PERFORMANCE OF WHEAT-BUSHBEAN INTERCROPPING UNDER DIFFERENT ROW RATIOS

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CERTIFICATE

This is to certify that the thesis entitled, "Performance of whear-bushbean intercropping under different row 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 results of a piece of bonafide research work carried out by SUJIT HOWLADER, Registration No.00403 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by him.

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Dedicated to my beloved parents

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PERFORMANCE OF WHEAT-BUSHBEAN INTERCROPPING UNDER DIFFERENT ROW RATIOS

ABSTRACT

An experiment on the performance of wheat – bushbean intercropping at different row ratios (3:1, 4:1, 5:1, 6:1, 3:2, 4:2, 5:2, 6:2, 7:2 and 8:2) along with the sole wheat and bushbean was conducted at the Agronomy Field, Sher-e Bangla Agricultural University, Dhaka-1207 during the period from December, 2005 to March, 2006. The experiment was laid out in a randomized complete block design with three replications. At the maturity, seeds were harvested, while at the vegetative stage, fresh pods of bushbean were considered as yield. Among the intercropping patterns, the highest wheat equivalent yield values of 5.095 and 4.734 were obtained with 3:2 row ratios of wheat and bushbean intercropping pattern at maturity and vegetative stages respectively. It was observed that the highest land equivalent ratio value was obtained with 4:1 row ratio at maturity stage while with 3:2 row ratio at vegetative stage. The highest monetary advantage (Tk.17355.40/ha) was found with 3:2 row ratio when pods of bushbean were harvested at marketable size. But when crops were grown for seed production, the highest monetary advantage (Tk. 4466.67 /ha) was found with 4:1 row ratio.

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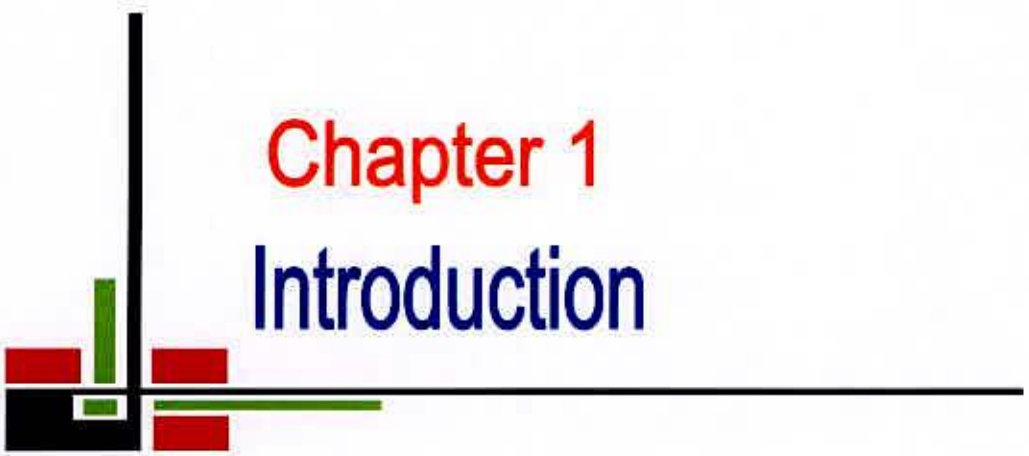
LIST OF ABBREVIATIONS

Abbreviation		Full word
%	:	Percentage
BBS	:	Bangladesh Bureau of Statistics
BARI	:	Bangladesh Agriculture Research Institute
BRRI	:	Bangladesh Rice Research Institute
cm	:	Centimeter
et al.	:	*et alia* and other people
etc.	:	et cetera (means and the rest)
Fig.	:	Figure
FAO	:	Food and Agriculture Organization
g	:	Gram
IRRI	:	International Rice Research Institute
J.	:	Journal
m	:	Meter
mm		Millimeter
No.	:	Number
NS	:	Not significant
pH	:	Negative logarithm of hydrogen ion concentration (-log $[H^+]$)
ppm	:	Parts per million
UK	:	United Kingdom



Chapter 1

Introduction

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world. It ranks first both in hectare and production. About one third of the total population of the world live on it (Hunshell and Malik, 1983). At present wheat is the second most important cereal crop after rice in Bangladesh. About 642.10 thousand hectares of land in Bangladesh is covered by wheat cultivation with the annual production of 1253 thousand mt (BBS, 2005). Wheat is well adapted to our climates and can play a vital role in reducing our food shortage. Wheat grain is rich in food value containing 12.1%, 1.72% fat, 69.60% carbohydrate and 27.60% minerals (BARI, 1997). It is preferable to rice for its higher grain protein content (rice 8.27% protein) (Maltern *et al.,* 1970). The average yield of wheat in Bangladesh was 2.24 t/ha in 2004-2005 (BBS, 2005) which is not satisfactory rather it is low compared to that of the leading wheat growing countries. In Holland, UK, France and Norway the average yields were 7.1, 5.9, 5.6 and 4.1 t/ha respectively during 1986 (FAO, 2000). The causes of lower yield of wheat in Bangladesh were attributed to many factors like lack of good variety, quality seeds, untimely seeding and poor knowledge about management packages such as spacing, seed rate, irrigation, fertilizer application and other cultural operations. Proper agronomic manipulations could elevate the yield of wheat nearer to the level of its potentiality.

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

Recently, intercropping has been recognized as a beneficial system of crop production as it increases total production and reduces the risk of total crop failure and stabilize production under rain fed condition (Rao and Willey, 1983). Intercropping is proved to be an excellent technique 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 intercropping such as mixed intercropping, row intercropping, strip intercropping and relay intercropping.

Intercropping with leguminous crops is beneficial as it helps to improve the soil fertility in addition to the increase of productivity. Bushbean (*Phaseolus vulgaris* L.) is one of the leguminous crop whose pods are used as fresh vegetable and seeds are used as pulse. It is a minor vegetable crop of Bangladesh belonging to the family leguminsae and sub family papiolionaceae. It is originated from the central and South America (Swiader *et al.*, 1992).

It is widely cultivated in the temperate subtropical region and also in many parts of the tropics (Purseglove, 1987). It is more suitable as a winter (Rabi) crop in the north-eastern part of India (AICPIP, 1987). According to the recent FAO statistics bushbean including other related species of the genus *Phaseolus* occupied 27.08 million hectares of the world's cropped area and the production of dry pods was about 18.94 million tons with an average yields of 699 kg/ha (FAO, 2000). Brazil is the largest bushbean producing country in the world. In Bangladesh there is no statistics about the area and production of this crop. It is a new crop in our country and is cultivated in Sylhet, Cox's Bazaar, Chitagang Hill tracts and some other parts in a limited scale.

Immature pods of bushbean are marketed fresh, frozen or canned. The dry seeds also frozen or canned. The dry plants are also used as hay, silage and as green manures. After harvest, plants can be feed to cattle sheep and horses. Its edible pods supply protein, carbohydrate, fat, fiber, thiamin, riboflavin, Ca and Fe and the seed contains significant amount of thiamin, niacin and folic acid. (Rashid, 1993).

Bushbean is also called French bean. This is a short durated crop, it can be grown well in intercropping with some main crops such as wheat, maize sunflower and sugarcane (Francis *et al.*, 1977). In Bangladesh, it is also grown commercially for the purpose of exporting to other countries. Hortex Foundation exported 23.86 tons for vegetable bushbean during July – December, 2001 (Anon., 2001.)

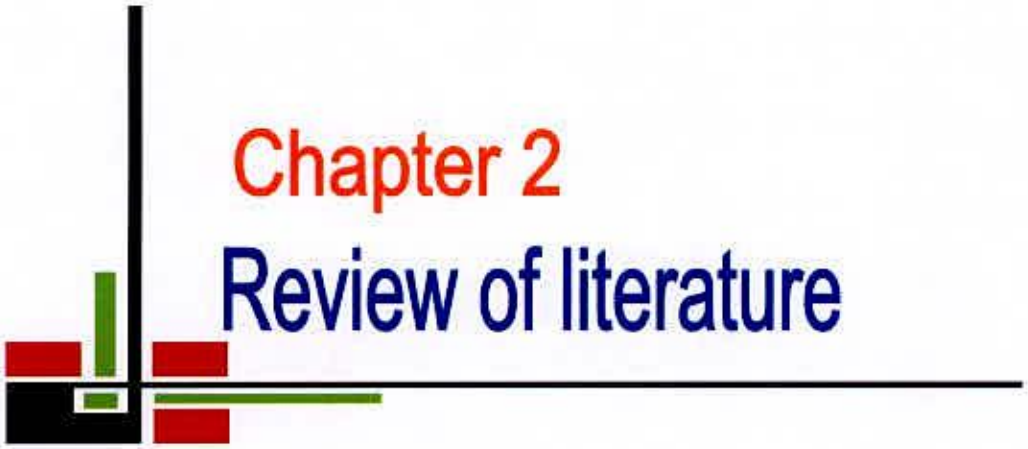
The subsistence farmers of our country may be benefited from intercropping practice. Successful results from intercropping can be obtained provided a suitable companion crop is selected to grow with the main crop. As bushbean is a rabi crop, it competes with wheat and other rabi crops. Farmers generally will intend to practice intercropping if they get more yield and more profit than sole wheat. However, under Bangladesh conditions, information regarding this aspect is lacking.

Moreover, in the presence context of scarce land resource, the scope for horizontal expansion of cropping is strictly limited in Bangladesh. Only vertical expansion may the alternative possibility by utilizing temporal and spatial resources through the adoption of

intercropping practices. With this view point in mind, an experiment was conducted with the following objectives;

i. to achieve an increased productivity from an unit area of land under wheat-bushbean intercropping.

ii. to examine monetary benefit from wheat-bushbean intercropping.



Chapter 2
Review of literature

REVIEW OF LITERATURE

In the countries with high populations, intercropping is practiced through crop intensification. For successfulness, it is essential to find suitable companion crops (Hoque and Hobbs, 1976). 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 (Agboola and Fayemi, 1971; Hoque and Hobbs, 1976; Miah and Carangal, 1979; Srivastrava and Singh, 1980).

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 (Ram *et al.*, 1963; Rahman *et al.*, 1982).

Intercropping also was found to be helpful to improve nutritional quality of diet (Andrew, 1972), allowed better control of weeds (Rao and Shetty, 1976), decreased the incidence of insect pests (Singh and Singh, 1983), increased land equivalent ratio (Rao and Willey, 1983), reduced soil erosion and helped in the better use of sunlight and water.

Hunshell and Malik. (1983) reported that intercropping maintained superiority to sole cropping in term of momentary gain.

Islam *et al.* (1992) reported that intercropping was an essential practice to reduced the risk of dependence upon a single crop. The higher equivalent yield along with higher biomass and efficient use of growth resources under intercropping than those of sole cropping was also reported (Sinde *et al.*, 1991).

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

Rhaman (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 renumerative.

The benefit in terms of productivity is measured by the term land equivalent ratio or LER. 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. The higher was the LER, the more was the agronomic benefit from intercropping. The LER might be increased up to 2.00 (Andrew, 1972). LER measures the crop productivity of a unit area covered by a crop mixture vis-à-vis that of the sole component. (Sharma *et al.* 1982).

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

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.

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

Nergis *et al.* (2003) stated that weed was significantly controlled by wheat + sunflower and wheat + linseed at 3:1 and 3:1 row ratios respectively.

Marksuder *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.

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 where 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.

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 and Singh (1983) stated 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).

Sobhan (1986) reported that the highest land equivalent ratio (LER) under intercropping treatment was received when sunnhemp was grown at row spacing of 60 cm with three rows or 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). Martin and Snaydon (1982) conducted two field experiments with barley and field bean which grown in pure stands, alternate row mixtures and within row mixtures. In both experiments the land equivalent ratio based on seed yield was consistently greater than 1.00.

Manson *et al.* (1986) stated that intercropping does not always increase the total yield. Sometime it reduces the yield too. Cassava yields were reduced by 2.3 to 4.7 t/ ha^{-1} when intercropped with cowpea or peanut. Willey (1979) pointed out that the productivity of an intercropping system could be improved through minimizing the inter specific completion between the companion crops.

Hunshell and Malik. (1983) reported that intercropping of maize + black gram gave higher yield but was statistically at par with sole cropping system. Singh *et al.* (1988) also reported the superiority of black gram as an intercrop to maize. Quayyum and Maniruzzaman (1995) also obtained greater yield under maize + black gram cropping system than the pure maize yield.

Kulmi and Soni (1997) conducted a field experiment on wheat + sunflower intercropping under in 2:1, 2:2, 4:1 or 2:2 row ratios. The crops were also grown under a mixed cropping systemic 1:1, 2:1 or 4:1 ratio. 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).

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 geometrically 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.

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.

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 wheat: level row ratios of 4:3, 5:3, 8:3 or 10:3.Wheat grain yield was highest (4040 kg/ ha) with the 10:3 row ratio. This treatment produced lentil seed yield of 4241 kg/ha. The second highest yield was obtained form 8:3 ratio whereas wheat was 3760 kg and lentil was 481 kg.

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.

Singh and Sarawgi (1995) conducted an experiment on the effect of row ratio, nitrogen & irrigation in 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.

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

Hossain *et al.* (1992) studied that wheat was intercropped with *Cicer arietenum* cv. *Annegeril*, 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 respectively. Wheat safflower intercropping gave the highest wheat equivalent yield (3.07 t/ha) and net returns.

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

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

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

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

Dahatonde *et al.* (1991) conducted an experiment on the performance of wheat + bushbean (French bean) intercropping system. Under wheat- bushbean row ratios of 6:3 or 3:2 with recommended fertilizer rates. Bushbean grown alone produced the highest equivalent yield of 4.01 t/ ha and the highest net returns. The next best wheat equivalent yield of 3.60 t/ha was shown by wheat/bushbean row ratio 3:2 receiving recommended fertilizer rates.

Hiremath *et al.* (1989) 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 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.

Ali (1993) found 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) of wheat and land equivalent ratio (LER) than the other treatments.

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 ratio was produced from the 3:1 row ratio.

Nargis *et al.* (2004) reported 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). Whereas 100 % lentil + 60 % wheat rate recorded the greatest plant height.

Alam *et al.* (1997) suggested 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.

Nazir *et al.* (1997) 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 mono cropped wheat.

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 intercropping (1:1) gave the highest wheat yield equivalent of 3.02 t/ ha followed by the wheat/ lentil intercropping (2.91) which also gave the highest best monetary returns.

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.

Anjaneyulu *et al.* (1982) studied the 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.

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.

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

Jain *et al.* (1993) found that intercropping 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.

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) from 100% maize + 50% cowpea was second as compared to sole maize crop (6.0 t/ ha). Additionally (0.8 t/ ha) of cowpea grain yield was obtained form that intercropping combination. The same combination also gave highest gross return, net return, benefit cost ratio (3.0) and LER (1.25).

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 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 in the rabi (winter) season.

Rafey and Prasad (1992) reported French bean either alone or in combination with buckwheat (1:1) recorded significantly higher gross and net returns over remaining treatments. The sole crop of French bean 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.

Hiremath *et al.* (1989) found that soybean when intercropped with wheat under different row probations decreased the growth and seed yield of soybeans significantly compared to sole soybean. However 1:2 and 3:1 row ratios of wheat soybean gave the highest gross returns.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Farm of Shere-e-Bangla Agricultural University, Dhaka during the period from December 2005 to March 2006.

3.1 Location:

The experimental land was situated at the southwestern part of SAU Farm. It was located at $90^0 33'$ E longitudes and $23^0 77'$ N latitude at an altitude of I meter above the sea level. The land was medium high and well drained.

3.2 Climate:

The annual precipitation and potential evaporation of the site were 2152_{mm} and 1297_{mm}, respectively. The average maximum and minimum temperature was 30.34^oC and 21.21^o c respectively with the mean temperature of 25.77^o c.

The temperature during the cropping period ranged between 12.2^o c to 30.1^o c. The humidity varied from 72.52% to 80.2%. The day length ranged between 10.5 -11.0 hours only and there was slightly a rainfall during the experimental period. The weekly average air temperature and relative humidity of the site during the experimental work have been shown in Appendix I.

3.3 Soil Properties:

The soil of the experimental site belonged to the agro-ecological region of "Madhupur Tract" (AEZ NO - 28). It was Deep Red Brown Terrace soil and belonged to Nodda cultivated series. The topsoil was silty clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47 – 5.63.(Soil properties was given in Appendix II.)

3.4 Planting Materials:

Two types of crops having dissimilar growth habits were used in the experiment. The crops were wheat (*Triticum aestivum* L) and bushbean (*Phaseolus vulgaris* L.). Between them wheat was grown as main crop and bushbean as companion crop.

3.5 Plant Characters and Variety:

3.5.1 Wheat:

A high yielding wheat variety 'Kanchan' was selected as a planting material. The variety was released by BARI in 1993 and it was found that the variety completed its life cycle in 110-120 days. Its germination percentage was 84%. The height of the variety is 90-100 cm, produces 5-6 tillers plant^{1} and has dark green leaf. The flag leaf is stout and less broad, spike is long and each spike contains 35- 48 number of seeds. Seed is amber in color, size is large and 1000 seed weight is 48-52 g. It has the ability to give better yield when sown in late. For this quality, the variety has become popular to the farmers. Without irrigation its yield ranges from 2 to 3.5 t/ha and with irrigation its yield varies from 3.5 - 4.0 t/ha (BARI, 1997).

3.5.2 Bushbean:

Bushbean belongs to the leguminosae and sub family papiolionaceae and the principal species is *Phaseolus vulgaris* which is originated in the central to South America.

The bushbean plant is an annual, 35-40 cm in height with a single stem and usually several branches.

3.6 Experimental Treatments:

The experiment consisted the following treatments of different row ratio of wheat and bushbean.

T_1= Sole wheat

T_2= 3:1 (Wheat: Bushbean)

T_3= 4:1 "

T_4= 5:1 "

T_5= 6:2 "

T_6= 3:2 "

T_7= 4:2 "

T_8= 5:2 "

T_9= 6:1 "

T_{10}= 7:2 "

T_{11}= 8:2 "

T_{12}= Sole bushbean.

3.7 Experimental Design and Layout:

The experiment was laid out in a randomized complete block deign with three replications. The size of each unit plot was 3.m x 2 m and each plot was separated by 0.5 m wide space. The experimental field was divided into three blocks and between the blocks 1.0 m space was provided.

3.8 Land Preparation:

The experimental field was first opened on November 15, 2005. The land was ploughed thoroughly with a power tiller and given laddering to obtain the desirable tilth. All weeds, stubbles and crop residues of the field were removed prior to sowing of seeds and the whole experimental area was divided into 36 unit plots, maintaining the desired spacing. The field layout was done according to the experimental design adopted. Then all basal doses of fertilizers as per schedule were incorporated into the soil and finally the plots were made ready for sowing.

3.9 Fertilizer Application:

The experimental plot was fertilized with 3.9, 3.3, .99, 2.13 kg/ ha of NPK and S which was equivalent to the rates of 183 – 152 – 45 - 98 kg/ ha of urea, triple super phosphate, muriate of potash and gypsum respectively and given cow dung at 10 t/ ha. Half of the urea, whole amount of triple super phosphate, muriate of potash and gypsum were applied as basal in the plot uniformly during final land preparation. The remaining half urea was applied as top dressing at 21 days after sowing just after weeding and thinning.

3.10 Seed Rate and Seed Sowing:

The seed rate used for two crops under study were as wheat @ 60 kg/ ha and bushbean @ 40 kg/ ha. After final land preparation the seeds of both crops were sown on December 3, 2005.

In row intercropping treatments seeds of both crops were sown in row as per experimental specification. Row to row distance was 20 cm. Seeds were covered properly with soil. Germination of the both seed started within 3 to 5 days.

3.11 Intercultural operation:

Weeding and thinning were done at 21 days after sowing while half of urea was also top dressed. Two light irrigation were given at the time of 21 days after sowing. After irrigation the wheat was top-dressed. Another irrigation was given at the tillering stage.

The wheat crop was not infested by any insect pest and diseases but bushbean was infested by insect pest. Therefore contact insecticide (Malathian @ 22.2 mm per 10 litres of water) was given one time.

3.12 Harvesting and Sampling:

At full maturity, the wheat crop was harvested plot wise on March 21, 2006. Before harvesting, five plants of wheat from each plot was selected randomly and uprooted, crop of each plot was harvested separately and marked with tags, brought to the threshing floor and sun died for three days. After threshing seeds and stover were then separated, cleaned and dried under sun for 4 consecutive days. Then these were weighted separately to record the seed yield which was converted to t/ ha. The bushbean crop was harvested at two-growth stages; one vegetative stage and other was seed maturity stage. At vegetative stage was was harvested at 65 DAS when crop was attained most marketable size. The whole bushbean crop was harvested plot wise on March 01, 2006. Sample plants were processed in the similar way for data collection.

3.13 Data Collection:

The data on yield contributing characters of both the crops were collected as follows:

3.13.1 Wheat:

i) Plant height (cm)

ii) Number of tillers /plant

iii) Number of leaves / plant

iv) Leaf area (cm^2)

v) 1000 seed weight (g)

vi) Number of seeds/ plant

vii) Seed yield (t/ ha)

3.13.2 Bushbean:

i) Plant height (cm)

ii) Number of branches / plant

iii) Number of pods / plant

iv) Pod fresh weight /plant

v) 1000 seed weight (g)

vi) Number seeds / pod

vii) Seed yield (t/ha)

3.14 Procedure of Recording Data:

The detail outline of data recording is given below:

a. Plant height (cm)

The height of five plants was measured from the ground level to tip of the plants and then averaged.

b. Number of leaves / plant

Total number of leaves of five plants were counted and then averaged.

c. Number of branches/ tillers

Total number of branches of bushbean / tillers of wheat were counted from five plants and then averaged.

The total weight of five dry plants were measured and then averaged.

d. Pod fresh weight (gm)

Three plants from each plot were sampled randomly and pods were collected. Pods were harvested at two different stages;

i. when they attained at marketable size (65 DAS) and ii. at maturity stage (81 DAS).

Pod fresh weights were recorded at first harvest. The total fresh weight of pods/ plant were measured and then averaged.

e. Number of seeds /pod

The number of seeds/ pod were counted from five plants and then averaged.

f. Leaf area (cm^2)

The length of all leaves of a plant were measured and then averaged. Like wise the breadth of all leaves of a plant were measured and averaged. Leaf area was then determined by multiplying length and breadth with a correction factor (0.80) following the formulae of Hopkins (1939).

$$\text{Leaf area} = 0.80 \times \text{Length of leaf} \times \text{Breadth of leaf}$$

g. 1000 seed weight (g)

One thousand seeds were randomly taken from each plot. The seeds were then dried and weighted with sensitive electrical balance.

h. **Seed Yield (t/ ha)**

i. Wheat:

The crop was harvested plot wise as per experimental treatments and threshed. Seeds were cleaned and then sun dried for seven days. The seed yield /plant were recorded at 12% moisture level.

ii. Bushbean:

The crop was harvested plot wise as per experimental treatments and threshed. Seeds were cleaned and then sun dried for seven days. The seed yield /plant was recorded at 14% moisture level. Seed yield was recorded from the second harvest of pods at maturity stage.

3.15 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 in accordance with the following formulae (IRRI, 1973).

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

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

$$\text{LER} = \frac{\text{Intercrop yield of main crop}}{\text{Yield of sole main crop}} + \frac{\text{Intercrop yield of companion crop}}{\text{Yield of sole companion crop}}$$

LER was determined at two stages ; i) at the maturity: at this time weight of dry seeds of both crops were included ii) at the vegetative stage : at this time the fresh pod yield of bushbean at 65 DAS and dry seed weight of wheat at maturity were included.

3.16 Wheat equivalent yield (WEY):

Wheat equivalent yield was calculated and it was computed by converting the yield of companion crop (bushbean) into the yield of wheat (seed) on the basis of prevailing market prices using the following formula (Anjaneyulu *et al.*, 1982).

$$\text{Wheat equivalent yield} = Y_w + \frac{Y_b \times P_b}{P_w}$$

(For intercropping)

Where,

Y_w = Seed yield of wheat (intercrop) (t/ ha)

Y_b = Seed yield of bushbean (intercrop)(t/ ha)

P_w = Market price of wheat seed (Tk.12/ kg)

P_b = Market price of bushbean seed (Tk. 50/ kg)

3.17 Monetary Advantage:

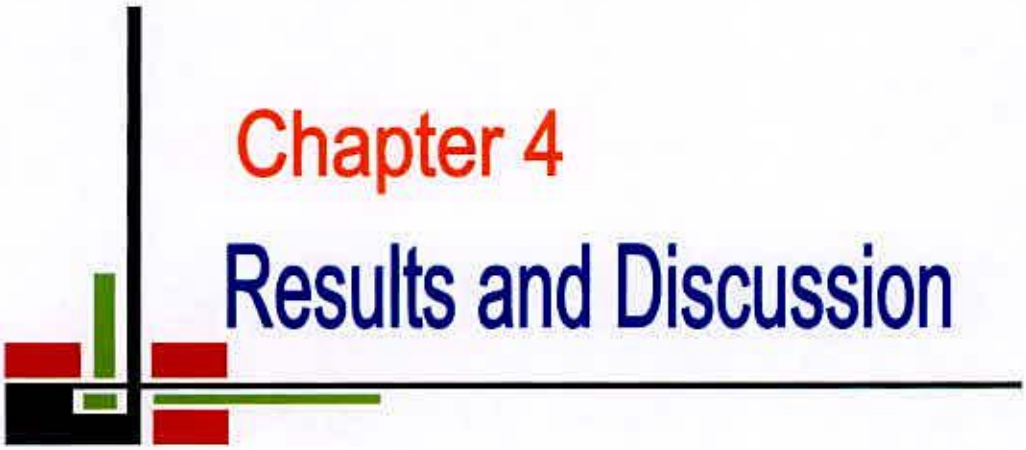
The monetary advantages (TK/ ha) were calculated for each component crop separately as per following formulae (Willey, 1979 a).

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

Where, LER = Land Equivalent Ratio

3.18 Statistical Analysis:

Data collected for different parameters were compiled and tabulated in proper form. 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

RESULTS AND DISCUSSION

Results of the experiment have been presented in this chapter. A brief discussion has also been made while presenting the results of the individual parameters.

4.1 Growth and yield contributing characters of wheat

4.1.1 Plant height

Plant height of wheat was significantly influenced by different row ratios intercropping patterns (Table1). The highest plant height (90.67 cm) was recorded in T_1 (sole wheat) which was statistically similar to 90.66 cm, 90.16 cm, 89.96 cm, 89.88 cm, 89.79 cm, 89.6 cm obtained respectively from the treatments T_2, T_5, T_9, T_4, T_3 and T_{10}. The lowest plant height (86.82 cm) was observed in T_8 (5:2 row ratios of wheat and bushbean intercropping pattern) which was statistically similar to T_7 (4:2 row ratios of wheat and bushbean intercropping pattern). Treatments T_6 (88.66 cm) and T_{11} (88.67 cm) were identical to T_3, T_4, T_9, T_5, T_{10} but statistically lower than T_1 and T_2 while they were higher than T_7 and T_8.

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

4.1.2 Number of tillers / plant

The number of litters of wheat was not significantly affected by different row ratio intercropping patterns of wheat and bushbean (Table1). Numerically highest number of tillers /plant (3.00) was obtained from T_1 (sole wheat) followed by T_4, T_3, T_2, T_9, T_7, T_8, T_{10}, T_{11} and T_5 treatments. The lowest number of tillers (2.73) was obtained from 6:2 row ratios of wheat and bushbean intercropping pattern.

Similar findings were also found by Nargis *et al.* (2004)) and also by Ashok *et al.* (2001). They found that number of tillers/plant of wheat was not significantly affected by wheat based–intercropping system. Singh, *et al.* (1995) also reported similar result.

4.1.3 Number of leaves / plant

Number of leaves /plant of wheat as revealed from the Table1 are not affected by the variation in the intercropping pattern with bushbean. Numerically treatment T_3 (4:1) with 8.27 number of leaves /plant was recorded to be the highest which was then followed by 8.22, 8.19 and 8.16 of T_6, T_4 and T_9 respectively. The value 7.78 being the lowest number of leaves /plant obtained from T_5 (6:2).

However Singh *et al.* (1995) reported that there was no significant difference of leaves number of wheat with intercropping system.

4.1.4 Leaf area

The leaf area of wheat was affected significantly by different row ratio intercropping patterns (Table1). The highest leaf area (25.808 cm^2) was recorded from T_3 (4:1 row ratio of wheat and bushbean intercropping pattern) which was statistically similar to 25.304 cm^2, 24.824 cm^2 leaf area obtained respectively from T_5(6:2), T_4(5:1), The lowest leaf area (22.975 cm^2) was recorded from T_{11} (8:2 row ratio of wheat and bushbean intercropping pattern) which was statistically similar to 23.040 cm^2, 23.200 cm^2, 23.872 cm^2, 24.161 cm^2, 24.256 cm^2 leaf area obtained respectively from T_8(5:2), T_{10}(7:2), T_6(3:2), T_7(4:2), T_2(3:1).

The higher leaf area found where, there was the higher plant population of wheat and there was less competition with bushbean for light, space and nutrients.

4.1.5 Number of grain /plant

The Number of grains /plant of wheat were not significantly influenced by intercropping of wheat and bushbean under different row ratios (Table1). Treatment T_2 (3:1 row ratio of wheat and bushbean intercropping pattern) gave numerically the highest number of grains /plant which were followed by T_3 (4:1), T_9 (6:1), T_1 (sole wheat), T_4 (5:1), T_6 (3:2), T_7 (4:2), T_{10} (7:2), T_5 (6:2), T_{11} (8:2) and T_8 (5:2).

Ashok *et al.* (2001) reported the number of grain /plant of wheat when intercropped, was not significantly different from sole crop.

4.1.6 1000 seed weight

Thousands seed weight of wheat was significantly influenced by different row ratio intercropping patterns (Table 1). The highest 1000 seed weight (45.00 g) was observed in T_1 (sole wheat) which was statistically highest than all others.

Nargis *et al.* (2004) reported that 1000 seed weight varied significantly with intercropping. Likewise, Cheng *et al.* (2003) reported that higher nitrogen application under wheat + blackgram intercropping system, 1000 seed weight was greater than monocropped wheat.

4.1.7 Seed yield

The seed yield of wheat was significantly influenced by different row ratio intercropping patterns with bushbean (Fig1). The significantl highest seed yield (3.025 t/ha) was obtained from T_1 (sole wheat). However, this was similar to 2.95 and 2.91 t/ha obtained from T_3 and T_9 treatments respectively. These values were higher than others obtained from rest of the treatments. The highest seed yield in sole wheat might have resulted due to the highest wheat plant population and there was no competition for light, space, nutrients and moisture among the plants. The second highest seed yield of wheat (2.952 t/ha) obtained from T_3 (4:1 row ratio of wheat and bushbean intercropping patterns) which was statistically similar to T_9 (6:1) and T_4 (5:1) but statistically higher than yields obtained from other treatments. The lowest seed yield of wheat (1.832 t/ha) obtained from T_6 (3:2 row ratio of wheat and bushbean intercropping pattern) was statistically similar to T_7 (4:2 row ratio of wheat and bushbean intercropping pattern).

Dutta *et al*. (1991) found that wheat yield was highest (2.21 t/ha) in sole crop and when intercropped varied from 1.15 t/ha in 2:1 wheat: pea intercropped to 1.84 t/ha in 4:1 wheat: L. *usitatissimum* intercropped.

Table1. Growth and yield characters of wheat as influenced by different row intercropping arrangements with bushbean

Treatment	Plant height (cm)	No. of tillers/ plant	No. of leaves/plant	Leaf Area (cm^2)	Number of grains/plant	1000 seed weight (g)
T_1	90.67	3.00	8.07	24.680	32.00	45.00
T_2	90.66	2.89	8.07	24.256	34.00	40.00
T_3	89.79	2.94	8.27	25.808	33.67	41.50
T_4	89.88	2.96	8.16	24.824	32.00	39.03
T_5	89.96	2.73	7.78	25.304	30.00	40.00
T_6	88.66	2.79	8.22	23.872	32.00	40.00
T_7	87.02	2.81	7.97	24.161	31.00	40.00
T_8	86.82	2.81	7.99	23.080	30.00	40.25
T_9	90.16	2.85	8.19	24.528	33.00	40.50
T_{10}	89.16	2.79	7.90	23.200	31.00	38.50
T_{11}	88.67	2.76	7.96	22.975	30.00	40.05
$LSD_{0.05}$	1.476	NS	NS	1.5080	NS	2.587
CV (%)	5.97	4.37	3.29	3.69	5.87	3.76

N S = Not significant

Row ratio treatments:

T_1 = Sole Wheat

T_2 = 3 : 1 (Wheat : Bushbean

T_3 = 4 : 1 (Wheat : Bushbean)

T_4 = 5 : 1 (Wheat : Bushbean)

T_5 = 6 : 2 (Wheat : Bushbean)

T_6 = 3 : 2 (Wheat : Bushbean)

T_7 = 4 : 2 (Wheat : Bushbean)

T_8 = 5 : 2 (Wheat : Bushbean)

T_9 = 6 : 1 (Wheat : Bushbean)

T_{10} = 7 : 2(Wheat : Bushbean)

T_{11} = 8 : 2 (Wheat : Bushbean)

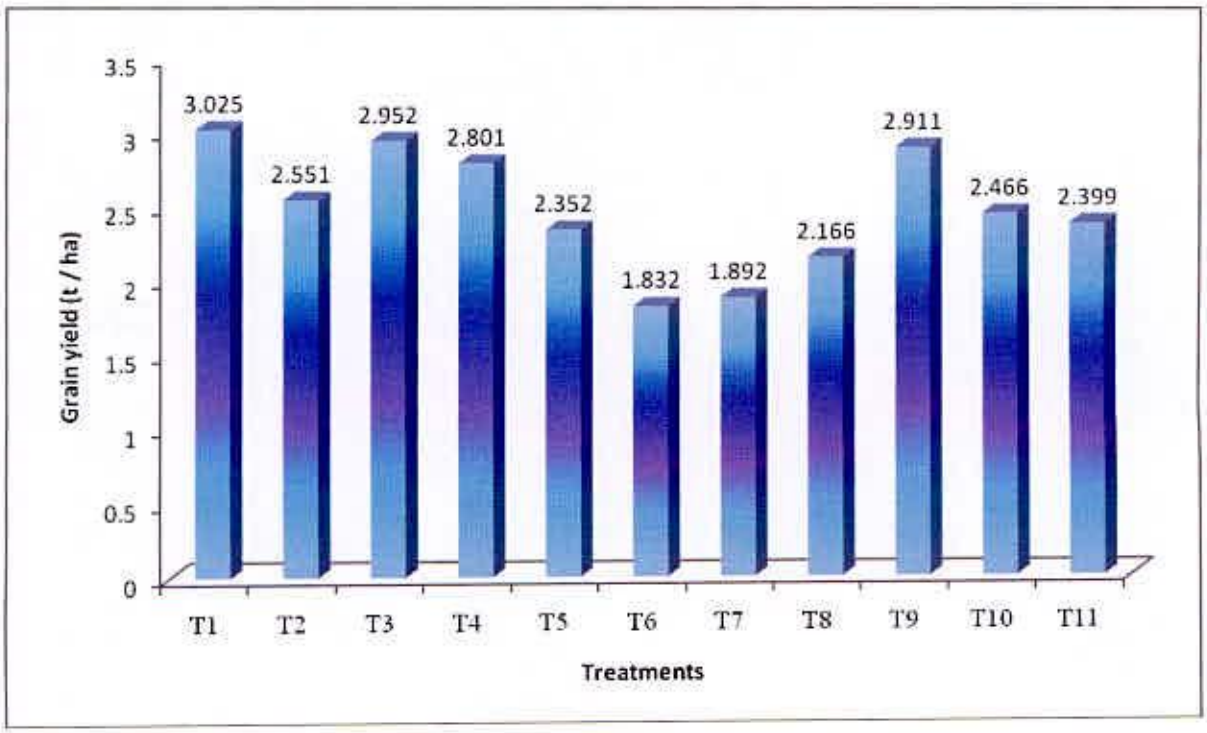


Fig. 1 Grain yield of wheat under different wheat-bushbean intercropping patterns ($LSD_{(0.05)} = 0.152$)

Row ratio treatments:

T_1 = Sole Wheat
T_2 = 3 : 1 (Wheat : Bushbean
T_3 = 4 : 1 (Wheat : Bushbean)
T_4 = 5 : 1 (Wheat : Bushbean)
T_5 = 6 : 2 (Wheat : Bushbean)
T_6 = 3 : 2 (Wheat : Bushbean)
T_7 = 4 : 2 (Wheat : Bushbean)
T_8 = 5 : 2 (Wheat : Bushbean)
T_9 = 6 : 1 (Wheat : Bushbean)
T_{10} = 7 : 2(Wheat : Bushbean)
T_{11} = 8 : 2 (Wheat : Bushbean)

Growth and yield contributing characters of bushbean

4.2.1 Plant height

The plant height of bushbean was significantly influenced by different row ratio intercropping patterns (Table 2). The highest plant height (37.46 cm) was recorded in T_6 (3:2 row ratio of wheat and bushbean intercropping pattern) which was statistically similar to sole bushbean (T_{12}), T_7, T_8, T_9, T_{10}, T_{11} but was statistically higher than T_2, T_3, T_4 and T_5 treatments. The lowest plant height (34.74 cm) was observed in T_4 (5:1 row ratio of wheat and bushbean intercropping pattern) which was statistically similar to T_2 and T_4 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.

4.2.2 Number of branches /plant

The Number of branches /plant was affected significantly by different row ratio intercropping patterns (Table 2). The maximum number of branches /plant (6.57) was obtained from T_{12} (sole bushbean). Number of branches /plant of 6.46, 6.34, 6.37, 6.27, 6.24, 6.22 and 5.99 were obtained respectively from 3:2, 5:2, 4:2, 6:2, 7:2, 8:2 and 4:1 row ratio of wheat bushbean intercropping. The lowest number of branches /plant (5.56) was obtained from T_9 (6:1 row ratio of wheat and bushbean intercropping pattern) which was similar to the treatment T_4 (5:1), T_3 (4:1) and T_2 (3:1).

This result indicated that the highest number of branches /plantwere found where there was no or less competition for space, light, water and nutrients.

4.2.3 Number of pods /plant

The number of pods /plant was significantly affected by intercropping treatment (Table 2). The highest number of pods /plant (26.42) was observed from T_{12} (sole bushbean) which was statistically similar to 25.85 and 25.76 obtained from T_6 (3:2) and T_7 (4:2) treatments respectively. However, these values were statistically higher than those obtained from rest of the treatments. The next highest number of pods /plant obtained from T_5 (6:2) was statistically similar to those of T_6, T_7, T_8, T_5, T_{10} and T_{11} but was higher than T_2 (3:1), T_3 (4:1), T_4 (5:1) and T_9 (6:1) treatments. The lowest value of number of pods was given by T_9.

This result showed that the highest number of pods /plant was found where there was no or less competition for space, light, water and nutrients.

4.2.4 Number of seed /plant

The number of seed /plant was significantly affected by intercropping treatment (Table 2). The highest number of seeds (44.39) was observed in T_{12} treatment (sole bushbean) which was significantly higher than those of other treatments. The second highest number of seed /plant (39:06) was observed in T_6 (3:2) which however, was statistically lower than 44.39. The lowest value 25.32 was obtained from the treatment T_2 (3:1).

This result indicated that the highest number of seeds /plant was found where there was no or less competition for space, light, water and nutrients.

4.2.5 1000 seed weight

Thousands seed weight in bushbean varied significantly due to different row ratios of wheat-bushbean intercropping (Table 2). The highest 1000 seed weight (179.50 g) was found in T_6 (3:2) which was statistically similar to 179.30 g obtained from T_{12} (sole bushbean). These two values were significantly different from the values obtained from other treatments. Next highest value (177.00 g) was obtained form T_8 (5:2) which was significantly at par with 176.00 g obtained from T_7 (4:1). T_7 was again at par with 175.33 g and 175.00 g obtained from T_5 (6:2) and T_{10} (7:2) respectively. But the value of was significantly higher than 174.00 g which was the lowest value obtained from T_{11} (8:2).

4.2.6 Fresh pods yield at marketable size

The T_{12} treatment (sole bushbean) gave the highest fresh pods yield (5.0 t/ha) (Fig 2.). The second highest fresh pods yield (1.739 t/ha) was recorded in T_6 (3:2) treatment which was followed by 1.285 t/ha obtained from T_7 (4:2). The 4th highest vegetative yield (0.969 t/ha) was obtained from T_8 (5:2) followed by 0.807, 0.789, 0.689, 0.651 and 0.624 t/ha which way statistically similar to each other obtained from T_5 (6:2), T_2 (3:1), T_4 (5:1), T_{10} (7:2) and T_3 (4:1) respectively. The lowest fresh pods yield (0.47 t/ha) was found in T_9 (6:1) which was statistically similar to 0.499 t/ha obtained from T_{11} (8:2).

4.2.7 Seed yield

Since the yield contributing characters viz - number of branches /plant, number of pods /plant, number of seed /plant and 1000 seed weight varied significantly with the variation in the intercropping ratios with wheat, so the yield of bushbean both at harvest and at vegetative also different significantly from one another. Like other parameters in yield also the treatment T_{12} (sole bushbean) gave the highest yield (2.08 t/ha), (Fig 3.) which was 219% higher than the next highest yield (0.652 t/ha) obtained from T_6 (3:2). The second highest yield (0.652 t/ha) was significantly higher (39%) from the third highest yield (0.469 t/ha) which was statistically higher than fourth highest yield (0.458 t/ha) while the 4th highest was significantly higher than 0.339, 0.257, 0.248, 0.232 and 0.118 t/ha, the later one statistically lowest obtained from T_4.

Similar result was reported by Dahatonde *et al.* (1991). They conducted an experiment on the performance of wheat + bushbean (French bean) intercropping system. Under wheat- bushbean row ratios of 6:3 or 4:2 with recommended fertilizer rates. Bushbean grown alone produced the highest equivalent yield of 4.01 t/ ha and the highest net returns. The next best wheat equivalent yield of 3.60 t/ha was shown by wheat/bushbean row ratio 4:2 receiving recommended fertilizer rates.

Table 2. Growth and yield characters of bushbean as influenced by different row intercropping arrangements with wheat

Treatment	Plant height (cm)	No. of branches/ plant	No. of pods/ plant*	Number of seeds/ plant	1000 seed weight (g)
T_2	35.13	5.87	23.33	44.39	179.30
T_3	35.55	5.99	24.01	25.00	169.50
T_4	34.74	5.66	23.27	27.11	168.33
T_5	36.27	6. 27	25.29	34.32	177.00
T_6	37.46	6.46	25.85	25.32	167.50
T_7	37.09	6.37	25.76	39.06	179.50
T_8	37.11	6.39	25.27	36.00	176.00
T_9	37.02	5.56	23.21	26.37	169.33
T_{10}	36.66	6.24	25.22	29.50	175.33
T_{11}	36.33	6.22	25.12	28.32	175.00
T_{12}	37.33	6.57	26.42	29.50	174.00
$LSD_{0.05}$	1.019	0.536	0.981	1.023	1.439
CV (%)	1.65	5.12	2.32	1.92	8.49

*Number of pods /plant was recorded at 65 DAS.

Row ratio treatments:

T_2 = 3 : 1 (Wheat : Bushbean)
T_3 = 4 : 1 (Wheat : Bushbean)
T_4 = 5 : 1 (Wheat : Bushbean)
T_5 = 6 : 2 (Wheat : Bushbean)
T_6 = 3 : 2 (Wheat : Bushbean)
T_7 = 4 : 2 (Wheat : Bushbean)
T_8 = 5 : 2 (Wheat : Bushbean)
T_9 = 6 : 1 (Wheat : Bushbean)
T_{10} = 7 : 2(Wheat : Bushbean)
T_{11} = 8 : 2 (Wheat : Bushbean)
T_{12} = Sole Bushbean

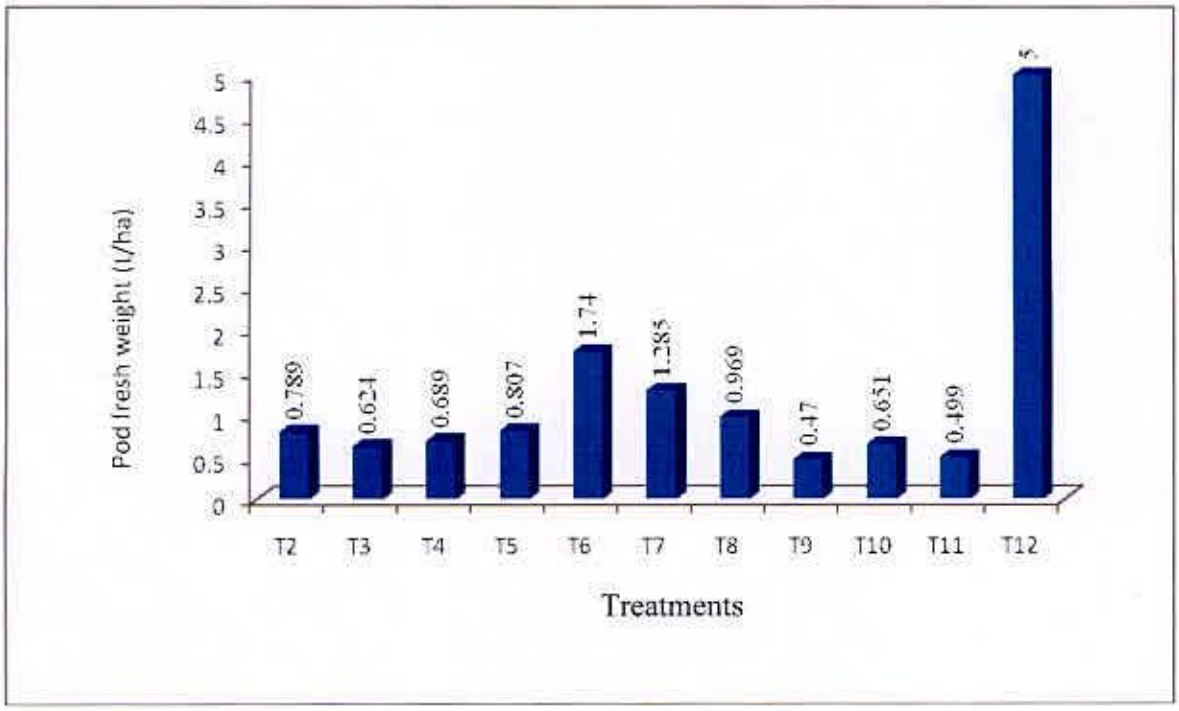


Fig. 2 Fresh pod yield of bushbean at marketable size under different wheat-bushbean intercropping patterns (LSD $_{(0.05)}$ = 0.326)

Row ratio treatments

T_2 = 3 : 1 (Wheat : Bushbean

T_3 = 4 : 1 (Wheat : Bushbean)

T_4 = 5 : 1 (Wheat : Bushbean)

T_5 = 6 : 2 (Wheat : Bushbean)

T_6 = 3 : 2 (Wheat : Bushbean)

T_7 = 4 : 2 (Wheat : Bushbean)

T_8 = 5 : 2 (Wheat : Bushbean)

T_9 = 6 : 1 (Wheat : Bushbean)

T_{10} = 7 : 2(Wheat : Bushbean)

T_{11} = 8 : 2 (Wheat : Bushbean)

T_{12} = Sole Bushbean

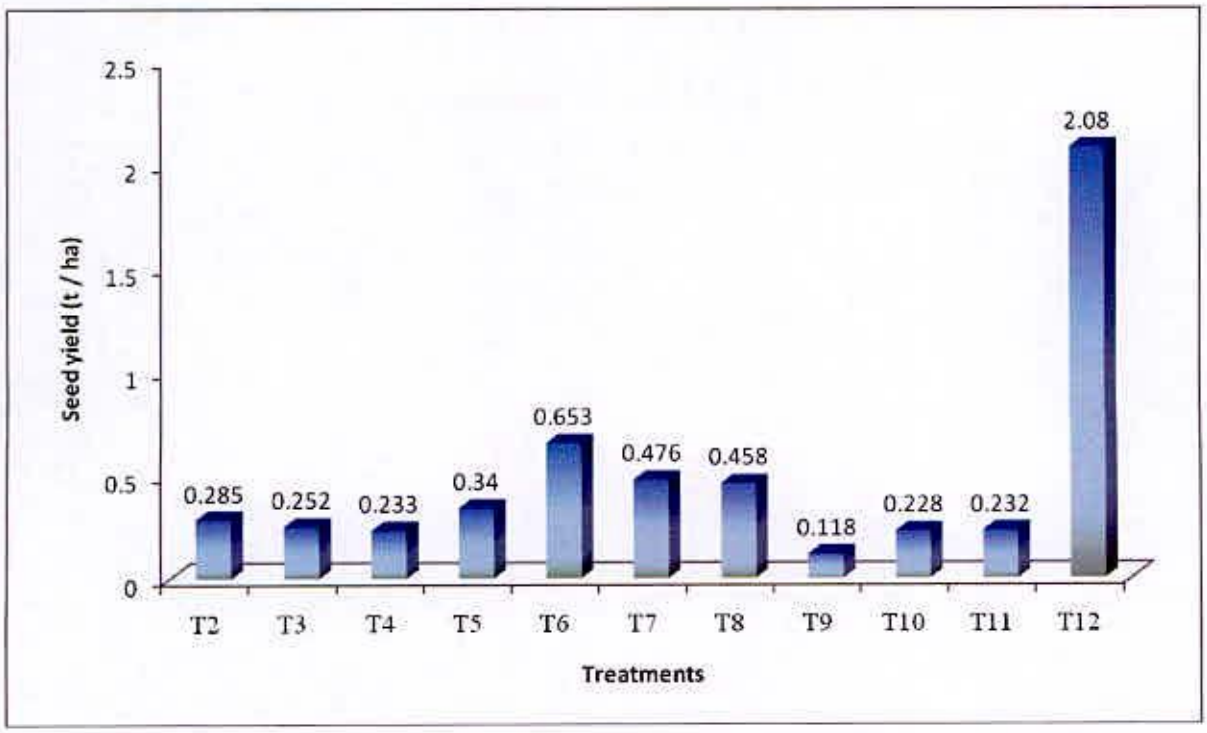


Fig. 3 Seed yield of bushbean under different wheat-bushbean intercropping patterns (LSD $_{(0.05)}$ = 0.010)

Row ratio treatments

T_2 = 3 : 1 (Wheat : Bushbean)_

T_3 = 4 : 1 (Wheat : Bushbean)

T_4 = 5 : 1 (Wheat : Bushbean)

T_5 = 6 : 2 (Wheat : Bushbean)

T_6 = 3 : 2 (Wheat : Bushbean)

T_7 = 4 : 2 (Wheat : Bushbean)

T_8 = 5 : 2 (Wheat : Bushbean)

T_9 = 6 : 1 (Wheat : Bushbean)

T_{10} = 7 : 2(Wheat : Bushbean)

T_{11} = 8 : 2 (Wheat : Bushbean)

T_{12} = Sole Bushbean

4.3 Relative Yield

The data presented in Table 3 revealed that the relative yield of wheat decreased with the decrease in rows of wheat. Among different combinations of intercropping of wheat with bushbean expect for T_1 (Sole wheat), the highest relative yield of wheat (0.986 t/ha) was found in T_3 (4: 1 row ratio of wheat and bushbean intercropping pattern) and the lowest relative yield (0.606 t/ha) was found in T_6 which was statistically similar to T_7 (4: 2 row ratio of wheat and bushbean intercropping pattern).

Relative yield of bushbean decreased significantly at both the maturity and vegetative stage in comparison to sole crop of bushbean (T_{12}), (Table 3). The highest relative yield of bushbean at maturity stage (0.835 t/ ha) was obtained in T_6 (3: 2 row ratio of wheat and bushbean intercropping pattern) which was statistically identical to T_7 (4: 2 row ratio of wheat and bushbean intercropping pattern). The lowest value was found (0.225 t/ ha) in T_9 (6: 1 row ratio of wheat and bushbean intercropping pattern).The highest relative yield of bushbean at vegetative stage (0.310 t/ha) was obtained in T_6 (3: 2 row ratio of wheat and bushbean intercropping pattern) which was statistically identical to T_7 (4: 2 row ratio of wheat and bushbean intercropping pattern). The lowest (0.057 t/ha) value was found in T_9 (6:1 row ratio of wheat and bushbean intercropping pattern). Treatments T_2, T_3, T_4, T_{10} and T_{11} gave similar results.

The result revealed that the relative yield of wheat was more when four rows wheat was grown alternate with one row bushbean.

The reduction of relative yield for bushbean was mainly due to competition with the main crop (wheat) for moisture, nutrients and light. (Bora, 1999).

Table 3. Relative yield of wheat and bushbean under different intercropping treatments

Treatment	Wheat	Bush bean	
	Relative yield (t/ha)	Maturity	Vegetative
		Relative yield	Relative yield
T_1	1.00	--	--
T_2	0.843	0.379	0.119
T_3	0.986	0.300	0.121
T_4	0.926	0.331	0.111
T_5	0.778	0.387	0.163
T_6	0.606	0.835	0.310
T_7	0.626	0.618	0.257
T_8	0.716	0.465	0.220
T_9	0.963	0.225	0.057
T_{10}	0.815	0.313	0.109
T_{11}	0.793	0.240	0.111
T_{12}	--	1.00	1.00
$LSD_{0.05}$	0.054	0.0172	0.077
CV (%)	3.77	10.86	11.08

NS = Not significant

Row ratio treatments:

T_1 = Sole Wheat
T_2 = 3 : 1 (Wheat : Bushbean)
T_3 = 4 : 1 (Wheat : Bushbean)
T_4 = 5 : 1 (Wheat : Bushbean)
T_5 = 6 : 2 (Wheat : Bushbean)
T_6 = 3 : 2 (Wheat : Bushbean)
T_7 = 4: 2 (Wheat : Bushbean)
T_8 = 5 : 2 (Wheat : Bushbean)
T_9 = 6 : 1 (Wheat : Bushbean)
T_{10} = 7 : 2(Wheat : Bushbean)
T_{11} = 8 : 2 (Wheat : Bushbean)
T_{12} = Sole Bushbean

4.4 Combined yield

The combined yield of wheat and bushbean was influenced significantly at both maturity and vegetative stage by different row ratio intercropping patterns (Table 4). The significantly highest combined yield at maturity stage (3.204 t/ha) was found in T_3 (4:1 row ratio of wheat and bushbean intercropping pattern). The next highest value (3.034 t/ha) was found in T_4 (5:1 row ratio of wheat and bushbean intercropping pattern) but this was statistically similar to T_9 (6:1 row ratio of wheat and bushbean intercropping pattern). The lowest combined yield (2.362 t/ha) was found in T_7 (4:2 row ratio of wheat and bushbean intercropping pattern) which was also at par with those of $T_5 - T_{11}$ in this respect.

Similar result was also obtained by Singh *et al.* (1995). They reported that the combined yield of wheat and lentil under wheat + lentil intercropping system was significantly higher than the sole crop.

Table 4. Combined yield of wheat and bushbean under different intercropping treatments

Treatment	Combined seed yield(t/h)
	Harvest
T_2	2.800
T_3	3.204
T_4	3.034
T_5	2.692
T_6	2.485
T_7	2.362
T_8	2.624
T_9	3.030
T_{10}	2.694
T_{11}	2.632
$LSD_{0.05}$	0.1616
CV (%)	3.44

Row ratio treatments:

T_2 = 3 : 1 (Wheat : Bushbean)
T_3 = 4 : 1 (Wheat : Bushbean)
T_4 = 5 : 1 (Wheat : Bushbean)
T_5 = 6 : 2 (Wheat : Bushbean)
T_6 = 3 : 2 (Wheat : Bushbean)
T_7 = 4: 2 (Wheat : Bushbean)
T_8 = 5 : 2 (Wheat : Bushbean)
T_9 = 6 : 1 (Wheat : Bushbean)
T_{10} = 7 : 2 (Wheat : Bushbean)
T_{11} = 8 : 2 (Wheat : Bushbean)

4.5 Productivity performance

The productivity performance of wheat and bushbean under different row ratios of intercropping was measured by land equivalent ratio, wheat equivalent yield and monetary advantage. The productivity parameters are presented in Fig. 4 to 7 and Table 5.

4.5.1 Land equivalent ratio (LER)

Intercropping offered significant effect on land equivalent ratio. Four rows of wheat alternate with one row of bushbean (T_3) were found to be superior in respect of LER (Table-5) at maturity stage. However, there was no significant difference among T_3, T_4 and T_9 in this respect. Three rows of wheat alternate with two rows of bushbean intercropping pattern (T_6) were found to be superior in respect of LER (Table-5) at the vegetative stage.

The LER value greater than one indicated that there was an yield advantage due to intercropping compared to the sole cropping (Palaniappan, 1988). The highest LER value (1.097) at maturity stage and (1.44) at vegetative stage were obtained in T_3 (4:1 row ratio of wheat and bushbean intercropping pattern) and T_6 (3:2 row ratio of wheat and bushbean intercropping pattern) respectively. The second highest LER at maturity stage (1.037) was obtained in T_4 which was statistically identical to (1.019) was obtained in T_9. The lowest LER at maturity stage (0.883) was found in T_7 which was statistically identical to 0.905, 0.919, 0.924, 0.936 and 0.940 were obtained from T_{11}, T_6, T_{10}, T_8 and T_5 respectively. The second highest LER (1.277) in respect of

fresh pod yield at vegetative stage was obtained in T_3 which was statistically identical to 1.242, 1.217, 1.189, 1.180 and 1.165 values of T_7, T_2, T_9, T_8 and T_5 treatments respectively. The lowest LER (1.037) at vegetative stage was found in T_4 which was statistically identical to 1.040 which was obtained from T_{11}. The LER value of 1.44 meant that by intercropping 2.95 t wheat and 1.74 t bushbean was produced from one hectare of land instead of growing them separately in 1.44 hectare of land to achieve the same total yield.

Similar finding were observed by 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.

4.5.2 Wheat equivalent yield (WEY)

Wheat equivalent yield of different intercropping patterns of wheat and bushbean at maturity and vegetative stage have been shown in Table 5. The wheat equivalent yield both at maturity and vegetative stage varied significantly in different intercropping treatments. Among the treatments, the highest wheat equivalent yield at both maturity (5.045 t/ha) and vegetative stage (4.734 t/ha) were obtained in T_6 (3:2 row ratio of wheat and bushbean intercropping pattern). The next highest WEY at maturity stage (4.457 t/ha) was obtained in T_8 (5:2 row ratio of wheat and bushbean intercropping pattern). The lowest WEY at maturity stage (3.504 t/ha) was obtained in T_9 which was statistically identical to the values of 3.562 t/ha and 3.607 t/ha obtained from T_{11} and T_{10} respectively. The second highest WEY at vegetative stage (4.039 t/ha) was found in T_7 (4:2 row ratio of wheat and bushbean intercropping pattern) which was statistically identical to the values of 3.994, 3.991, 3.869, 3.786, 3.70, 3.698 and 3.554 t/ha obtained from T_3, T_4, T_2, T_8, T_5, T_9 and T_{10} respectively. The lowest WEY at vegetative stage (3.234 t/ha) was obtained with T_{11} (8:2 row ratio of wheat and bushbean intercropping pattern).

Similar finding were found by Dahatonde *et al.* (1991). They conducted an experiment on the performance of wheat + bushbean (French bean) intercropping system. Under wheat- bushbean row ratios of 6:3 or 3:2 with recommended fertilizer rates. Bushbean grown alone produced the highest equivalent yield of 4.01 t/ ha and the highest net returns. The next best wheat equivalent yield of 3.60 t/ha was shown by wheat/bushbean row ratio 3:2 receiving recommended fertilizer rates.

4.5.3 Monetary advantage

The monetary advantage provides an appropriate economic assessment of intercropping in terms of increased value per unit land. The highest monetary advantage at maturity stage (Tk. 4466.67 /ha) was obtained in T_3 (4:1row ratio of wheat and bushbean intercropping pattern) (Table 5). The second highest monetary advantage at maturity stage (Tk. 1712.25 /ha) was found in T_4 (5:1 row ratio of wheat and bushbean intercropping pattern) which was statistically identical to Tk. 795.01/ha obtained from T_9 (6:1row ratio of wheat and bushbean intercropping pattern). The negative values of monetary advantage were found in at maturity only with T_6, T_7, T_8, T_5, T_{10} and T_{11} treatments.

The highest monetary advantage at vegetative stage (Tk. 17355.40 /ha) was obtained with T_6 (3:2 row ratio of wheat and bushbean intercropping pattern). The next highest monetary advantage (Tk. 10412.02 /ha) was obtained with T_3 (4:1 row ratio of wheat and bushbean intercropping pattern) which was statistically identical to Tk. 9690.09 /ha, 9401.72, 8265.02, 7043.13, 6935.30 and Tk. 6274.17 /ha from T_4, T_7, T_2, T_9, T_8 and T_5 treatments respectively. The lowest value of monetary advantage (Tk. 1241.52 /ha) was found with the treatment T_{11} (8:2 row ratio of wheat and bushbean intercropping pattern).

Similar result was found by 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.

Table 5. Land equivalent ratio, wheat equivalent yield and monetary advantage of wheat and bushbean at maturity and vegetative stages under different intercropping treatments

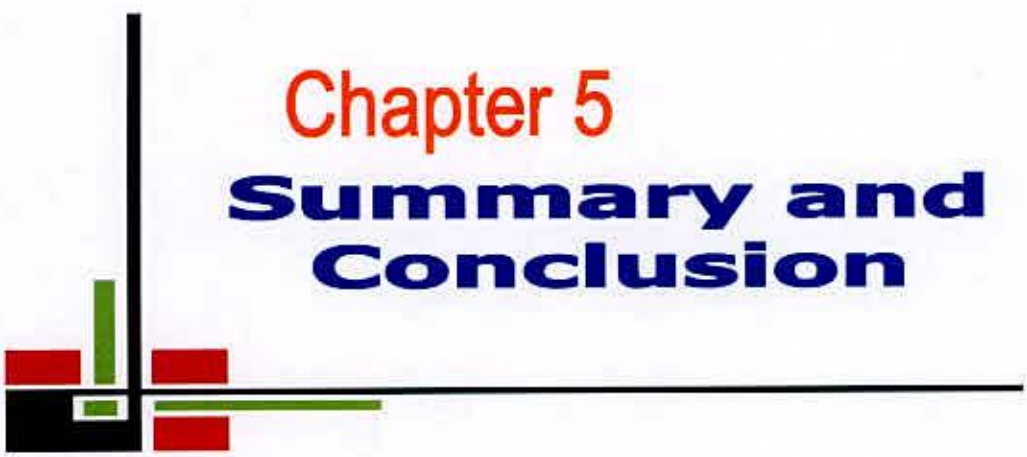
Treatment	LER		Wheat equivalent yield (t/ha)		Monetary advantages (Tk/ha)	
	Maturity*	Vegetative**	Maturity*	Vegetative**	Maturity*	Vegetative**
T_2	0.962	1.217	3.796	3.869	-1780.82	8265.02
T_3	1.097	1.277	4.213	3.994	4466.67	10412.57
T_4	1.037	1.037	3.965	3.991	1712.25	9690.09
T_9	1.019	1.189	3.504	3.698	795.01	7043.13
T_6	0.919	1.440	5.095	4.734	-5426.68	17355.40
T_7	0.883	1.242	4.242	4.039	-6864.84	9401.72
T_8	0.936	1.180	4.457	3.786	-3698.13	6935.30
T_5	0.940	1.165	4.052	3.700	-3085.53	6274.17
T_{10}	0.924	1.128	3.607	3.554	-3551.63	5207.23
T_{11}	0.905	1.040	3.562	3.234	-4549.55	1241.52
$LSD_{0.05}$	0.054	0.077	0.1769	0.2429	3348	2721
CV (%)	3.71	3.35	2.55	3.67	88.80	19.38

*Seeds of both the crops at maturity were considered.

** Fresh pods of bushbean at vegetative stage and seeds of wheat at maturity were considered.

Row ratio treatments:

T_2 = 3 : 1 (Wheat : Bushbean)
T_3 = 4 : 1 (Wheat : Bushbean)
T_4 = 5 : 1 (Wheat : Bushbean)
T_5 = 6 : 2 (Wheat : Bushbean)
T_6 = 3 : 2 (Wheat : Bushbean)
T_7 = 4: 2 (Wheat : Bushbean)
T_8 = 5 : 2 (Wheat : Bushbean)
T_9 = 6 : 1 (Wheat : Bushbean)
T_{10} = 7 : 2(Wheat : Bushbean)
T_{11} = 8 : 2 (Wheat : Bushbean)



Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Field, Sher -e- Bangla Agricultural University, Dhaka, during the period from December, 2005 to March, 2006 to find out the effect of different intercropping practices on the productivity of wheat and bushbean. Twelve treatment combinations of intercropping of wheat and bushbean at row ratio arrangements along with sole wheat, sole bushbean, 3:1, 4:1, 5:1, 6:1, 3:2, 4:2, 5:2, 6:2, 7:2 and 8:2 were tested. The experiment was laid out in a randomized complete block design with three replications.

The seeding rates for wheat and bushbean were 60 kg /ha and 40kg /ha respectively. Fertilizers were applied @ 183 kg N /ha, 152 kg P/ha, 45 kg K /ha and 98 kg gypsum /ha. Seeds of both crops were sown on December 03, 2005. Weeding and thining were done at 21 DAS. The crop was harvested at maturity stage. For pod yield of bushbean, the pods were collected at the most marketable size at 65 DAS and the fresh weight was recorded. At harvest the data on growth and seed yield characters of both the crops were recorded. Relative yield, combined yield, land equivalent ratio, wheat equivalent yield were computed. The data were statistically analyzed and means were compared by Least Significant Difference (LSD) technique.

The result of the experiment indicated that most of the crop characters of wheat were remarkably influenced by intercropping. The highest plant height (90.67 cm) was obtained from sole wheat which however, was statistically identical to three rows of wheat alternate with one row of bushbean intercropping pattern and the

lowest (86.82 cm) was with the 5:2 row ratios of wheat and bushbean intercropping pattern. In four rows of wheat alternate with one row of bushbean intercropping pattern gave the significantly highest (32.60 cm^2) leaf area. Thousands seed weight was significantly affected by intercropping. The highest 1000 seed weight (45.00 g) was obtained with sole wheat and the next highest (41.50 g) was obtained with 4:1 row ratio of wheat and bushbean intercropping and the lowest (38.50 g) with 7:2 row ratio intercropping. Number of tillers /plant, Number of leaves /plant was not significantly affected by intercropping.

Wheat yield was affected significantly due to different row ratios of intercropping treatments. The highest seed yield (3.025 t/ha) was obtained from sole wheat. The highest seed yield in sole wheat was attributed mainly to higher plant population per unit area. The lowest wheat yield (1.832 t/ha) was recorded in three rows of wheat alternate with two rows of bushbean intercropping pattern.

Number of branches /plant, number of pods /plant, number of seeds /plant, 1000 seed weight, seed yield both at maturity stage and pod yield at the vegetative stage of bushbean was significantly affected by intercropping at varying row ratios. The highest bushbean seed yield (2.082 t/ha) and pod yield (5.00 t/ha) was obtained in the sole bushbean. The lowest seed yield (0.1185 t/ha) and pod yield (0.4703 t/ha) was obtained with 6:1 row ratio of wheat and bushbean intercropping pattern. The lower yield of bushbean may be attributed to lesser plant population density and also

to the increased competition of bushbean for space, light, water and other growth resources in the 6:1 row ratio.

Relative yield of wheat and bushbean were found to be significantly lower in intercrop treatments than their respective sole crop yields. Land equivalent ratio differed in different intercropping treatments. The highest land equivalent ratio (1.097) was obtained at maturity stage in 4:1 row ratio of wheat and bushbean intercropping pattern at the harvesting. But that at the vegetative stage (1.44) while considering the pod yield was manifested by the 3:2 row ratio of intercropping. The equivalent yield of wheat also varied significantly in different intercropping patterns. Among the intercropping patterns the highest wheat equivalent yield both at maturity (5.045 t/ha) and vegetative stage (4.734 t/ha) were obtained in three rows of wheat alternate with two rows of bushbean intercropping pattern.

The highest monetary advantage at maturity stage (Tk. 4466.67 /ha) was obtained with four rows of wheat alternate with one row of bushbean intercropping pattern. While that at the vegetative stage (Tk. 17355.40 /ha) was obtained with three rows of wheat alternate with two rows of bushbean intercropping pattern. The negative monetary advantage was noticed in most of the treatments expect 4:1, 5:1, 6:1 row ratio of wheat and bushbean intercropping pattern at harvesting.

The highest combined yield at maturity stage (3.204 t/ha) was obtained in four rows of wheat alternate with one row of bushbean intercropping pattern.

Result of the present experiment, thus showed that bushbean can be successfully grown as intercrop with wheat without severe yield reduction. From the results of the present study it may be concluded that four rows of wheat alternate with one row of bushbean intercropping pattern at maturity stage gave the highest seed yield. But when pods were harvested at the vegetative stage, three rows of wheat alternate with two rows of bushbean intercropping pattern was proved to be superior in terms of productivity and economic return.

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Appendices

APPENDICES

Appendix I .Physical Characteristics and Chemical composition of soil of the experimental plot

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

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

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

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