion of legumes in the cropping system helped in solubilizing insoluble P in soil, improving the soil physical environment, increasing soil microbial activity and restoring organic matter and also had smothering effect on weed, increased productivity and nutrient use-efficiency in various systems.

Islam (2006) conducted a study and reported that higher yields of wheat (3.00 – 3.08 t $ha^{-1}$) were obtained with wheat 100% + grasspea 20% + fertilizer 100% and wheat 100% + grasspea 100% + fertilizer 120% treatments. Highest fodder yield (1.47 t $ha^{-1}$) 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. $ha^{-1}$ respectively and these were obtained with the treatment of wheat 100% + grasspea 100% + fertilizer 120%.

From the above findings it may be concluded that cause with legumes and other crops were found higher productivity & economically viable.

# CHAPTER 3

# MATERIALS AND METHODS

This chapter represents a brief description of the experimental site, soil, climate, experimental design, treatments, cultural operations, collection and preparation of plant samples, analytical methods followed in the determination of physical properties of samples.

## 3.1 Location

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from November 2006 to March 2007 to study the performance of wheat -grasspea mixed cropping under different seeding ratios.

## 3.2 Site selection

The experimental field was located at $90^{0}22^{/}$ E longitude and $23^{0}41^{/}$ N latitude at an altitude of 8.6 meters above the sea level. The land was in agro ecological zone of “Madhupur Tract” (AFZ no. 28). It was deep red brown terrace soil and belongs to “Nodda” cultivated series. The soil was clay loam in texture having pH range from 5.47 to 5.63. Organic matter content was very low (0.82 %). The physical and chemical characteristics of the soil have been presented in Appendix VIII.

## 3.3 Climate

Low temperature and minimum rainfall was the main feature of the rabi season. The monthly total rainfall, average sunshine hour, temperature during the study period (November to March) is shown in Appendix IX.

## 3.4 Planting materials

Two types of crops having dissimilar growth habits were used in the experiment. The crops were wheat (*Tritium aestivum*) and grasspea (*Lathyrus sativus*) where wheat was grown as main crop and grasspea as companion crop.

## 3.5 Plant characteristics and variety

### 3.5.1 Wheat

A high yielding wheat variety "BARI Gom-21" (Shatabdi) was selected as a planting material. The variety was released by WRC (Wheat Research Centre) of BARI in 2000. and the variety completed its life cycle in 105-112 days. The height of the variety is 90-100 cm, produces 4-6 tillers plant$^{-1}$. Leaves are flat, less droopy, lip of lower glume is long in spikelet (8-10 mm) and necks of lower glumes are high. Spikes are long and each spike contains 40-45 numbers of grains. Grains are white in color with larger in size. 1000 seed weight are 46-48 g. Flag leaf and lower stalk of spike are green in color though spikes are yellow at ripening stage.

The average yield of this variety is 3.60-5.00 t $ha^{-1}$. It had the ability to give 10-20 percent better yield than Kanchan when sown in late or suitable time. The variety was tolerate in leaf spot disease and resistant in leaf rust diseases. The variety is also tolerant to heat (BARI, 2004).

### 3.5.2 Grasspea

A high yielding grasspea variety "BARI khesari-2" was selected as planting material. The variety was released by BARI in 1995. The height of the variety is 55-60 cm. Leaf is broader than local variety. The color of flower is blue. Seed is slightly long, weight of 1000 seed is 50-55 g. The color of seed is slight grey. The percentage of protein is 24-26. It takes about 125-130 days from growing to ripening. Average yield of this variety is 1.5-2.00 t $ha^{-1}$.

### 3.6 Experimental treatments

The experiment had following treatments of different seeding ratios of wheat and grasspea.

$W_{100}$ = Wheat (W) 100% of the recommended seed rate

$G_{100}$ = Grasspea (G) 100% of the recommended seed rate

$W_{90}G_{10}$ = Wheat (W) 90% + Grasspea (G) 10% of the recommended seed rates of both

$W_{80}G_{20}$ = Wheat (W) 80% + Grasspea (G) 20% of the recommended seed rates of both

$W_{70}G_{30}$ = Wheat (W) 70% + Grasspea (G) 30% of the recommended seed rates of both

$W_{60}G_{40}$ = Wheat (W) 60% + Grasspea (G) 40% of the recommended seed rates of both

$W_{50}G_{50}$ = Wheat (W) 50% + Grasspea (G) 50% of the recommended seed rates of both

$W_{40}G_{60}$ = Wheat (W) 40% + Grasspea (G) 60% of the recommended seed rates of both

$W_{30}G_{70}$ = Wheat (W) 30% + Grasspea (G) 70% of the recommended seed rates of both

$W_{20}G_{80}$ = Wheat (W) 20% + Grasspea (G) 80% of the recommended seed rates of both

$W_{10}G_{90}$ = Wheat (W) 10% + Grasspea (G) 90% of the recommended seed rates of both

$W_{100}G_{100}$ = Wheat (W) 100% + Grasspea (G) 100% of the recommended seed rates of both

### 3.7 Experimental Design and layout

The experiment was laid out in a randomized complete block design with three replications. The experimental unit was divided into three blocks each of which representing a replication. Each block was divided into 12 plots in which treatments were applied at random. So, the total number of unit plots in the entire experiment was 3×12 =36. The distance maintained between two plots was 0.75 m and between blocks 1 m.

### 3.8 Details of the field operations

The cultural operations carried out during the experimentation are presented below:

#### 3.8.1 Land preparation

The experimental field was first ploughed on November 3, 2006. The land was ploughed thoroughly with a power tiller and given laddering to obtain the desirable tilth. The corners of the land were hammered to make the soil into small pieces. Weeds, stubbles and crop residues were cleaned from the land. The final ploughing and land preparation was done on November 13, 2006. The layout was done as per experimental design on November 14, 2006.

#### 3.8.2 Fertilizer application

At first, cowdung at the rate of 10 t $ha^{-1}$ was applied in the whole field.  Plots having wheat at the rate of 50% or more of the recommended seed rates were crop. So, fertilizer were applied only for wheat and no additional fertilizers were applied for grasspea, The experimental plots of wheat were fertilized at the rate of 200 kg, 160 kg, 45 kg and 115 kg $ha^{-1}$ of urea, triple super phosphate, muriate of potash and gypsum, respectively. Where as in sole grasspea fertilizers were applied at the recommended rate i.e., 42 kg urea, 82 kg TSP and 35 kg MP per hectare respectively. two third of the urea, whole amount of triple super phosphate, muriate of potash and gypsum were applied as basal in the plot uniformly before sowing. The remaining one third urea was applied as top dressing at 21 days after sowing just after weeding thinning, and irrigation of wheat plots.

**3.8.3 Seed Collection and sowing**

The wheat seeds (cv shatabdi) were colleted from wheat research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and Grasspea seeds were collected from Pulse and Oil seeds Centre, from same institute. Seeds were broadcasted on November 15, 2006 as per experimental treatments. The recommended seed rate of wheat and grasspea were 140 and 50 kg $ha^{-1}$ respectively. Wheat and grasspea seeds were mixed together and broadcast is well prepared first. After that seeds were covered with soil. Two guards were appointed from early morning to evening to protect the wheat seeds from birds especially pigeons and crows.

### 3.8.4 Germination test

Germination test was performed before sowing the seed in the field. Filter papers were placed on petridishes and the papers were socked with water where 25 seeds were placed at random in pertridish. Data on emergence were collected on percentage basis by using the following formula:

$$\text{Germination test (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds set for germination}} \times 100$$

### 3.8.5 Weeding

Weeds were controlled through three weeding at 20, 50 and 80 days after sowing. The weeds identified were kakpaya ghash (*Dactyloctenium aegyptium L),* Shama (*Echinocloa crussgalli),* Durba (*Cynodon dactylon*), Arail (*Leersia hexandra),* Mutha (*Cyperus rotundus* L), Bathua (*Chenopodium album,* Shaknatey (*Amaranthus viridis* ), Foska begun

(*Physalis beterophylls*), Titabegun (*Solanum torvum*), and Shetlomi (*Gnaphalium luteolabum L*).

### 3.8.6 Irrigation

Germination of seeds was ensured by light irrigation. Three irrigations were given at crown root initiation, heading and grain filling stages (21, 55 and 70 days after sowing) respectively. During irrigation care was taken so that water could not flow from one plot to another or overflow the boundary of the plots. Excess water of the field was drained out.

### 3.8.7. Pest management

The wheat crop was infested by Aphid and rodents. Therefore, contact insecticide (Malathion @ 20 mm per 10 litres of water) was given two times and 2% zinc sulphide was applied. Grasspea was not infested by any insect pest.

### 3. 8.8 Harvesting and sampling

At full maturity, the wheat and grasspea crop was harvested plot wise on March 23, 2007. Before harvesting, 10 plants of wheat and grasspea from each plot was selected randomly and uprooted. Grasspea was first harvested and then wheat. Those were marked with tags, brought to the threshing where seeds and stover were separated, cleaned and died under sun for 4 consecutive days. Crop of each plot was harvested from 6 $m^2$ separately. Then those were weighted separately to record the seed yield which was converted to t $ha^{-1}$.

### 3.9 Recording of data

The following data of both crops were collected during the study period.

#### 3.9.1 Wheat

1. Plant population $m^{-2}$ at harvest
2. Plant height from 30 DAS to harvest
3. No. of tillers plant $^{-1}$
4. Length of spike $plant^{-1}$
5. No of grains $plant^{-1}$
6. Dry matter accumulation $plant^{-1}$ from 30 DAS to harvest.
7. 1000 grain weight (g)
8. Grain yield (t $ha^{-1}$)
9. Straw yield (t $ha^{-1}$)
10. Harvest index (%)

#### 3.9.2 Grasspea

1. Plant population $m^{-2}$ at harvesting.
2. Plant height from 30 DAS to the harvest

3. No. of branches plant$^{-1}$.

4. Date of first flowering.

5. Date of 50% flowering.

6. Date of pod formation.

7. Date of 100% podding.

8. Dry matter plant$^{-1}$

9. No. of pods plant$^{-1}$

10. No. of seeds pod$^{-1}$

11. 1000 seed weight (g)

12.Seed yield ha$^{-1}$

13. Straw yield ha$^{-1}$

14.Biological yield

15.Harvest index (%)

**3.10 Procedure of recording data**

**3.10. 1 Plant population m$^{-2}$**

One square meter area at the centre of each plot was demarcated by stick and the number of wheat and grasspea plants was counted.

**3.10.2 Plant height (cm)**

Ten plants were selected and tagged at 30 DAS. Plant height was measured always on those plants from the base to the tip of the longest leaf at 30 DAS, 60 DAS, 90 DAS and 130 DAS and mean plant height was determined in cm.

### 3.10.3 Number of tillers or branches

Number of total tillers of wheat and branches of grasspea plant$^{-1}$ was counted and converted into $1m^2$ and the mean values were recorded.

### 3.10.4 Flowering (%)

First grasspea flower initiation was found at 63 DAS whereas 50% flower was opened at 70 DAS and 100% flower opened at 78 DAS. First pod initiation was found at 77 DAS.

### 3.10.5 Length of spike plant$^{-1}$ (cm)

Spike length of the plant from the base of the flag leaf to the tip of the spikelets were measured and recorded.

### 3.10.6 Number of grains and pods

Total number of grains of wheat and pods of grasspea were counted from ten plants and then averaged.

### 3.10.7 Number of seeds and pods

The number of seeds per spike of wheat and number of pods $plant^{-1}$ of grasspea were counted from ten plants and then averaged.

### 3.10.8 Total dry matter $plant^{-1}$ (g)

The dry weight of plants was recorded in gram. Data were collected at 30, 60, 90 and 130 DAS (at harvest). Ten plants were uprooted with the help of nirani (hand hoe) and cleaned with water; plants were over dried at $80^0$ C until a constant weight was obtained.

### 3.10.9 Thousand grain /seed weight (g)

Thousand grain /seeds were randomly taken from the harvest of each plot. The seeds were weighted at about 12% moisture level using an electric balance.

### 3.10.10 Seed yield (t $ha^{-1}$)

#### 3.10.10.i Wheat

The crop was harvested plot wise as per experimental treatments from demarked $6m^2$ area. Threshed seeds were cleaned and then sun dried for seven days to 12% moisture level. Each sample plot was weighed and values were converted to t $ha^{-1}$.

### 3.10.10. ii Grasspea

The crop was harvested plot wise as per experimental treatments from control $6m^2$ area.Threshed seeds were cleaned and then sun dried for seven days to 10% moisture level. Each sample plot was weighed and values were converted to t $ha^{-1}$.

### 3.10.11 Straw yield (t $ha^{-1}$)

Having finished the threshing, drying weight of straw of each sample plot was measured and converted to t $ha^{-1}$.

### 3.10.12 Harvest index (%)

Harvest index was determined by dividing economic yield from total biological yield (grain $straw^{-1}$) from the same area (Donald, 1963) and multiplied by 100.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}} \times 100$$

### 3.10.13 Relative yield and land equivalent ratio (LER)

Relative yield and land equivalent ratio was used for comparing intercropping treatments. To evaluate the productivity advantage of intercropping, LER was calculated. LER values were computed from grain yield data of the crop as per of the following formulae (IRRI, 1973).

$$\text{Relative yield of wheat} = \frac{\text{Intercrop yield of wheat}}{\text{Sole crop yield of wheat}}$$

$$\text{Relative yield of grasspea} = \frac{\text{Intercrop yield of grasspea}}{\text{Sole crop yield of grasspea}}$$

Land equivalent ratio (LER) = Relative yield of wheat + Relative yield of grasspea.

LER in its simplest form has been defined as the relative area of sole crops that would be required to produce the yield achieved by intercropping. An LER value of 1.25 would indicate yield advantage of 25% (Willey, 1979).

### 3.10.14 Equivalent yield (t $ha^{-1}$)

In the intercropping system, equivalent yields were used as criteria for evaluating the productivity. Wheat equivalent was calculated and it was computed by converting the yield of companion crop (grasspea) in to the yield of main crop (wheat) on the basis of prevailing market prices using the following formula (Anjaneyulu *et al.*,1982).

$$\text{Wheat equivalent yield} = Y_w + \frac{Y_g \times P_g}{P_w}$$

(for intercropping)

Where,

$Y_w$ = Seed yield of wheat (intercrop) (t $ha^{-1}$)

$Y_g$ = Seed yield of grasspea (intercrop) (t $ha^{-1}$)

$P_w$ = Market price of wheat seed (Tk. 25 $kg^{-1}$)

$P_g$ = Market price of grasspea seed (Tk. 38 $kg^{-1}$)

Similarly,

$$\text{Grasspea equivalent yield} = Y_g + \frac{Y_w \times P_w}{P_g}$$

(for intercropping)

Where,

$Y_w$= Seed yield of wheat (intercrop) (t $ha^{-1}$)

$Y_g$= Seed yield of grasspea (intercrop) (t $ha^{-1}$)

$P_w$= Market price of wheat seed (Tk. 25 $kg^{-1}$)

$P_g$= Market price of grasspea seed (Tk. 38 $kg^{-1}$)

**3.10.15 Monetary Advantage (Tk. $ha^{-1}$)**

The monetary advantages (Tk. $ha^{-1}$) were calculated for each component crop separately as per following formulae (Willey, 1979a)

$$\text{Monetary advantages} = \text{Value of combined yield} \times \frac{\text{LER} - 1}{\text{LER}}$$

Where, LER = Land equivalent ratio

### 3.10.16 Economic analysis

Total number of labourer used for different operations were recorded along with cost of variable inputs to compute the variable cost of different treatments. The cost and return analysis was done for each treatment on per hectare basis.

**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.

$$\text{Benefit- cost ratio (BCR)} = \frac{\text{Gross return (Tk. ha}^{-1})}{\text{Total cost of production (Tk. ha}^{-1})}$$

## 3.11 Statistical analysis

Data collected for different parameters were compiled and tabulated in proper from. Appropriate statistical analysis was made by MSTAT computer package program and the treatment means were compared by least significance difference (LSD) at 5% level of significance.

# CHAPTER 4

# RESULTS AND DISCUSSION

The present experiment was conducted to determine the performance of wheat grasspea mixed cropping under different seeding ratios. Data on plant character, yield contributing characters and yield were recorded to find out the significance of wheat grasspea mixed cropping at different seeding ratios. The analysis of variance (ANOVA) of the data is given in Appendices. The results have been presented, discussed, and interpretations given under the following headings.

## 4.1 Wheat

### 4.1.1 Growth characters of wheat as influenced by wheat - grasspea mixed cropping at variable seeding ratios

#### 4.1.1.1 Plant height (cm)

Plant height increased with the advancement of plant age .Plant height of wheat was affected by the intercropping systems (Fig 1).

At 30 DAS, highest plant height 29.73cm was obtained from $W_{80}G_{20}$ whereas lowest (22.80 cm) obtained with $W_{10}G_{90.}$ All other treatments were statistically similar in respect of plant growth.

At 60 DAS, highest plant height 51.55 cm was obtained in $W_{80}G_{20}$ and lowest plant height of wheat was 36.89cm which was obtained in $W_{10}G_{90}$. Plant height of 48.55, 46.66 and 46.33 cm were obtained from $W_{60}G_{40}$, $W_{30}G_{70}$ and $W_{100}G_{100}$, respectively which were statistically similar. Rest crop combination ($W_{100}$, $W_{20}G_{80}$, $W_{90}G_{10}$ and $W_{70}G_{30}$) showed plant height of 44.78 cm, 44.44 cm, 44.11 cm and 43.00 cm, respectively which were also statistically similar. Treatments $W_{10}G_{90}$, $W_{50}G_{50}$, $W_{40}G_{60}$ and $W_{70}G_{30}$ were also found to be statistically similar in this respect.

At 90 DAS, plant height of wheat was not significantly affected by different seed rate ratios under mixed cropping condition. But maximum plant height of wheat (86.55 cm) which was obtained from $W_{90}G_{10}$ and lowest plant height of wheat 80.22cm from $W_{20}G_{80}$.

At harvest, the highest plant height (95.33cm) was recorded in $W_{60}G_{40}$ which was significantly similar to 87.44 cm, 87.11 cm, 91.89cm, 88.55 cm, 89.77 cm, 88.78 cm, 87.33 cm from treatments $W_{100}$, $G_{100}$, $W_{80}G_{20}$, $W_{70}G_{30}$, $W_{50}G_{50}$, $W_{40}G_{60}$, $W_{20}G_{80}$ and $W_{100}G_{100}$, respectively the lowest height (81.33 cm) was observed in $W_{10}$ $G_{90}$ which was statistically similar to those of $W_{100}$, $W_{90}G_{10}$, $W_{80}G_{20}$, $W_{70}G_{30}$, $W_{50}$ $G_{50}$, $W_{40}G_{60}$, $W_{30}G_{70}$, $W_{2}G_{80}$ and $W_{100}G_{100}$ in this respect.

Islam (2006) found that plant height of wheat was significantly affected by intercropping systems.

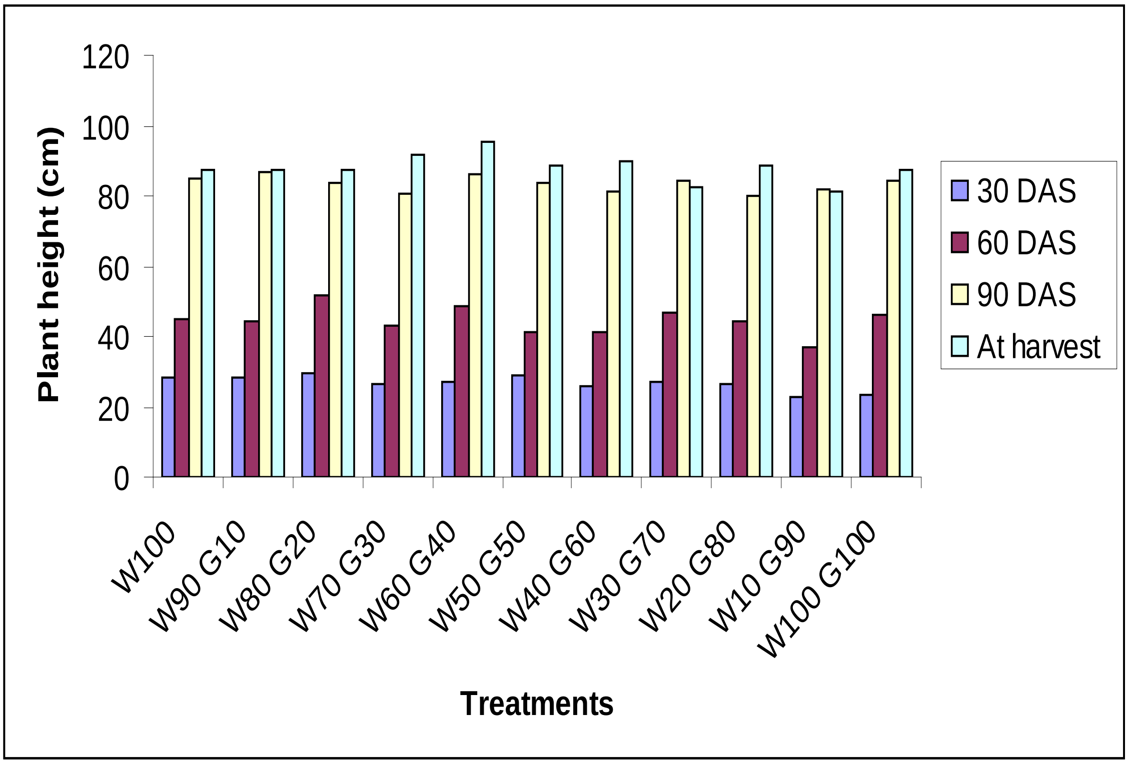


**Fig. 1 Plant height at different growth stages of wheat as affected by wheat- grasspea mixed crop system under different seed rates (LSD $_{0.05}$=NS, 6.05, NS and NS at 30, 60, 90 DAS and at harvest, respectively)**

### 4.1.1.2 Dry matter weight (g)

Dry matter weight of wheat was significantly affected by the mixed cropping systems (Fig.2). It increased with the advancement of age. Maximum dry matter weight of 1.54, 2.91, 15.56 and 17.49 g were obtained from sole crop ($W_{100}$) at 30, 60, 90 DAS and at harvest, respectively. Whereas, the lower dry matter weight of 0.48, 1.41, 9.42 and 10.51 g were obtained from combination of $W_{10}G_{90}$ at 30, 60, 90 DAS and at harvest, respectively.

The highest dry matter weight from sole crop ($W_{100}$) might be due to no grasspea plants and so there was no competition for moisture, nutrients, space and light.

However, dissimilar findings were also found by Islam (2006) who reported that dry matter weight of wheat was significantly affected by the intercropping system.

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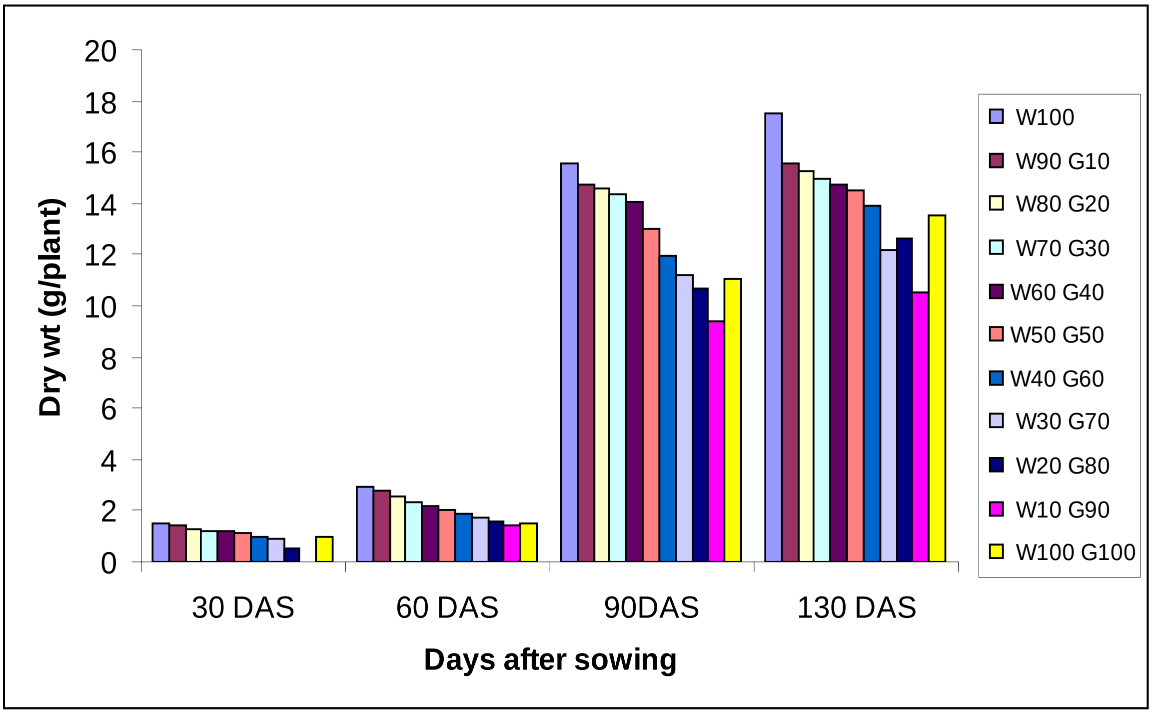


**Fig. 2 Dry matter accumulation of wheat as influenced by different mixed cropping arrangements with grasspea (LSD $_{0.05}$ = NS, 0.77, NS, NS at 30, 60, 90 DAS and at harvest, respectively)**

### 4.1.1.3 Population density $m^{-2}$

Population per $m^2$ of wheat was significantly affected under different seeding ratios by mixed cropping patterns (Table 1). The highest population per $m^2$ of wheat (100.00) was obtained from the treatment $W_{100}$. The lowest population per $m^2$ of wheat (11.00) was recorded from the treatment $W_{10}G_{90}$. However, the population density of 83.33 and 81.33 were obtained from the treatments $W_{80}G_{20}$ and $W_{90}$ $G_{10}$ which were, however, statistically similar. It revealed from the findings that wheat plant population $m^{-2}$ decreased gradually with the decrease of wheat seeding ratios.

### 4.1.1.4 Number of tillers plant$^{-1}$

The number of tillers of wheat was not significantly affected by seed rate ratios under mixed cropping patterns of wheat and grasspea (Table 1). Numerically, highest number of tillers plant$^{-1}$ (2.92) was obtained from $W_{50}G_{50}$ and $W_{60}G_{40}$ respectively which were statistically similar in this respect. The lowest number of tillers (1.54) was obtained from $W_{100}G_{100}$ might be due to this high competition between wheat and grasspea due to maximum (100%) seed rates.

Similar findings were also found by Nargis *et al. (*2004) and also by Ashok *et al.* (2001). They found that number of tillers plant$^{-1}$ of wheat was significantly affected by wheat based intercropping systems. Singh, *et al.* (1995) also reported similar results.However, Islam (2006) and Howlader (2006) reported that number of tillers plant$^{-1}$ of wheat was not significantly affected under wheat based intercropping systems.

**Table 1 Population per meter square and number of tillers per plant of wheat at different seeding ratios under mixed cropping system**

| Treatments | Population $m^{-2}$ | No. of tillers $plant^{-1}$ |
|---|---|---|
| $W_{100}$ | 100.00 | 2.65 |
| $W_{90}G_{10}$ | 88.67 | 2.70 |
| $W_{80}G_{20}$ | 83.33 | 2.86 |
| $W_{70}G_{30}$ | 81.33 | 2.89 |
| $W_{60}G_{40}$ | 60.33 | 2.92 |
| $W_{50}G_{50}$ | 49.67 | 2.92 |
| $W_{40}G_{60}$ | 41.67 | 2.72 |
| $W_{30}G_{70}$ | 31.33 | 2.43 |
| $W_{20}G_{80}$ | 20.00 | 2.66 |
| $W_{10}G_{90}$ | 11.00 | 2.79 |
| $W_{100}G_{100}$ | 95.00 | 1.54 |
| **LSD** $_{(0.05)}$ | 3.13 | NS |
| CV (%) | 3.06 | 18.91 |

W =Wheat G=Grasspea

### 4.1.1.5 Length of Spike (cm)

Data was collected at 90 DAS and at harvest. Spike length of Wheat was significantly affected at harvest by different seed rate ratios under mixed cropping patterns (Table 2).

At 90 DAS, spike length of wheat was not significantly affected by different seeding ratios. Highest spike length (14.10 cm) of wheat was obtained from $W_{50}$ $G_{50}$ and the lowest 12.34 cm from $W_{20}$ $G_{80}$.

At harvest, Spike length of wheat was not also significantly affected by different seeding ratios under mixed cropping patterns. The highest spike length of wheat 15.46 cm was obtained from $W_{50}G_{50}$ and the lowest 13.20 cm was obtained from sole crop. Rest treatments were statistically similar in this respect.

Ghanbari *et al.* (2002) and Nargis *et al.* (2004) also reported significant effect on spike length of wheat under intercropping system.

**Table 2 Spike length of wheat as in influenced by different mixed cropping arrangements with grasspea**

| Treatments | Length of spike (cm) | |
|---|---|---|
| | 90 DAS | At harvest |
| $W_{100}$ | 13.01 | 13.20 |
| $W_{90}$ $G_{10}$ | 13.21 | 14.94 |
| $W_{80}$ $G_{20}$ | 13.09 | 14.58 |
| $W_{70}$ $G_{30}$ | 13.44 | 14.03 |
| $W_{60}$ $G_{40}$ | 13.31 | 13.45 |
| $W_{50}$ $G_{50}$ | 14.10 | 15.46 |
| $W_{40}$ $G_{60}$ | 13.74 | 14.23 |
| $W_{30}$ $G_{70}$ | 13.10 | 14.83 |
| $W_{20}$ $G_{80}$ | 12.34 | 14.65 |

| | | |
|---|---|---|
| $W_{10}$ $G_{90}$ | 12.44 | 14.61 |
| $W_{100}$ $G_{100}$ | 12.44 | 14.00 |
| **$LSD_{(0.05)}$** | NS | NS |
| CV (%) | 13.41 | 9.27 |

W =Wheat G=Grasspea

### 4.1.2 Yield and yield attributes of wheat as influenced by mixed cropping of wheat with grasspea at variable seeding ratios

#### 4.1.2.1 Number of spike plant$^{-1}$

Number of spike plant$^{-1}$ was not significantly affected by different seed rate ratios under mixed cropping patterns of wheat and grasspea (Table 3). But maximum number of spike plant$^{-1}$ was 3.92 which was recorded in $W_{50}G_{50}$ and the lowest 2.87 from $W_{100}G_{100}$ which might be due to high competition in these treatments. Islam (2006) found that number of spike/plant of wheat was not significantly affected by wheat- grasspea intercropping system at different and seed rates.

However, Singh *et al.* (1996) also reported that there was no significant effect on spike number of wheat under intercropping system.

### 4.1.2.2 Number of grains spike$^{-1}$

Number of grains spike$^{-1}$ was significantly influenced by mixed cropping of wheat and grasspea under different seeding ratios (Table 3). The highest no. of grains spike$^{-1}$ (28.40) was recorded from $W_{10}G_{90}$ whereas lowest number of grains spike$^{-1}$ (25.02) was recorded from highest seeding ratio of both the crops ($W_{100}G_{100}$) which resulted strong competition among the wheat as well as grasspea plants for nutrients, space, light and moisture etc. The number of grains spike$^{-1}$ was increased with the decrease of wheat population.

### 4.1.2.3 Thousand grain weight (g)

Thousand grain weight of wheat were not significantly influenced by different seeding ratios of wheat and grasspea under different mixed cropping patterns (Table 3). But maximum grain weight (36.96 g) was observed from sole crop of wheat which might due to higher populations and no competition from grasspea plants for nutrients, space, light and moisture. The lowest 1000 grain weight (32.98 g) was obtained from maximum seeding ratios ($W_{100}G_{100}$) where plants were under strong competition for nutrients, space, light and moisture.

Nargis *et al.* (2004) also reported that 1000 grain weight of wheat varied significantly with intercropping. Cheng *et al.* (2003) reported that intercropping yield was greater than monocropped wheat.

**4.1.2.4 Grain yield**

Grain yield of wheat was significantly affected by different seed rate ratios of mixed cropping patterns with grasspea (Table 3). The highest grain yield (3.14 t $ha^{-1}$) was produced in sole wheat. There was no significant difference in grain yield between 70 to 90 kg seed $ha^{-1}$ of wheat & yield reduction was shown from sole crop. The lowest grain yield (0.41 t $ha^{-1}$) was produced in $W_{10}G_{90}$ due to lower population of wheat.

Dutta *et al.* (1991) reported that highest wheat yield was obtained in sole crop which decreased when intercropped with pea.

**Table 3 Grain yield and yield attributes of wheat as influenced by different mixed cropping arrangements of wheat with grasspea under different seeding ratios**

| Treatments | No. of spike $plant^{-1}$ | No. of grain $spike^{-1}$ | 1000 grain wt. (g) | Grain yield (t $ha^{-1}$) |
|---|---|---|---|---|
| $W_{100}$ | 3.65 | 26.00 | 36.96 | 3.14 |
| $W_{90}$ $G_{10}$ | 3.66 | 26.29 | 36.02 | 3.09 |
| $W_{80}$ $G_{20}$ | 3.86 | 26.46 | 35.98 | 3.07 |
| $W_{70}$ $G_{30}$ | 3.87 | 26.85 | 35.72 | 3.05 |
| $W_{60}$ $G_{40}$ | 3.89 | 26.92 | 35.53 | 2.15 |
| $W_{50}$ $G_{50}$ | 3.92 | 27.01 | 35.19 | 1.85 |
| $W_{40}$ $G_{60}$ | 3.72 | 27.53 | 35.27 | 1.45 |
| $W_{30}$ $G_{70}$ | 3.46 | 27.64 | 35.22 | 1.11 |
| $W_{20}$ $G_{80}$ | 3.66 | 28.00 | 35.44 | 0.73 |
| $W_{10}$ $G_{90}$ | 3.79 | 28.40 | 35.89 | 0.41 |
| $W_{100}$ $G_{100}$ | 2.87 | 25.02 | 32.98 | 1.79 |
| **LSD $_{(0.05)}$** | NS | 0.02 | NS | 0.02 |
| CV (%) | 15.45 | 3.21 | 8.20 | 3.07 |

W =Wheat G=Grasspea

### 4.1.3 Harvest index (%)

Harvest index was significantly affected by different seed rate ratios of wheat and grasspea under mixed cropping patterns (Table 4). Highest harvest index (43.28) was obtained from $W_{70}G_{30}$ and the lowest (29.05) from $W_{10}G_{90}$ where seeding ratio of wheat was maximum & grasspea minimum. There was no definite trend was followed in case of harvest index.

Islam (2006) also found that harvest index of wheat was significantly affected by intercropping system.

**Table 4 Harvest index of wheat under different wheat grasspea mixed cropping patterns**

| Treatments | Harvest index value (%) |
|---|---|
| $W_{100}$ | 41.13 |
| $W_{90}$ $G_{10}$ | 40.68 |
| $W_{80}$ $G_{20}$ | 42.62 |
| $W_{70}$ $G_{30}$ | 43.28 |
| $W_{60}$ $G_{40}$ | 42.29 |
| $W_{50}$ $G_{50}$ | 36.57 |
| $W_{40}$ $G_{60}$ | 39.44 |
| $W_{30}$ $G_{70}$ | 39.13 |
| $W_{20}$ $G_{80}$ | 31.24 |
| $W_{10}$ $G_{90}$ | 29.05 |
| $W_{100}$ $G_{100}$ | 39.51 |
| **LSD (0.05)** | 0.64 |
| CV (%) | 0.98 |

W =Wheat G=Grasspea

## 4.2 Grasspea

### 4.2.1 Growth characters of grasspea as influenced by mixed cropping at variable seeding ratios

#### 4.2.1.1 Plant height (cm)

Plant height increased with the advancement of age. However, at 30 DAS, plant height of grasspea was not significantly affected by the mixed cropping systems (Fig 3). Maximum plant height (12.38 cm) was obtained from $W_{40}G_{60}$ followed by (11.76 cm) from $W_{70}G_{30.}$ The lowest plant height (10.25 cm) was obtained from maximum plants $m^{-2}$ of both the crops. At early stage of growth, slight variation was observed among the different treatments.

At 60 DAS, plant height of grasspea was significantly affected by different seeding ratios under mixed cropping condition. At this stage maximum plant height (29.33 cm) was obtained in $W_{80}G_{20}$ and which was followed by seeding ratio in $W_{90}G_{10,}$ $W_{80}G_{20,}$ $W_{70}G_{30}$, $W_{60}G_{40}$ and $W_{50}G_{50,}$ respectively.

At 90 DAS, plant height of grasspea was not significantly affected by different seed rate ratios under mixed cropping patterns. Maximum plant height of grass pea was (64.00 cm) obtained in $W_{90}G_{10}$ which was followed by $W_{80}G_{20}$ . The lowest plant height of 34.22 cm was obtained from sole crop which was statistically similar to those of $W_{10}G_{90}$, $W_{20}G_{80}$, $W_{30}G_{70}$, $W_{40}G_{60}$, $W_{50}G_{50}$ and $W_{100}G_{100}$, respectively.

At harvest, the highest plant height (88.22 cm) was recorded in both sole crop combination ($W_{100}G_{100}$ ). The lowest plant height (40.11 cm) was recorded in $W_{10}G_{90}$ which was statistically similar to sole crop of grasspea (40.44 cm). The highest plant height of $W_{100}G_{100}$ was statistically similar to those of $W_{70}G_{30}$, $W_{60}G_{40}$, $W_{90}G_{10}$, $W_{50}G_{50}$, $W_{80}G_{20}$ and $W_{20}G_{80}$ but was significantly higher than $W_{30}G_{70}$ and $W_{40}G_{60}$ treatments.

Pratibha *et al.* (2000) showed that thickness and height of sunflower plants were almost identical under both planting geometry of the intercropping and sole cropping. The growth parameters were inferior under intercropping particularly with 1:2 row planting geometry than those of the sole crops.

Howlader (2006) also found that plant height of bushbean was significantly influenced by different row ratios under intercropping patterns.

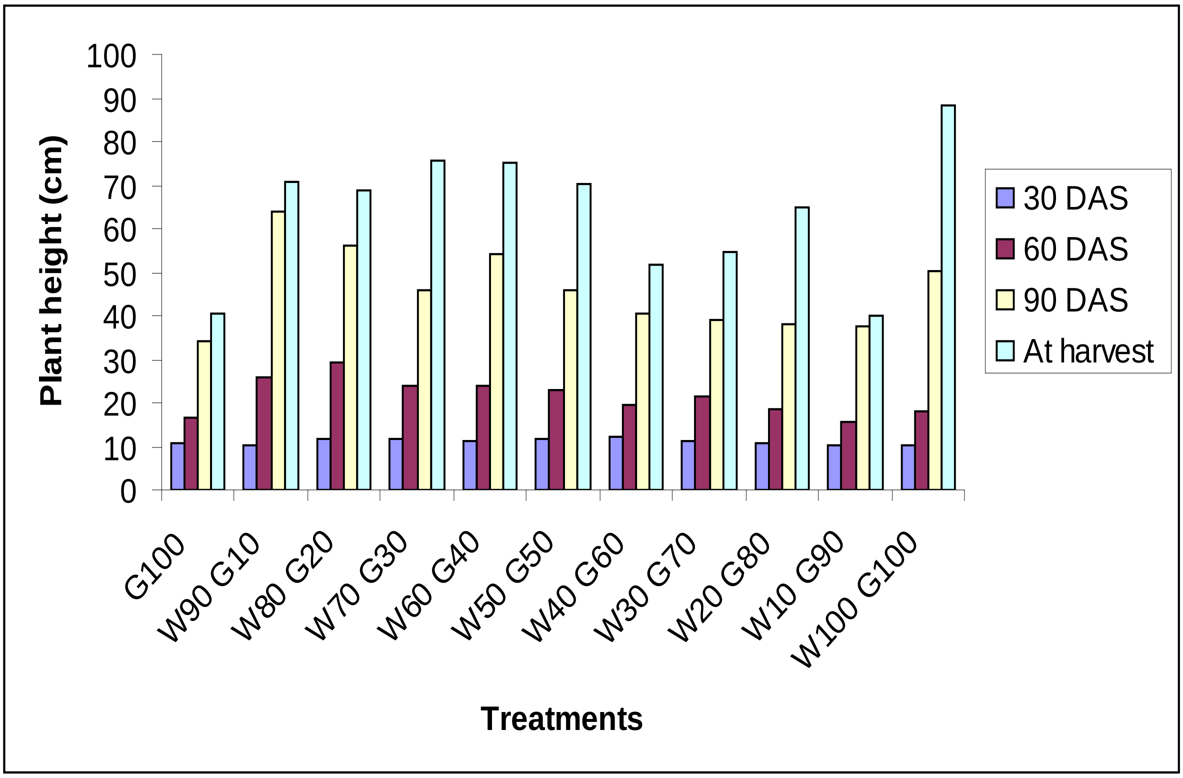


**Fig. 3 Plant heights at different growth stages of grasspea under mixed cropping with wheat at variable seed ratios (LSD $_{0.05}$ = NS, 6.41, 14.97 and 21.62 at 30, 60, 90 DAS and at harvest, respectively)**

### 4.2.1.2 Branches of grasspea

Figure 4 shows that the number of branches/plant of grasspea was not significantly affected by different seeding ratios under mixed cropping patterns. Number of branches plant$^{-1}$ was monitored at 53 DAS (Pre-flowering stage). It was found that the highest branches of grasspea (6.33) were obtained form $W_{50}G_{50}$ and lowest (4.00) from $W_{100}G_{100}$.

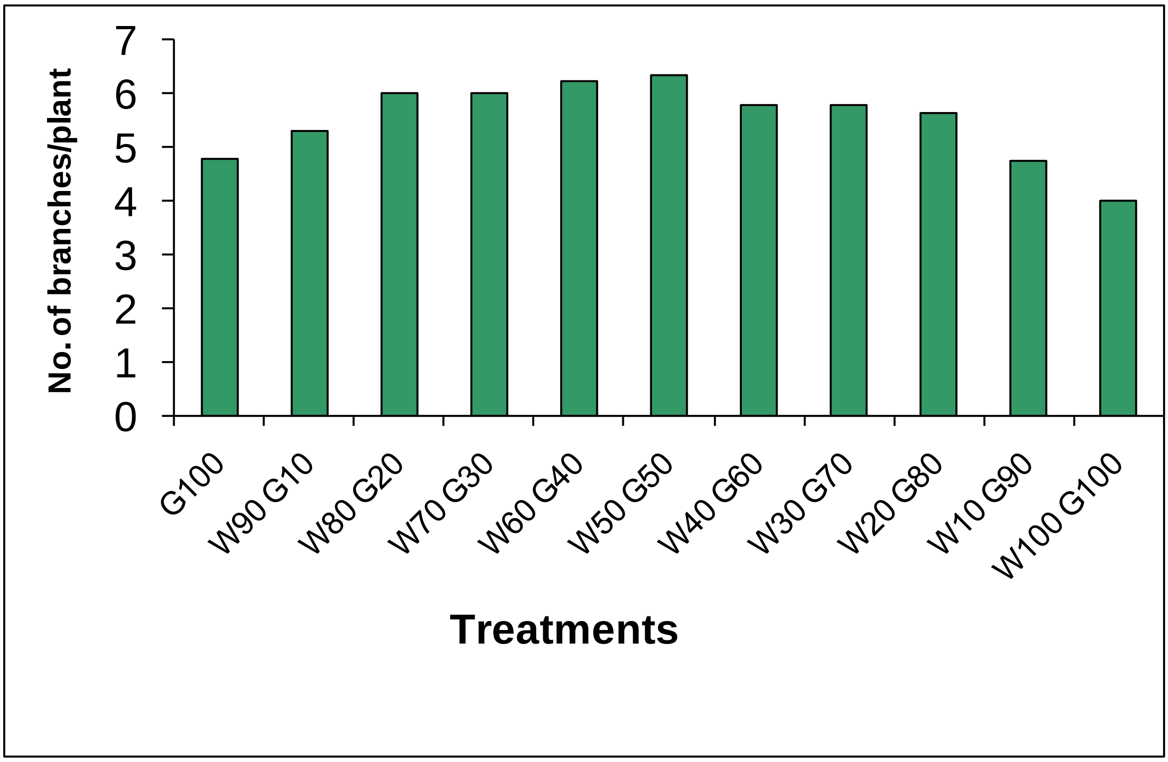


**Fig. 4 Number of branches/plant of grasspea as influenced by different mixed cropping arrangements of grasspea with wheat (LSD $_{0.05}$ = NS at 53 DAS)**

### 4.2.1.3 Dry matter weight (g)

Dry matter weight of grasspea was significantly affected by the different seed rate ratios under mixed cropping patterns. At all stages, it was observed that highest value of 0.15, 0.73, 2.22 and 2.18 g were obtained 30, 60, 90 DAS and at harvest, respectively which were found in sole crop of grasspea.

AT 30 DAS, all the treatments were statistically similar and the lowest dry matter per plant was obtained from highest seeding ratio ($W_{100}G_{100}$).

At 60 DAS, the lowest dry matter weight of grasspea (0.25 g) was obtained from $W_{100}G_{100}$ which, however, was statistically similar to $W_{10-90}G_{10-90.}$ The highest dry matter of $G_{100}$ was also statistically similar to $W_{10-50}G_{50-90}$ and $W_{70}G_{30}$.

At 90 DAS, the highest dry matter weight of grasspea was also found with sole crop of grasspea which was however at par with $W_{90}G_{10}$, $W_{80}G_{20}$ and $W_{70}G_{30}$ respectively. The lowest dry matter weight of grasspea (0.41 g) was obtained from $W_{10}G_{90}$, which was statistically similar to $W_{20}G_{80}$, $W_{30}G_{70}$, $W_{100}G_{100}$, $W_{40}G_{60}$, $W_{50}G_{50}$, $W_{60}G_{40}$ and $W_{70}G_{30.}$

At harvest, significantly higher dry matter weight (2.18 g) was obtained from sole crop ($G_{100}$) which was statistically similar to $W_{50}G_{50}$, $W_{20}G_{80}$, $W_{10}G_{90}$ and $W_{40}G_{60}$ showing 1.27 g, 1.27 g, 1.25g and 1.11 g respectively. The lowest dry matter weight (0.48 g) was obtained from $W_{100}G_{100.}$

Similar findings were also found by Singh (1979) and Singh (1983). They reported that the highest dry matter weight of grasspea might be attributed to favourable growth rhythm, duration, light, nutrition supply and water requirements in the sole grasspea as there was no competition.

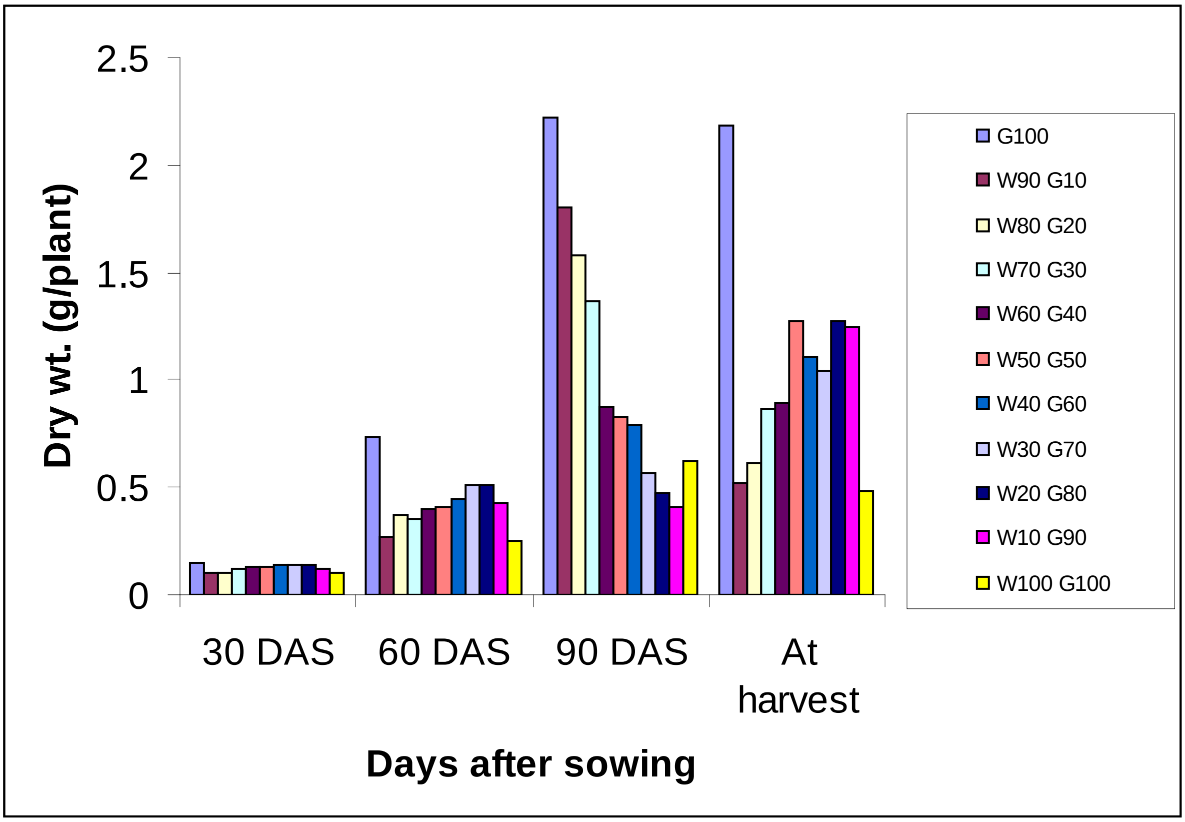


**Fig. 5 Dry matter accumulation of grasspea as influenced by different mixed cropping arrangements with wheat (LSD $_{0.05}$ = NS, NS, 0.92, NS at 30, 60, 90 DAS and at harvest, respectively)**

### 4.2.1.4 Population density

Population per $m^2$ of grasspea was significantly influenced by different seed rate ratios under mixed cropping patterns (Table 5). The highest population $m^{-2}$ of grasspea (40.33) was obtained from sole crop ($G_{100}$).There was trend to increase plant population with the increase of seed rate from 10 to 90 kg $ha^{-1.}$ The lowest population$m^{-2}$ (9.10) was obtained from $W_{90}G_{10.}$ All other treatments were statistically dissimilar in this respect.

### 4.2.1.5 Number of branches plant$^{-1}$ at harvest

The number of branches plant$^{-1}$ was significantly affected by different seeding ratios wheat and grasspea under mixed cropping patterns (Table 5). Maximum number of branches plant$^{-1}$ (3.99) was obtained from sole crop ($G_{100}$)$_.$ The highest number of branches of $G_{100}$ indicated that there was no competition for space, light, water and nutrients in this treatment. The lowest number of branches plant$^{-1}$ (1.50) was obtained from$W_{100}G_{100}$ which was statistically different from other treatments. There was trend to increase branches plant$^{-1}$ with the decrease of wheat seeding ratio but reverse in case of grasspea.

**Table 5 Population per meter square and number of branches per plant of grasspea as influenced by different mixed cropping arrangements with wheat at different seed rate ratios under mixed cropping system**

| Treatments | Population $m^{-2}$ | No. of branches $plant^{-1}$ |
|---|---|---|
| $G_{100}$ | 40.33 | 3.99 |
| $W_{90}$ $G_{10}$ | 9.10 | 2.73 |
| $W_{80}$ $G_{20}$ | 11.03 | 2.81 |
| $W_{70}$ $G_{30}$ | 14.51 | 2.89 |
| $W_{60}$ $G_{40}$ | 18.00 | 2.95 |
| $W_{50}$ $G_{50}$ | 22.56 | 3.02 |
| $W_{40}$ $G_{60}$ | 25.28 | 3.03 |
| $W_{30}$ $G_{70}$ | 29.32 | 3.28 |
| $W_{20}$ $G_{80}$ | 32.00 | 3.68 |
| $W_{10}$ $G_{90}$ | 33.52 | 3.88 |
| $W_{100}$ $G_{100}$ | 34.58 | 1.50 |
| **LSD ( 0.05)** | 5.05 | 0.96 |
| CV (%) | 9.06 | 18.50 |

W =Wheat G=Grasspea

### 4.2.2 Yield and yield attributes of grasspea as influenced by mixed cropping at variable seeding ratios

#### 4.2.2.1 Number of pods $plant^{-1}$

The number of pods $plant^{-1}$ was significantly affected by different seed rate ratios of under mixed cropping systems

(Table 6). The significantly highest number of pods plant$^{-1}$ (15.53) was obtained from $W_{100.}$ The lowest number of pods plant$^{-1}$ (10.02) was recorded in $W_{100}G_{100}$ which was statistically similar to $W_{20}G_{80,}$ $W_{10}G_{90,}$ $W_{90}G_{10}$, $W_{40}G_{60}$, $W_{80}G_{20}$ and $W_{70}G_{30,}$ respectively. This result revealed that the highest number of pods plant$^{-1}$ of sole crop ($G_{100}$) was found due to the fact that there was no or less competition for space, light, water and nutrients among the plants in this treatment.

Howlader (2006) reported that number of pods plant$^{-1}$ was significantly affected by intercropping patterns. He showed that the highest number of pods plant$^{-1}$ was found where there was no or less competition for space light, water and nutrients among the plants.

**4.2.2.2 Number of seeds pod$^{-1}$**

The number of seeds pod$^{-1}$ in grasspea was not significantly affected by different seed rate ratios of under mixed cropping patterns. Maximum number of seeds pod$^{-1}$ was found in sole crop ($G_{100}$) while lowest number of seeds pod $^{-1}$ was found in $W_{100}G_{100.}$

Dakua (1992) reported that number of seeds pod$^{-1}$ in chickpea was not significantly affected by intercropping systems.

#### 4.2.2.3 Thousand seed weight (g)

Significantly thousand seed weight in grasspea was affected by mixed cropping patterns. Maximum seed weight (46.14 g) was obtained in $W_{60}G_{40}$ which was statistically similar to $W_{70}G_{30}$, $G_{100}$, $W_{50}G_{50}$, $W_{80}G_{20}$, $W_{40}G_{60}$, $W_{90}G_{10}$, $W_{30}G_{70}$, $W_{20}G_{80}$ and $W_{10}G_{90.}$ The lowest thousand seed weight (39.88g) was obtained in $W_{100}G_{100}$ which however, was statistically dissimilar to other treatments.

Howlader (2006) found that weight of thousand seeds in bushbean was significantly affected when grown as an intercrop with wheat.

#### 4.2.2.4 Seed yield (t ha$^{-1}$)

Seed yield of grasspea was significantly affected by different seed rate ratios under mixed cropping condition. The highest seed yield of grasspea (1.39 t ha$^{-1}$) was obtained in sole crop ($G_{100}$) .there are trend to increase seed yield with the increase of seed rate(10 to 90 kg seed ha$^{-1}$) but reverse in case of wheat population.

Howlader (2006) found that grain yield of was significantly affected by different row ratios but the highest pod yield of bushbean was produced in sole situation.

**Table 6 Growth and yield attributes of grasspea as influenced by different mixed cropping arrangements of grasspea with wheat at different seed rate ratios**

| **Treatments** | **No. of pods plant$^{-1}$** | **No. of seeds pod$^{-1}$** | **1000 seed weight (g)** | **Seed yield (t ha$^{-1}$)** |
|---|---|---|---|---|
| $G_{100}$ | 15.53 | 3.48 | 46.02 | 1.39 |
| $W_{90}$ $G_{10}$ | 10.49 | 2.33 | 45.49 | 0.10 |
| $W_{80}$ $G_{20}$ | 11.02 | 2.67 | 45.70 | 0.15 |
| $W_{70}$ $G_{30}$ | 11.46 | 2.87 | 46.04 | 0.28 |
| $W_{60}$ $G_{40}$ | 12.00 | 2.91 | 46.14 | 0.36 |
| $W_{50}$ $G_{50}$ | 11.87 | 3.16 | 45.86 | 0.50 |
| $W_{40}$ $G_{60}$ | 10.10 | 3.22 | 45.62 | 0.61 |
| $W_{30}$ $G_{70}$ | 10.50 | 3.31 | 45.39 | 0.70 |
| $W_{20}$ $G_{80}$ | 10.01 | 2.67 | 45.34 | 0.81 |
| $W_{10}$ $G_{90}$ | 10.25 | 3.45 | 44.86 | 0.99 |
| $W_{100}$ $G_{100}$ | 10.02 | 2.15 | 39.88 | 0.29 |
| **LSD $_{0.05}$** | 1.47 | 1.02 | 1.90 | 1.39 |
| CV (%) | 7.66 | 20.61 | 2.52 | 0.10 |

W =Wheat G=Grasspea

### 4.2.3 Harvest index (%)

Harvest index of grasspea was significantly affected by different seeding ratios under mixed cropping condition (Table 7). Maximum harvest index (41.24) was obtained from sole crop ($G_{100}$) which was followed by $W_{10}G_{90}$, $W_{20}G_{80}$ and $W_{100}G_{100}$, respectively the lowest harvest index (35.17) was obtained from $W_{90}G_{10}$ combination where maximum plant population of grasspea.

**Table7. Harvest index of grasspea under different wheat grasspea mixed cropping systems**

| **Treatments** | **Harvest index value (%)** |
|---|---|
| $G_{100}$ | 41.24 |
| $W_{90}$ $G_{10}$ | 35.17 |
| $W_{80}$ $G_{20}$ | 36.14 |
| $W_{70}$ $G_{30}$ | 36.41 |
| $W_{60}$ $G_{40}$ | 36.97 |
| $W_{50}$ $G_{50}$ | 37.42 |
| $W_{40}$ $G_{60}$ | 38.36 |
| $W_{30}$ $G_{70}$ | 38.53 |
| $W_{20}$ $G_{80}$ | 39.47 |
| $W_{10}$ $G_{90}$ | 39.65 |
| $W_{100}$ $G_{100}$ | 38.70 |
| **LSD $_{(0.05)}$** | 0.91 |
| CV (%) | 1.41 |

W =Wheat G=Grasspea

## 4.3 Relative yield of wheat and grasspea and LER

### 4.3.1 Relative yield of wheat

The relative yield of wheat decreased with the decrease is seed rate a ratio of wheat.It was significantly affected by different seed rate ratios under mixed cropping pattern (Table 8). Wheat seeding ratio from 70 to 90 kg $ha^{-1}$ was statistically similar and higher than rest of the treatments. On the contrary, the lowest relative yield of wheat (0.13) was obtained from lowest plant population of wheat and maximum from grasspea ($W_{10}G_{90}$) .it was noted that wheat grain yield decreased from 2 to 87%.

Similar result was also reported by Howlader (2006) who found that the relative yield of wheat decreased with the decrease in rows of wheat when intercropped with bushbean.

### 4.3.2 Relative yield of grasspea

Relative yield of grasspea in the mixedcropping treatments decreased significantly in comparison with $G_{100}$ (Table 8). The second highest relative yield of grasspea (0.71) was obtained from $W_{20}G_{80}$ which means that 29% yield reduction was noted against sole crop of grasspea.The yield reduction varied from 29 to 93% in different treatments. Maximum reduction from seeding ratio $W_{90}G_{10}$ and minimum from $W_{10}G_{90}$ combination.

### 4.3.3 Land equivalent ratio (LER)

The results showed that mixed cropping offered significant effect on land equivalent ratio under different seed rate ratios treatments (Table 8). The treatment $W_{70}G_{30}$ was found to be superior in respect of LER. However, there was no significant difference among $W_{70}G_{30}$, $W_{80}G_{20}$ and $W_{90}G_{10}$ in this respect.

In contrast, Willey (1979) described that where the LER was greater than 1, it revealed that the intercrop was more productive than the component crops grown as sole crops. On the contrary, sole cropping was more productive than the intercropping where LER was less than 1. LER value was greater than 1, which indicated that there was a yield advantage due to mixed cropping of wheat and grasspea compared to sole cropping (Palaniappan, 1988). In this study the highest LER value (1.17) was obtained from $W_{70}G_{30.}$ The LER value of 1.17 meant that by mixed cropping 3.05 t of wheat and 0.28 t of grasspea were produced from one hectare of land instead of growing them separately in 1.17 hectares of land. The second highest LER of 1.09 was obtained from $W_{20}G_{80}$, which was statistically identical to $W_{90}G_{10}$. The lowest LER (0.84) was found in $W_{100}G_{100}$ which was statistically identical to $W_{20}G_{80}$, $W_{10}G_{90}$, $W_{50}G_{50}$,$W_{30}G_{70}$, respectively.All those seeding ratio failed to show yield advantage than sole crop.

Similar finding was also observed by Mead and Willey (1980) while calculating land equivalent ratio in buck wheat and french bean intercropping. In that study the buck wheat-french bean in the ratio of 1:1 recorded higher land equivalent ratio compared to sole cropping of each of the component.

Rahman and Shamsuddin (1981) reported that wheat at 30% of its normal seed rate intercropped with lentil was found to be the best combination giving the highest LER value of 1.45.

Bhuiyan (1981) examining mixed crop combination of lentil, gram and soybean with wheat under different proportions of normal wheat seed rate recorded higher LER values of 1.37, 1.23 and 1.15 respectively.

**Table 8 Relative yield of wheat and grasspea under different mixed cropping treatments**

| Treatments | Relative yield of wheat (t/ha) | Relative yield of grasspea (t/ha) | LER |
|---|---|---|---|
| $W_{100}$ | 1.00 | | 1.00 |
| $G_{100}$ | | 1.00 | 1.00 |
| $W_{90}$ $G_{10}$ | 0.98 | 0.07 | 1.05 |
| $W_{80}$ $G_{20}$ | 0.98 | 0.11 | 1.09 |
| $W_{70}$ $G_{30}$ | 0.97 | 0.20 | 1.17 |
| $W_{60}$ $G_{40}$ | 0.68 | 0.26 | 0.94 |
| $W_{50}$ $G_{50}$ | 0.59 | 0.36 | 0.85 |
| $W_{40}$ $G_{60}$ | 0.47 | 0.43 | 0.90 |
| $W_{30}$ $G_{70}$ | 0.36 | 0.51 | 0.89 |
| $W_{20}$ $G_{80}$ | 0.23 | 0.58 | 0.81 |
| $W_{10}$ $G_{90}$ | 0.13 | 0.71 | 0.84 |
| $W_{100}$ $G_{100}$ | 0.57 | 0.21 | 0.77 |
| **LSD $_{(0.05)}$** | 0.22 | 0.25 | 0.13 |
| CV (%) | 20.45 | 21.10 | 8.90% |

W =Wheat G=Grasspea

**4.4. Combined yield of wheat and grasspea**

Combined yield obtained in the intercropping treatments were always higher than those obtained in the sole crop (Fig.6). These increased combined yield may be due to better utilization of space, soil nutrient and moisture. De *et al*. (1978) reported that water use efficiency under intercropping was higher than in maize pure cropping. It was also found to be increased in intercropping systems with soybean and mungbean.

The lowest combined yield (1.40 t $ha^{-1}$) was found in $W_{10}G_{90}$. Whereas, the significantly highest combined yield (3.33 t $ha^{-1}$) was found in $W_{70}G_{30}$.

The next highest values (3.19 t $ha^{-1}$ and 3.15 t $ha^{-1}$) were found from $W_{80}G_{20}$ and $W_{90}G_{10}$ treatments which were also statistically similar.

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 that of the sole crop.

Results of another experiment Howlader (2006) showed that the combined yield of wheat and bushbean under wheat-bushbean intercropping system was significantly higher than that of the sole crop.

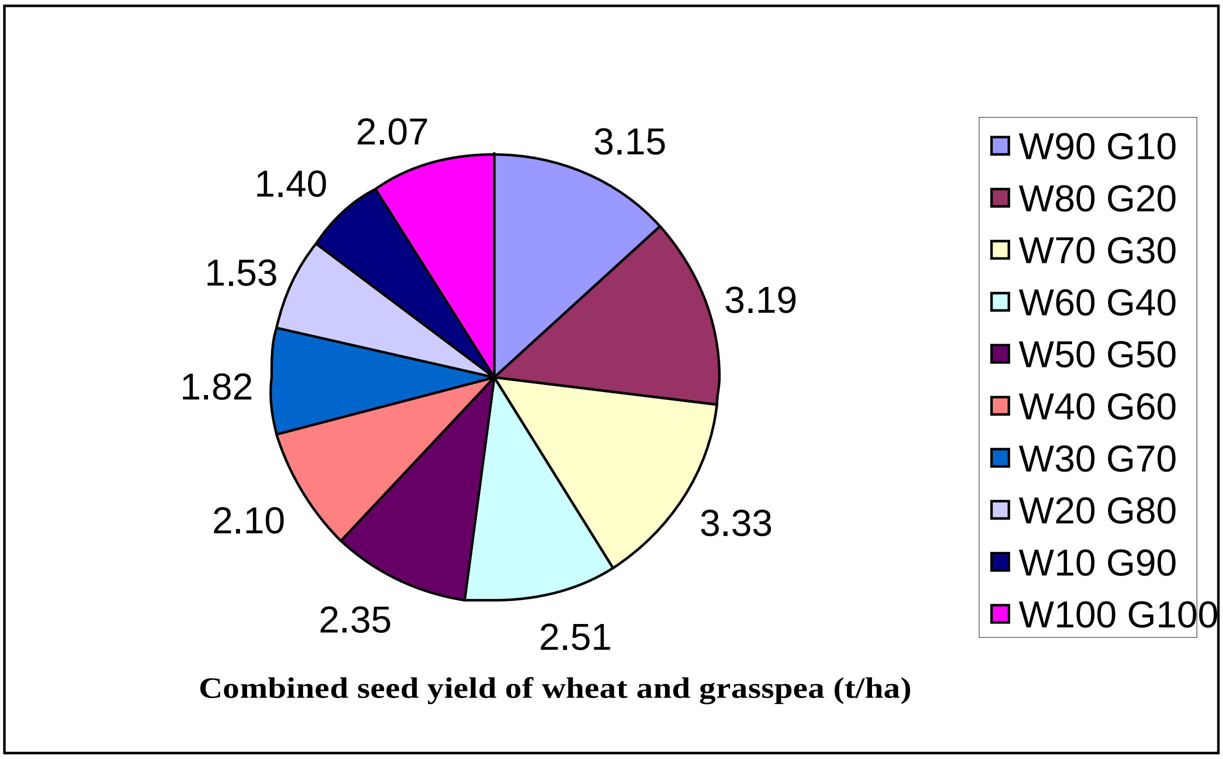


**Fig. 6 Combined yield of wheat and grasspea under different mixed cropping treatments (LSD $_{0.05}$ = 0.13).**

## 4.5 Productivity performance

The productivity performance of wheat and grasspea under different seed rate ratios of mixed cropping was measured by wheat equivalent yield (WEY), grasspea equivalent yield (GEY) and monetary advantage. The productivity parameters are presented in (Table 9)

### 4.5.1. Wheat equivalent yield (WEY)

Equivalent yield of wheat was significantly affected by different seed rate ratios under mixed cropping patterns. Maximum wheat equivalent yield

(3.48 t $ha^{-1}$) was obtained from $W_{70}G_{30}$ which was statistically identical to $W_{80}G_{20}$, $W_{90}G_{10}$ and $W_{20}G_{80}$, respectively. The lowest wheat equivalent yield of (1.91t $ha^{-1}$) was obtained from $W_{10}G_{90}$.

Hossain *et al.* (1992) observed that wheat safflower intercropping gave the highest wheat equivalent yield (3.04t/ha) and net returns.

### 4.5.2 Grasspea equivalent yield (GEY)

Grasspea equivalent yield was not significantly affected by different seed rate ratios under mixed cropping treatments but maximum GEY (2.29 t $ha^{-1}$) was obtained from seeding ratio of $W_{70}G_{30.}$ The lowest equivalent yield of grasspea was obtained from maximum seed rate of wheat but minimum from grasspea.

Some other workers working on mixed and intercropping of wheat and lentil under different seed ratios and planting arrangements also found similar results (Rahman and Shamsuddin, 1981., Rahman, 1984 and Ahmed *et al.,* 1987).

### 4.5.3 Monetary advantages (Tk. $ha^{-1}$)

Monetary advantages were affected by different seeding ratios under mixed cropping treatments. The highest monetary advantage value of Tk. 12685.94 $ha^{-1}$ was obtained from $W_{70}G_{30}$. The second highest monetary advantage value Tk. 6581.63 $ha^{-1}$ was obtained from $W_{80}G_{20}$. The third highest monetary advantage value of Tk. 4003.87 $ha^{-1}$ was obtained from $W_{90}G_{10}$. The lowest monetary advantage Tk. -94595.90 $ha^{-1}$ was obtained from $W_{10}G_{90}$ which showed negative value similar trend was followed by the rest treatments.

Similar result was also found by Singh *et al.* (1992) who stated that the monetary advantages over sole wheat indicated a positive gain from intercropping system. Maximum monetary advantage was recorded from wheat + grasspea with 3:1 row ratios followed by 1:1 row ratio. Sole crops failed to give maximum net return. Likewise, wheat when grown with grasspea gave 24 to 46% higher monetary advantages over sole wheat.

**Table 9 wheat equivalent yield, grasspea equivalent yield and monetary advantages under different mixed cropping treatments**

| Treatments | Wheat equivalent yield (t $ha^{-1}$) | Grasspea equivalent yield (t $ha^{-1}$) | Monetary advantages (Tk. $ha^{-1}$) |
|---|---|---|---|
| $W_{100}$ | 3.14 | | |
| $G_{100}$ | | 1.39 | |

| | | | |
|---|---|---|---|
| $W_{90}$ $G_{10}$ | 3.24 | 2.13 | 4003.87 |
| $W_{80}$ $G_{20}$ | 3.30 | 2.17 | 6581.63 |
| $W_{70}$ $G_{30}$ | 3.48 | 2.29 | 12685.94 |
| $W_{60}$ $G_{40}$ | 2.70 | 1.77 | -4302.03 |
| $W_{50}$ $G_{50}$ | 2.61 | 1.72 | -3438.14 |
| $W_{40}$ $G_{60}$ | 2.37 | 1.56 | -5937.53 |
| $W_{30}$ $G_{70}$ | 2.18 | 1.43 | -8702.24 |
| $W_{20}$ $G_{80}$ | 2.96 | 1.29 | -11470.80 |
| $W_{10}$ $G_{90}$ | 1.91 | 1.28 | -94595.90 |
| $W_{100}$ $G_{100}$ | 2.23 | 1.46 | -16352.00 |
| **LSD ( 0.05 )** | 0.77 | NS | 191.10 |
| CV (%) | 11.62 | 9.70 | 4.92 |

W =Wheat G=Grasspea

## 4.6 Economic (cost and return) analysis

### 4.6.1 Total variable cost

Total variable cost was significantly affected by different seed rate ratios under mixed cropping condition. The highest total variable cost of Tk. 51, 810ha$^{-1}$ was obtained from $W_{90}G_{10}$ which was statistically similar to $W_{100}G_{100}$ of Tk.51,410 ha$^{-1}$. The lowest total variable cost of Tk. 27,420 ha$^{-1}$ was obtained from sole crop of grasspea ($G_{100}$)

### 4.6.2 Gross return

Gross return was significantly affected by different seed rate ratios under mixed cropping conditions (Table 10). The highest gross return of Tk. 88,620 ha$^{-1}$ was obtained from $W_{70}G_{30}$ which was statistically different from other treatments. The lowest gross return of Tk. 47,820 ha$^{-1}$ was obtained from $W_{10}G_{90}$ which was statistically similar to $W_{20}G_{80}$ in this respect. The second highest value of Tk. 83,330ha$^{-1}$ was obtained from $W_{90}G_{10}$ which was statistically similar to the value of Tk. 82,750 ha$^{-1}$ obtained from $W_{80}G_{20}$.

Similar results were also found by Dakua (1992) who reported that the highest gross return was obtained in the treatment of intercropping wheat with chickpea (Chickpea 5 rows + wheat 2 rows). Singh *et al.* (1981) reported that the intercropping of wheat with chickpea, lentil or *lathyrus u*nder adequate moisture conditions, although, did not give higher total grain yield and dry matter, but was economically more profitable.

### 4.6.3 Net return

The highest net return Tk. 46,270 $ha^{-1}$ over variable cost was obtained from $W_{70}G_{30.}$ The second highest value of Tk. 38,910 $ha^{-1}$ was obtained from $W_{50}G_{50}$ which was also statistically similar to sole crop of wheat of Tk. 34,810 $ha^{-1}$. The lowest net returns Tk. 4348 $ha^{-1}$ was obtained form maximum population of both the crops ($W_{100}G_{100}$) which was statistically different from other treatments. All most mixed cropping treatments failure to show higher return than sole wheat crop except seeding ratio of $W_{70}G_{30}$ $W_{90}G_{10}$ and $W_{80}G_{20}$, respectively.

Raheja (1954) showed that the mixture of wheat and chickpea in seed proportion of 2 gave the highest net return than those of using individual seed rates.

### 4.6.4 Benefit-cost ratio

Benefit cost ratio was significantly affected by different seeding ratios under mixed cropping patterns. When benefit – cost ratio of each treatment was examined it was found that the treatment $W_{70}G_{30}$ gave the highest benefit-cost ratio (2.09) which was statistically different from other treatments. The second maximum benefit - cost ratio (1.96) was obtained from grasspea sole crop ($G_{100}$) which was statistically similar to $W_{50}G_{50}$ and $W_{60}G_{40}$ of LER value (1.91) and (1.87) respectively. The treatment comprises 70% wheat and 30% grasspea showed higher BCR than sole grasspea .Others treatment were failure to show higher benefit because cost was much less.

Thus the cost and return analysis in this study indicated that the treatment of $W_{70}G_{30}$ gave the best combinations in respect of gross return, net return and benefit cost ratio.

Nargis *et al.* (2004) studied an experiment and found that the row ratio of lentil and wheat at 1:2 and 3:1 and at 100% lentil + 40% wheat rate gave the highest number of branches per plant (3.25). Where as 100 % lentil + 60 % wheat rate recorded the greatest plant height.

Patra and Chatterjee (1986) found that benefit-cost ratios of 1.60 to 1.70 were obtained when soybean was grown with maize in 2:2 alternate pair rows spaced at 30 cm.

Hashem (1983) found the highest benefit cost ratio of 1:3.05 in 100% maize + 50% cowpea combination at the N level of 60 kg $ha^{-1}$.

**Table 10 Cost and return analysis of wheat-grasspea mixed cropping treatments under different seed rate ratios**

| Treatments | Total variable cost (Tk. $ha^{-1}$) | Gross return (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | Benefit cost ratio |
|---|---|---|---|---|
| $W_{100}$ | 45,690 | 80,500 | 34,810 | 1.76 |
| $G_{100}$ | 27,420 | 53,820 | 26,420 | 1.96 |
| $W_{90}$ $G_{10}$ | 51,810 | 83,330 | 31,490 | 1.60 |
| $W_{80}$ $G_{20}$ | 49,790 | 82,750 | 32,960 | 1.67 |
| $W_{70}$ $G_{30}$ | 42,350 | 88,620 | 46,270 | 2.09 |
| $W_{60}$ $G_{40}$ | 38,910 | 72,970 | 38,910 | 1.87 |
| $W_{50}$ $G_{50}$ | 35,110 | 67,250 | 25,800 | 1.91 |
| $W_{40}$ $G_{60}$ | 33,510 | 61,090 | 27,580 | 1.82 |
| $W_{30}$ $G_{70}$ | 33,200 | 56,220 | 25,020 | 1.80 |
| $W_{20}$ $G_{80}$ | 31,680 | 48,415 | 17,750 | 1.57 |
| $W_{10}$ $G_{90}$ | 28,620 | 47,820 | 18,900 | 1.65 |
| $W_{100}$ $G_{100}$ | 51,410 | 55,750 | 4348 | 1.08 |
| **LSD** **(0.05)** | 1082 | 698.8 | 5452 | 0.12 |
| CV (%) | 1.63 | 0.62 | 11.70 | 3.89 |

W =Wheat G=Grasspea

Price rate: Grasspea seed Tk. 38 $kg^{-1}$, wheat seed Tk. 25 $kg^{-1}$. Variable cost includes cost of fertilizers, labour, seeds, irrigation etc. Benefit cost ratio is based on the total variable cost only.

# CHAPTER 5
# SUMMERY AND CONCLUSION

An experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, during the period from 3 November, 2006 to 30 March, 2007 to study the performance of wheat-grasspea mixed cropping under different seeding ratios. Twelve treatment combinations of mixed cropping of wheat and grasspea at different seeding ratios along with sole wheat and sole grasspea were put under tried. To constitute mixed cropping treatments, 10-100% recommended seed rates of Wheat were combined with 10-100% the recommended seed rates of grasspea.  The experiment was conducted in randomized complete block design with three replications. The experimental materials included one recommended variety of wheat (Shatabdi) and one variety of grasspea ( BARI khesari- 2). The land preparation was done by a power tiller followed by harrowing, which was again ploughed twice by a power tiller and leveled by laddering. The recommended seed rate of wheat was 140 kg $ha^{-1}$ while that of grasspea was 50 kg $ha^{-1}$. Seeds of both crops were sown in 15th November, 2006. and  harvested at maturity stage.

Crop characters, yield of wheat and grasspea and LER were made. Economic performance of the treatments was also evaluated. The data were statistically analyzed and means were compared by least significant difference (LSD).

The results of the experiment showed that some of the crop characters and yield of both wheat and grasspea were significant due to effect of mixed cropping under different seeding ratios. The highest plant height (95.33 cm) of wheat was obtained from $W_{60}G_{40}$ and the lowest (81.330 cm) from $W_{10}G_{90.}$ Spike length of wheat at 90 DAS and at harvest was not significantly affected by different seeding ratios under mixed cropping patterns. Number of tiller plant$^{-1}$, number of spikes plant$^{-1}$, thousands seed weight of wheat were also not significantly affected by different seed rate ratios under mixed cropping patterns. But no. of grains spike$^{-1}$ was significantly affected by different seeding ratios under mixed cropping patterns. The highest number of grains spike$^{-1}$ (28.40) was obtained from $W_{10}G_{90}$ and the lowest (25.02) was obtained from $W_{100}G_{100}$.

Wheat grain yield was significantly affected due to different seed rate ratios of mixed cropping treatments. The highest grain yield (3.14 t ha$^{-1}$) was obtained from the sole wheat. The highest grain yield in sole wheat was attributed mainly to higher plant populations per unit area because of using higher seed rates. Among the mixed cropping treatments, $W_{70}$ $G_{30}$ gave maximum yield which reduced yield only 2% from sole crop. On the contrary the lowest wheat yield (0.41 t $ha^{-1}$) was obtained from $W_{10}G_{90}$ which may be due to using lowest rate. Plant height, population $m^{-2}$, No. of pods $plant^{-1}$, thousands seed weight of grasspea were significantly affected by different seeding ratios under mixed cropping treatments. However, number of branches of grass pea $plant^{-1}$, dry weight, and number of seeds $pod^{-1}$ was not significantly affected by different seeding ratios under mixed cropping patterns.

The yield of grasspea was also significantly affected by different seeding ratios under mixed cropping treatments. The highest grain yield of grass pea (1.39t $ha^{-1}$) was obtained from sole crop (G100) which may be attributed to higher seed rates and absence of any intra competition with wheat. Among the mixed cropping treatments, $W_{10}G_{90}$ gave the maximum grasspea yield. The lowest grain yield of grasspea (0.10 t $ha^{-1}$) was obtained from $W_{90}G_{10}$ which may be due to lowest seed rates used with the highest seed rates of wheat.

Harvest index values of wheat and grasspea were significantly affected by different seed rate ratios under mixed cropping treatments. Maximum harvest index of wheat (43.28%) was obtained from $W_{70}G_{30}$ and lowest (29.05%) from $W_{10}G_{90}$ but maximum harvest index of grasspea (41.24%) was obtained from sole crop ($G_{100}$) and the lowest (35.17%) from seeding ratios ($W_{10}G_{90}$).

Relative yield of wheat and grasspea were also found to be significantly lower in intercrop treatments than those of their respective sole crop. Land equivalent ratio was also significantly affected by different seed rate ratios under mixed cropping treatments. The highest land equivalent ratio of 1.17 was obtained from $W_{70}G_{30}$ and the lowest (0.34) from $W_{20}G_{80.}$ The highest wheat equivalent yield (3.48t $ha^{-1}$) and grasspea equivalent yield (2.29t $ha^{-1}$) were obtained from $W_{70}G_{30}$. On the contrary, the lowest wheat equivalent yield (1.91t $ha^{-1}$) and lowest grasspea equivalent yield (1.28t $ha^{-1}$) was obtained from $W_{10}G_{90.}$

The highest monetary advantage of Tk 12685.94 $ha^{-1}$ was obtained from $W_{70}G_{30}$ and the lowest (Tk.-94595.90 $ha^{-1}$) from $W_{10}G_{90.}$ Only treatments comprise $W_{70}G_{30,}$ $W_{80}G_{20}$ and $W_{90}G_{10}$ showed positive monetary advantage but other treatments revealed negative value.

The highest combined yield of 3.33 t $ha^{-1}$ was obtained from $W_{70}G_{30}$ and the lowest 1.40 t $ha^{-1}$ from $W_{10}G_{90.}$

The highest gross return of Tk. 88,620 $ha^{-1}$ and net return (Tk 47820 $ha^{-1}$) was obtained from $W_{70}G_{30}$. Only treatments $W_{70}G_{30}$ and $W_{60}G_{40}$ showed higher net return than sole crop of wheat .Other treatments failed to show higher return.

The benefit - cost ratio (2.09) was highest with $W_{70}G_{30}$ but other treatments showed lower benefit than sole of grasspea which might be due to lower cost.It is interesting for sole that BCR was higher in sole crop of grasspea.

Based on the results of the present study, it was seen that $W_{70}G_{30}$ mixed cropping gave highest LER, gross return, net return, combined yield, equivalent yield, benefit- cost ratio and monetary advantages among the treatments. From one year result showed that mixed cropping wheat with grasspea could be viable in terms of crop productivity, monetary advantage and soil fertility point of view.

However, although mixed cropping has been used traditionally for thousands of years, it is still poorly understood from an agronomic perspective. Mixed cropping systems are also more challenging to manage than pure stands, especially at harvest time. So, more research is needed for better understanding regarding how intercrops function and how to develop mixed cropping systems that are compatible with present farming systems.

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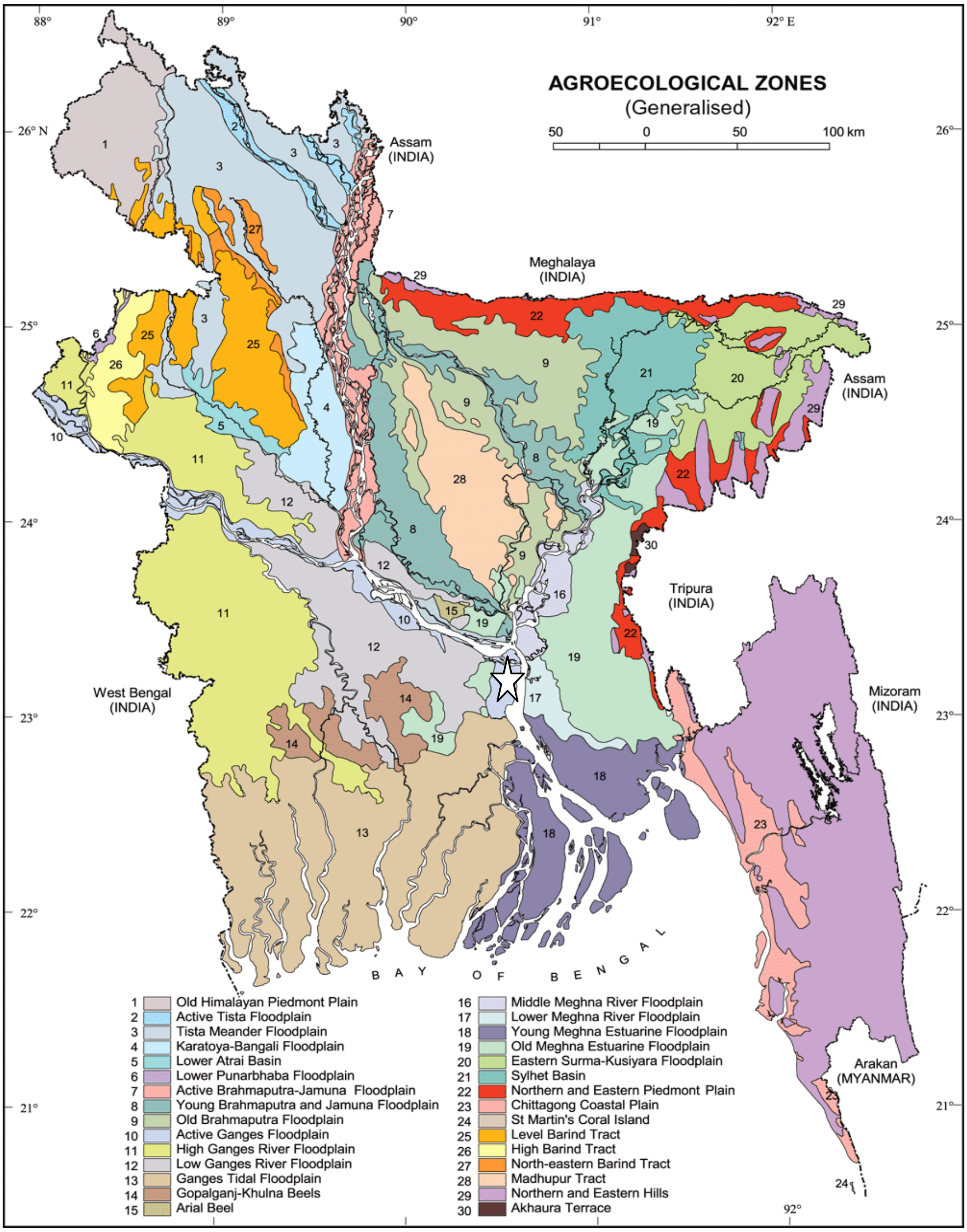
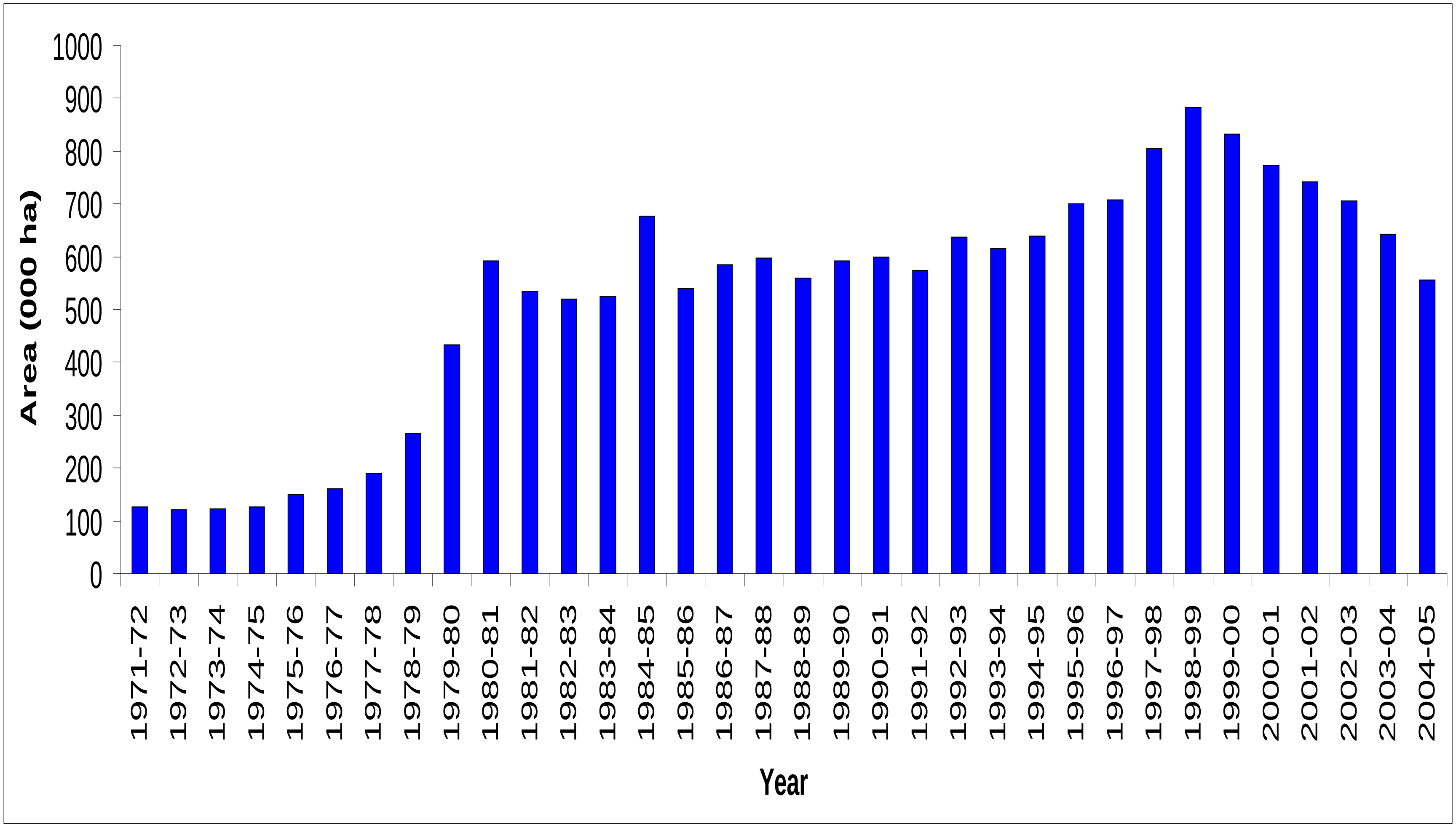
# APPENDICES

Appendix -I Maps showing the experimental site



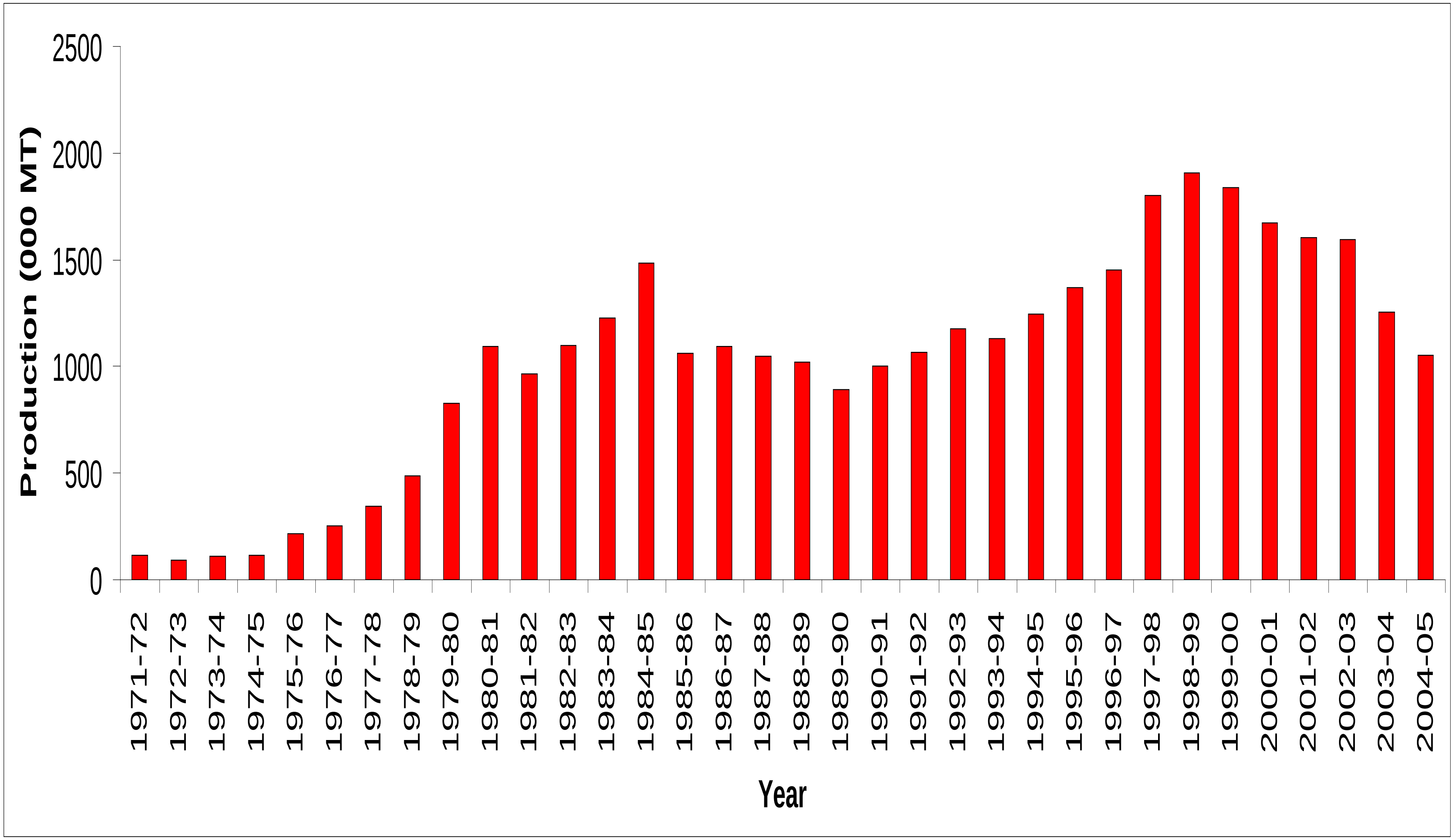

☆ Indicates experimental site (AEZ- 28)
Source: www.fao.org

Appendix- II. Area under wheat cultivation in Bangladesh (1971-72 to 2004-05)



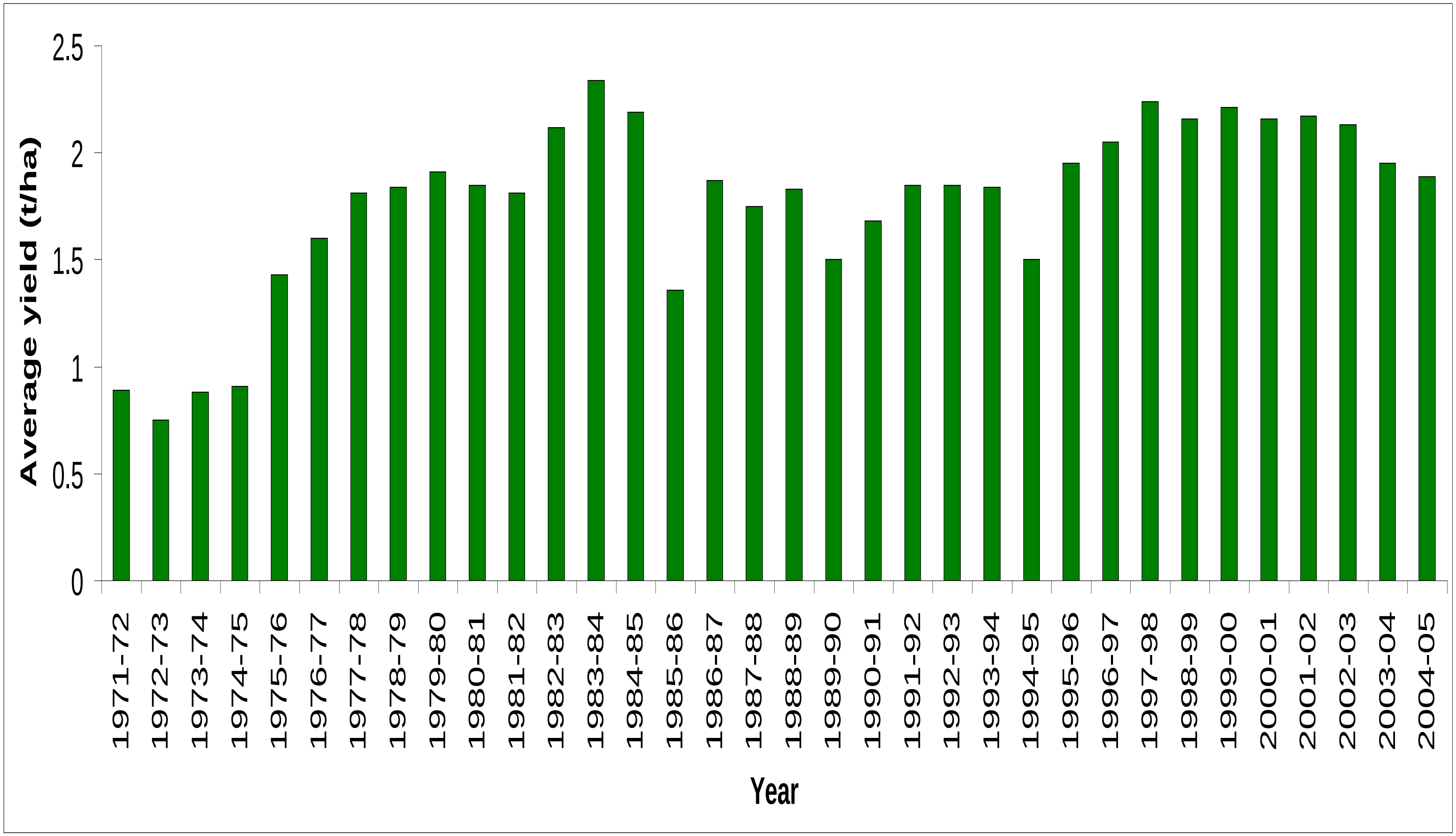

Source: BBS (2005)

Appendix – III. Production statistics of wheat in Bangladesh (1971-72 to 2004-05)



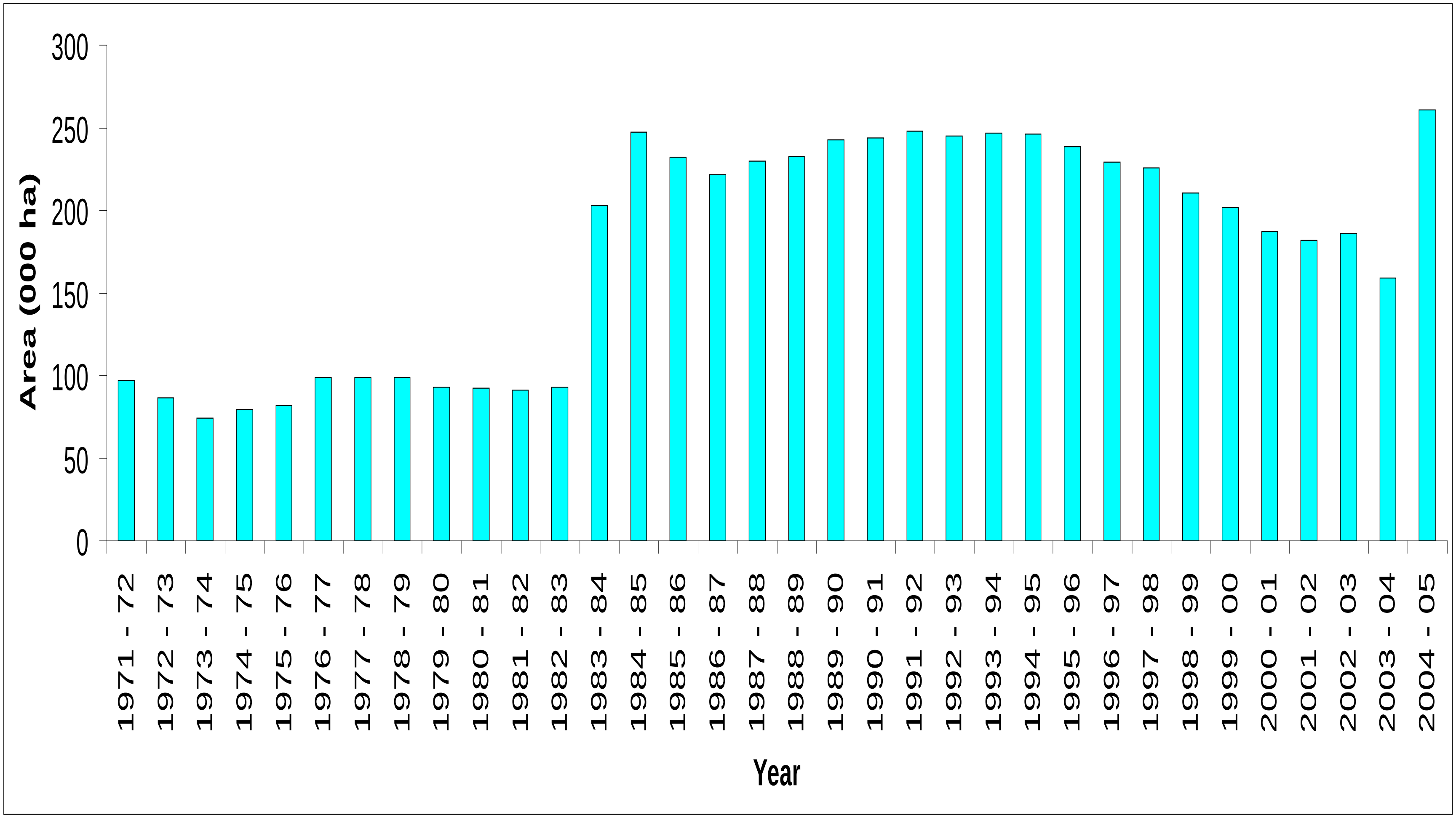

Source: BBS (2005)

Appendix – IV. Average yield of wheat in Bangladesh (1971-72 to 2004-05)



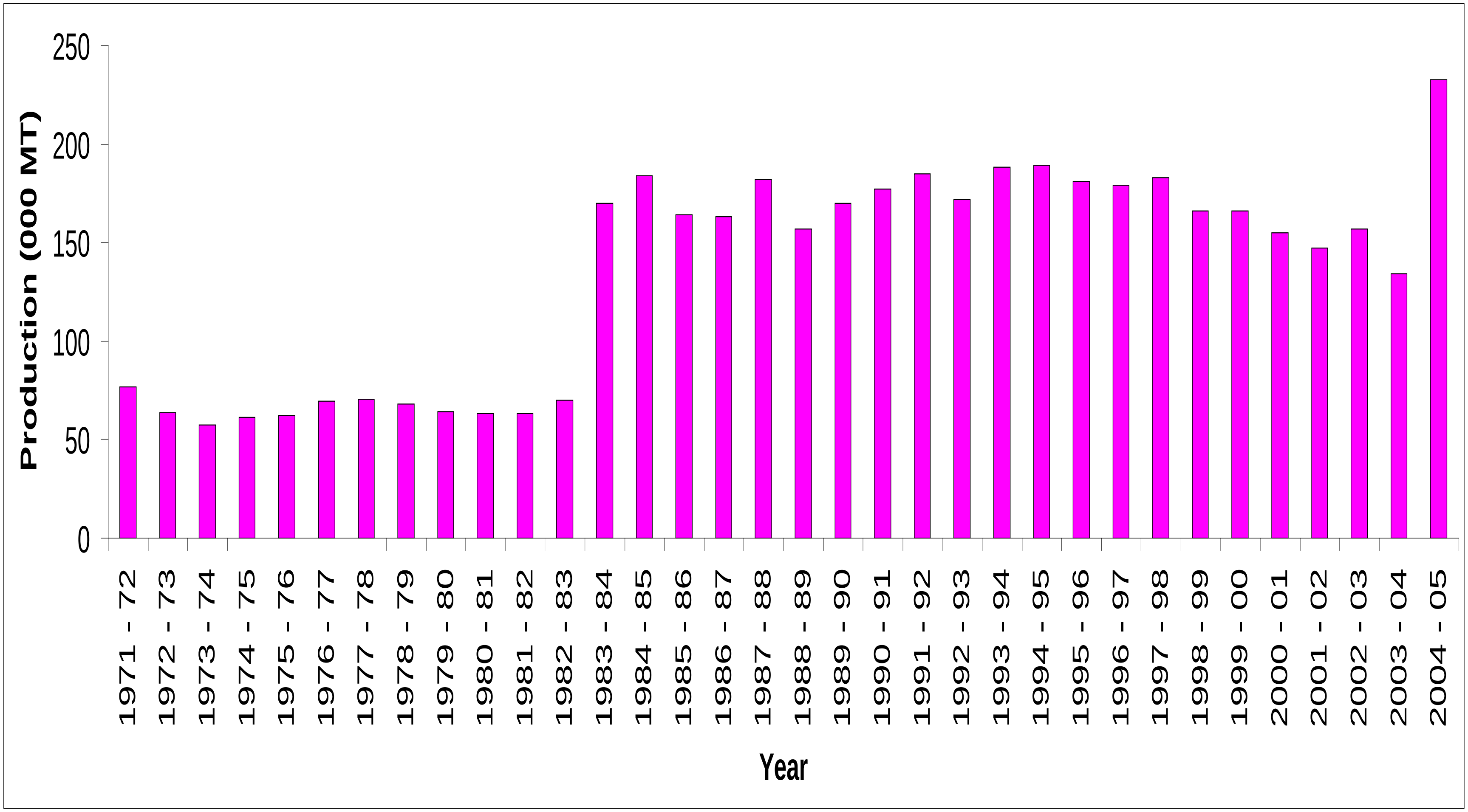

Source: BBS (2005)

Appendix – V. Area under grasspea cultivation in Bangladesh (1971-72 to 2004-05)



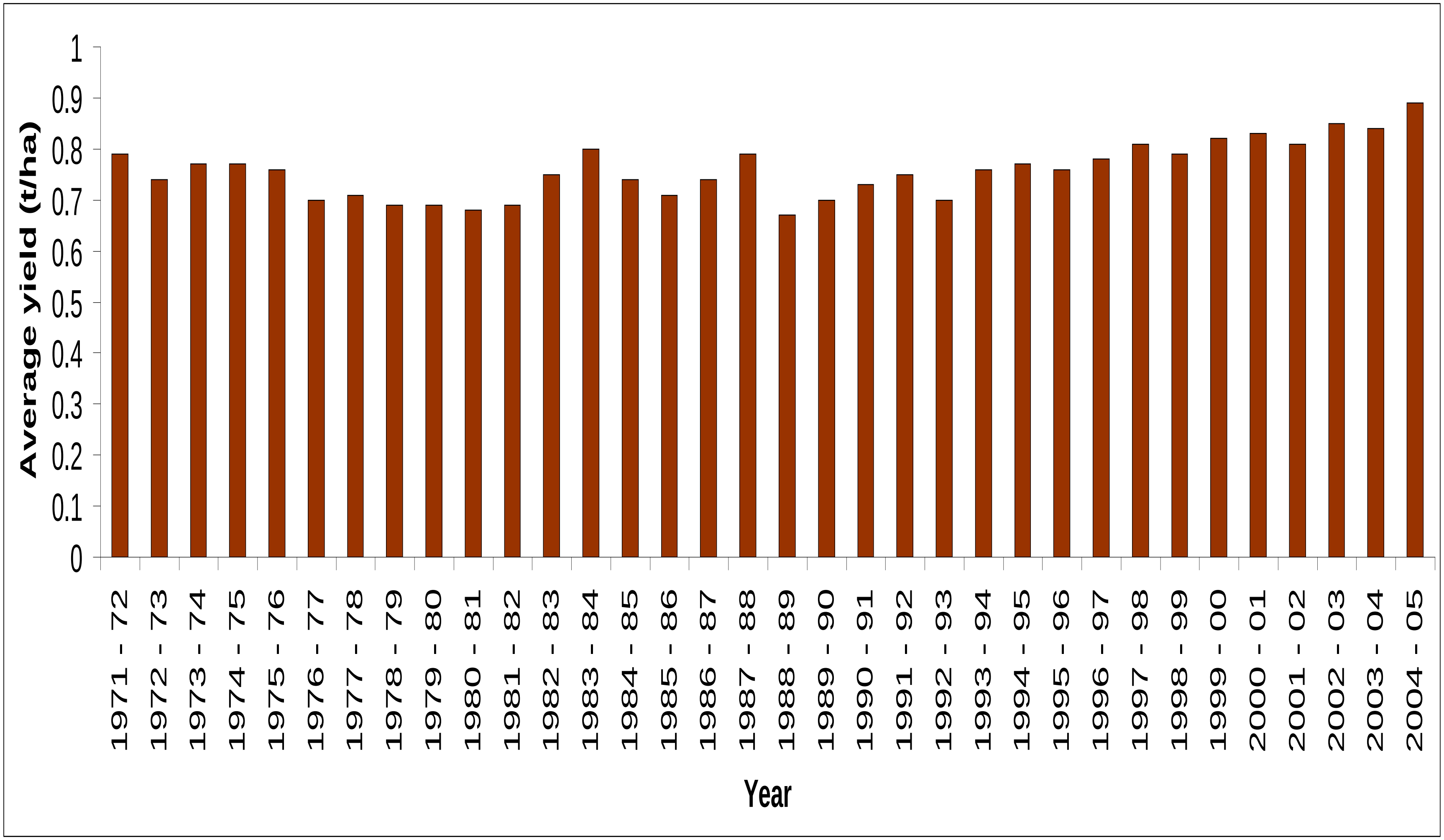

Source: BBS (2005)

Appendix –VI. Production statistics of grasspea in Bangladesh (1971-72 to 2004-05




Source: BBS (2005)

Appendix – VII. Average yield of grasspea in Bangladesh (1971-72 to 2004-05)



Source: BBS (2005)

Appendix- VIII. Physical and Chemical characteristics of initial soil (0-15cm depth) before seed sowing)

**A. Physical composition of the soil**

| Soil separates | (%) | Method employed |
|---|---|---|
| Sand | 36.90 | Hydrometer method (Day, 1995) |
| Silt | 26.40 | -do- |
| Clay | 36.66 | -do- |
| Texture class | clay loam | -do- |

**B. chemical composition of the soil**

| Sl. | Soil Characteristics | Analytical data | method employed |
|---|---|---|---|
| 1. | organic carbon (%) | 0.82 | Walkly and Black, 1947 |
| 2. | Total N (kg/ha) | 1790.00 | Bremner & Mulvaney, 1995 |
| 3. | Total S (ppm) | 225.00 | Bardsley and Lancster, 1965 |
| 4. | Total P (ppm) | 840.00 | Olsen and Sommers, 1982 |
| 5. | Available N (kg/ha) | 54.00 | Bremner, 1965 |
| 6. | Available P (kg/ha) | 69.00 | Olsen and Dean 1965 |
| 7. | Exchangeable K (kg/ha) | 89.50 | pratt, 1965 |
| 8. | Available S (ppm) | 16.00 | Hunter, 1984 |
| 9. | Ph (1:2.5 soil to water) | 5.55 | Jeckson, 1958 |
| 10. | CEC | 11.23 | Chapman , 1965 |

Source: Soil Resources Development Institute (SRDI)

Appendix- IX. Monthly Temperature, Rainfall and Relative humidity of the experiment site during the period from November 2006 to March 2007

| Year | Month | Air Temperature ($^0$c) | | | Relative (humidity (%) | Rainfall (mm) | Sun shine (hr) |
|---|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Mean | | | |
| 2006 | November | 29.7 | 20.1 | 24.9 | 65 | 5 | 178. |
| | December | 26.9 | 15.8 | 21.2 | 68 | Nil | 170.97 |
| 2007 | January | 24.6 | 12.5 | 18.55 | 66 | Nil | 175.40 |
| | February | 27.1 | 16.8 | 21.95 | 64 | Nil | 158.68 |
| | March | 31.5 | 19.6 | 25.55 | 47 | 160 | 255.01 |

Source: Bangladesh Meteorological Department (Climate division), Agargon, Dhaka-1207

Appendix -X. ANOVA for plant height and dry matter of wheat

| Sources of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | | | | Dry matter | | | |
| | | 30 DAS | 60 DAS | 90 DAS | At harvest | 30 DAS | 60 DAS | 90 DAS | At harvest |
| Replication | 2 | 9.462 | 47.827 | 47.451 | 4.793 | 0.480 | 0.899 | 22.83 | 9.547 |
| Treatment | 10 | $14.710^{ns}$ | $46.413^{*}$ | $14.804^{ns}$ | $45.440^{ns}$ | $0.323^{ns}$ | $0.802^{*}$ | $12.317^{ns}$ | $10.696^{ns}$ |
| Error | 20 | 12.258 | 12.619 | 22.115 | 27.463 | 0.232 | 0.205 | 8.040 | 6.026 |
| Total | 32 | | | | | | | | |

* Significant at 5%level

ns not significant

Appendix - XI. ANOVA for spike length and yield of wheat

| Sources of Variation | Degrees of freedom | Mean square | | |
|---|---|---|---|---|
| | | Spike length | | Yield (kg/ha) |
| | | 90 DAS | At harvest | |
| Replication | 2 | 0.405 | 100.684 | 0.066 |
| Treatment | 10 | $3.269^{ns}$ | $1.322^{ns}$ | $3.019^{*}$ |
| Error | 20 | 3.159 | 1.775 | 0.004 |
| Total | 32 | | | |

* Significant at 5%level

ns Not significant

Appendix – XII. ANOVA for growth and yield attributes of wheat.

| Sources of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Population /$m^2$ | Tiller /Plant | Spike/ plant | Grair/ spike | 1000 seed wt (g) |
| Replication | 2 | 1.485 | 0.527 | 0.310 | 0.256 | 80.300 |
| Treatment | 10 | 2973.485* | 0.466$^{ns}$ | 0.267$^{ns}$ | 2.795* | 2.816$^{ns}$ |
| Error | 20 | 3.385 | 0.250 | 0.321 | 0.746 | 8.465 |
| Total | 32 | | | | | |

* Significant at 5%level

ns Not significant

Appendix - XIII. ANOVA for plant height and dry matter of grasspea.

| Sources of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | | | | Dry Matter | | | |
| | | 30 DAS | 60 DAS | 90 DAS | At harvest | 30 DAS | 60 DAS | 90 DAS | At harvest |
| Replication | 2 | 6.340 | 25.534 | 7.917 | 200.781 | 0.005 | 0.071 | 0.455 | 1.048 |
| Treatment | 10 | $1.528^{ns}$ | $52.742^{*}$ | $259.407^{*}$ | $693.295^{*}$ | $0.001^{ns}$ | $0.052^{ns}$ | $1.061^{*}$ | $0.682^{ns}$ |
| Error | 20 | 2.148 | 14.147 | 77.209 | 161.190 | 0.001 | 0.026 | 0.289 | 0.332 |
| Total | 32 | | | | | | | | |

*Significant at 5% level

ns not significant

Appendix XIV. ANOVA for branches/ plant and at 53 DAS and yield of grasspea.

| Sources of variation | Degrees of freedom | Mean square | |
|---|---|---|---|
| | | Branches/ plant at 53 DAS | Yield (t/ha) |
| Replication | 2 | 3.602 | 0.000 |
| Factor | 10 | 1.283$^{ns}$ | 0.459$^{*}$ |
| Error | 20 | 1.346 | 0.001 |
| Total | 32 | | |

*Signification at 5%level

ns Not significant

Appendix – XV. ANOVA for growth and yield attributes of grasspea

| Sources of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Population/$m^2$ | Branches/ plant | Pods/ plants | seeds/ pod | 1000 seed wt (g) |
| Replication | 2 | 6.597 | 1.247 | 2.240 | 2.671 | 1.041 |
| Treatment | 10 | 866.680* | 1.383* | 7.383* | 0.590$^{ns}$ | 9.468* |
| Error | 20 | 8.776 | 0.324 | 0.748 | 0.364 | 1.294 |
| Total | 32 | | | | | |

*Significant at 5%level

ns Not significant

Appendix – XVI. ANOVA for harvest index value (%), relative yield of wheat and grasspea

| Sources of variation | Degrees of freedom | Mean square | | | |
|---|---|---|---|---|---|
| | | Harvest index value (%) | | Relative yield | |
| | | Wheat | Grasspea | Wheat | Grasspea |
| Replication | 2 | 0.183 | 0.292 | 0.013 | 0.027 |
| Treatment | 10 | 64.127* | 9.510* | 0.305* | .238* |
| Error | 20 | 0.144 | 0.288 | 0.017 | 0.022 |
| Total | 32 | | | | |

* Significant at 5%level

Appendix – XVII. ANOVA for combined yield (t/ha) and monetary advantage (tk/ha)

| Sources of variation | Degrees of freedom | Mean Square | |
|---|---|---|---|
| | | Combined yield (t/ha) | Monetary Advantage (tk/ha) |
| Replication | 2 | 0.008 | 18920.100 |
| Treatment | 9 | 1.440* | 2744019534.518* |
| Error | 18 | 0.006 | 12409.878 |
| Total | 29 | | |

* Significant at 5%level

Appendix XVIII. ANOVA for equivalent yield of wheat and grasspea.

| Sources of variation | Degrees of freedom | Mean Square | |
|---|---|---|---|
| | | Wheat equivalent yield (t/ha) | Grasspea equivalent yield (t/ha) |
| Replication | 2 | 0.001 | 0.205 |
| Treatment | 10 | $0.817^{*}$ | $0.404^{ns}$ |
| Error | 20 | 0.207 | 0.187 |
| Total | 32 | | |

* Significant at 5% level

ns Not significant

Appendix – XIX. ANOVA for LER and economic analysis.

| Sources of variation | Degrees of freedom | Mean Square | | | | |
|---|---|---|---|---|---|---|
| | | Land equivalent ratio (LER) | Total Cost (tk.ha) | Gross return (tk/ha) | Net return (tk/ha) | Benefit cost ratio (BCR) |
| Replication | 2 | 0.003 | 280000.000 | 227419.444 | 6485277.778 | 0.070 |
| Treatment | 11 | 0.136* | 235819906.614* | 644232087.785* | 353677484.937* | 0.197* |
| Error | 22 | 0.001 | 408181.818 | 170328.535 | 10368005.051 | 0.005 |
| Total | 35 | | | | | |

* Significant at 5% Level

## Appendix –XX. 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 | 19.00 Tk./kg |
| | iv. MP | 17.00 Tk./kg |
| | v. Gypsum | 10.00 Tk./kg |
| 4. | Seed (for sowing) | |
| | i. Wheat | 28.00 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 | 13.00% |
| 8. | Interest of cost of land | 13.00% |
| 9. | Miscellaneous | 500.00 Tk./ha |

**B. Rate of output (benefit)**

| **Sl. No.** | **Description** | **Rate** |
|---|---|---|
| 1. | Wheat (grain) | 25.00 Tk./kg |
| 2. | Grasspea (seed) | 38.00 Tk./kg |

# LIST OF PLATES

Plate-1 A field view of experimental plots under wheat-grasspea mixed cropping condition at variable seed rate ratios

Plate -2 A field view of experimental plots under wheat-grasspea mixed cropping condition at variable seed rate ratios at seedling stage

Plate -3 A field view of experimental plots under wheat-grasspea mixed cropping condition at variable seed rate ratios at tillering stage


Plate- 4 A field view of experimental plots under wheat-grasspea mixed cropping condition at variable seed rate ratios at tillering stage ($W_{70}$ $G_{30}$)

Plate- 5 A field view of experimental plots under wheat-grasspea mixed cropping condition at variable seed rate ratios at harvesting stage