Reprint **ISSN 1991-3036 (Web Version)**

International Journal of Sustainable Crop Production (IJSCP)

(*Int. J. Sustain. Crop Prod.*)

Volume: 7 **Issue: 1** **February 2012**

Int. J. Sustain. Crop Prod. 7(1):25-33(February 2012)

EFFICIENCY OF WHEAT-LENTIL AND WHEAT-CHICKPEA INTERCROPPING SYSTEMS AT DIFFERENT PLANTING CONFIGURATIONS

A.K. DAS, Q.A. KHALIQ AND M.L. HAIDER

An International Scientific Research Publisher

Green Global Foundation©

Publication and Bibliography Division

100 Leeward Glenway

Apartment # 1601

M3c2z1, Toronto, Canada

E-mails: publication@ggfagro.com, editor@ggfagro.com

http://ggfagro.com/ejournals/current issues

GGF

Nature is Power

IJSCP** issn 1991-3036, HQ:19-10 cantral place, saskatoon, saskatchewan, s7n 2s2, Canada

ISSN-1991-3036 (Online)
Int. J. Sustain. Crop Prod. 7(1):25-33(February 2012)

EFFICIENCY OF WHEAT-LENTIL AND WHEAT-CHICKPEA INTERCROPPING SYSTEMS AT DIFFERENT PLANTING CONFIGURATIONS

A.K. DAS[1], Q.A. KHALIQ[2] AND M.L. HAIDER[3]

[1&3]Department of Agricultural Extension, Khamarbari, Farmgate, Dhaka-1215; [2]Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706.

Corresponding author & address: Dr. Md. Latiful Haider, E-mail: latifulhaider@yahoo.com
Accepted for publication on 2 January 2012

ABSTRACT

Das AK, Khaliq QA, Haider ML (2012) Efficiency of wheat-lentil and wheat-chickpea intercropping systems at different planting configurations. *Int. J. Sustain. Crop Prod.* 7(1), 25-33.

This intercropping experiment was planned under the concept of cereal-legume intercropping system to find out the efficiency of wheat-lentil and wheat-chickpea intercropping systems at different planting configurations. During the experiment the data on yield parameters of the component crops were recorded under sole cropping and intercropped conditions. Finally intercropping efficiencies were calculated out from the recorded data. Grain yield in wheat, lentil and chickpea were higher in sole crops. But corresponding equivalent yields were higher than those in sole crops. Intercropping efficiencies varied significantly with the variation in crop combination and planting configurations. The intercropping efficiency LER, SLER, AYL and IA were recorded the highest 1.46, 1.69, 0.81 and 2.41, respectively in wheat-chickpea intercropping at 2:2 row ratios. Wheat was appeared as more competitive than lentil and chickpea, irrespective of the planting configurations. In the sole cropping system the BCR was the highest (2.26) for lentil. Under intercropping system the highest BCR (2.07) was recorded in wheat- lentil intercropping at 1:1 row ratio.

Key words: *intercropping, planting configuration, yield, equivalent yield, land equivalent ratio (LER), staple land equivalent ratio (SLER), aggressivity, competitive ratio (CR), actual yield loss (AYL), intercropping advantage (IA), gross return (GR) net return (NR) and benefit cost ratio (BCR)*

INTRODUCTION

The way in which the crop plants are arranged in the field is usually referred to as planting configuration. Keeping the total plant density constant, planting configuration can be varied by manipulating inter and intra row distances. Unjustified plant configuration leads to unevenness in competition for resource utilization. Competition may be too intense among some plants and less intense among others. The productivity of intercropping system depends, to a large extent on the nature and extent of plant competition (Harper 1977). In a situation where two crops are grown in combination both intra and inter-specific competition occurs (Spitters 1983) resulting in variations in growth manifested in total dry matter production and yield performance of the competing crops. In community level, plant competition can be modified and yield density relationships can be altered by manipulating plant configuration or spatial arrangement (Frappel 1979; Mayers and Foale, 1980). The pulse crop chickpea is a common crop and grown in the winter season as a post monsoon crop with the stored moisture in the soil profile. Cereals such as wheat and barley are intercropped with chickpea, lentil and peas in the post rainy season in the Indian sub continent (Aier 1949). In this system the complementary effects between species are more likely due to spatial difference in canopy height and rooting pattern rather than temporal differences. Since both the crops mature with little difference, yield advantage is low. This system usually occupies the land for 3 and ½ month to 5 months. Wheat - chickpea intercropping gave more yield advantage than sole crop but wheat was found more competitive in intercrop (Elangovan 1980; Palaniappan 1980). The legume effect from chickpea may be a reason for higher yield in chickpea. Thus keeping in mind the importance of planting configuration and the productivity of crops in cereal-legume intercropping system under intensive agriculture of Bangladesh, the present study was planned- to find out the planting configurations effect on the growth and yield of component crops under wheat-lentil and wheat-chickpea intercropping system.

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh. The treatment combinations were T_1 = sole wheat, T_2 = sole lentil, T_3 = sole chickpea, T_4 = wheat - lentil 1:1 row ratio, T_5 = wheat - chickpea 1:1 row ratio, T_6 = wheat - lentil 2:2 row ratio, T_7 = wheat - chickpea 2:2 row ratio, T_8 = wheat - chickpea 3:1 row ratio, T_9 = wheat - chickpea 3:1 row ratio. The experimental materials were BARI wheat variety, Saurav, BARI Chola-5 and BARI lentil- 1. Yield of crop was calculated from $4m^2$ demarcated areas from the experimental plots. The plot size was 5.0m x 4.0m and the experiment was laid out in RCBD design with 4 replications. Intercropping efficiencies and economic evaluation were done using different formula proposed by different researchers. Willey and Osiru (1972) proposed a concept of the land equivalent ratio (LER) as an index of combined yield for evaluating the effectiveness of all forms of intercropping. Land equivalent ratio (LER) is defined as the total land area required under sole cropping giving the yield obtained in the intercropping mixture. It is expressed as:

$$LER = (Yij/Yii) + (Yji/Yjj)$$

Where-
Y = Yield per unit area
Yii = Sole crop yield of component crop i
Yjj = Sole crop yield of component crop j
Yij = Inter crop yield of component crop i
Yji = Inter crop yield of component crop j

The partial LER values, Li and Lj, represent the ratio of the yields of crop i and j when grown as inter crops, relative to the sole crop. Thus,

Li = (Yij/ Yii) and Lj = (Yji/ Yjj)
LER is the sum of the two partial land equivalent ratios so that
LER = Li + Lj

When LER = 1, there is no advantage of inter cropping in comparison with sole cropping. When LER is greater than 1, a larger area of land is needed to produce the same yield of sole crop of each component crop than with an intercropping mixture. For example, when LER = 1.25 means 25% more land is needed to produce the same yield from the component as sole crop.

In the situation where the primary objective is to produce a fixed yield of one component (staple) crop, usually the cereal, and some yield of the legume, Reddy and Chetty (1984) proposed the concept of the staple land equivalent ratio (SLER) as an extension of the LER. It is based on the assumption of a basic requirement for minimum supply from a major staple crop such as the cereal and is the vital concept of cereal-legume intercropping and estimated as:

SLER = (Yi/ Yii) + Pij (Yji/ Yjj)

Where Yi/Yii is the desired standardized yield of the staple I, Pij is the proportion of land devoted to intercropping, and Yji/Yjj is the relative yield of crop j.

In intercropping system, crop competitions are quantified by aggressivity (Gilchrist 1965) and competitive ratio (Willey and Rao, 1980).

Aggressivity

Aggressivity of wheat (Aw) = Yiw/ (Ysw x Zw) – YiL/ (YsL x ZL).
Aggressivity of lentil (Al) = Yil/ (Ysl x Zl) – Yiw/ (Ysw x Zw).
Aggressivity of chickpea (Ac) = Yic/ (Ysc x Zc) – Yiw/ (Ysw x Zw).

Competitive ratio

Competitive ratio of wheat (CRw): {(Yiw/Ysw)/ (YiL/YsL)} x (ZL/Zw).
Competitive ratio of lentil (CRl): {(Yil/Ysl)/ (Yiw/Ysw)} x (Zw/Zl).
Competitive ratio of chickpea (CRc): {(Yic/Ycc)/ (Yiw/Ysw)} x (Zw/Zc).
Where,
Ysw = Yield of sole wheat
Yiw = Yield of intercrop wheat
YsL = Yield of sole legume
YiL = Yield of intercrop legume
Ysl = Yield of sole lentil
Yil = Yield of intercrop lentil
Zw = Proportion of wheat in intercrop
Zl = Proportion of lentil in intercrop
Zc = Proportion of chickpea in intercrop

Actual yield loss

Actual yield loss (AYL) is the proportion of yield loss or gain in intercrops in comparison to the respective sole crop, i.e. it takes into account the actual proportion of the component crops with its pure stand. Actual yield loss (AYL) was calculated by the following formula (Banik 1997).
$AYL = AYL_a + AYL_b$.
$AYLa = \{[(Y_{ab}/Z_{ab})/ (Y_{aa}/ Z_{aa})] - 1\}$
$AYLb = \{[(Y_{ba}/Z_{ba})/(Y_{bb}/ Z_{bb})] -1\}$

Where,
Y = Yield per unit area.
Z = Sown proportion

Subscripts aa and bb refers to pure stand (sole crops) of species A and B, and ab and ba refers to intercrops.

AYL_a and AYL_b are the partial yield loss represents the proportionate yield loss or gain of the species A and B when grown in intercrops, relative to their yield in pure stands. AYL is therefore the sum of the two partials AYL_a and AYL_b.

Intercropping advantage

Intercropping advantage (IA) was calculated using the following formula:

$IA = (P_a \times AYL_a) + (P_b \times AYL_b)$

Where IA= Intercropping advantage
P_a = Unit price of crop a.
P_b = Unit price of crop b.

Economic evaluation of intercropping system

In intercropping system net income advantages are secondary to risk reduction, particularly in farming system where subsistence is an important objective. The sources of reduced risk in intercropping as compared to sole cropping are usually attributed to both a reduced variance in out put and/ or net income and a higher probability of avoiding complete crop failure (Lyman *et al*. 1986). Several economic indices have been suggested to evaluate the systems and the most often used indices are given below.

Equivalent yield

Yield of individual crop was converted in to equivalent yield on the basis of prevailing market price of the individual crop (Anjaneyulu *et al*. 1982).

$$\text{Wheat equivalent yield for legume} = Y_w + \frac{Y_i \times P_i}{Pw}$$

Where,
Y_w = Yield of wheat (t ha^{-1})
Y_i = Yield of intercrop legumes (t ha^{-1})
P_i = Unit price of intercrop legume
P_w = Unit price of wheat
This assumes that appropriate economic assessment of intercropping should be in terms of increased value per unit area of land.

Gross returns

The total monetary value of the economic produce and by products obtained from the crop raised in the system i.e gross return (GR) was calculated based on the local market price of the produces and expressed in unit area basis.
GR = Total yield in kg ha^{-1} X Unit market price Tk kg^{-1}

Net return

This is also referred to as net profit. This is obtained by subtracting total variable cost of cultivation for the cropping system from the GR. This provides more meaningful basis for comparison of cropping system than gross return, since it represents the actual income of the farmer.
NR = Gross return – Total variable cost

Variable costs

Expenditure incurred on different items:
Labor cost, seed cost, fertilizer cost, pesticide cost and power tiller cost. The momentary cost of different treatments was computed on the basis of prevailing price.

Benefit cost ratio

Benefit cost ratio (BCR) = Gross Return/ Net Return

RESULTS AND DISCUSSION

Grain yield in wheat

Grain yield in wheat was found to be varied significantly with the variation in planting configuration (Table 1). The highest yield of wheat (3707 kg ha^{-1}) was recorded in sole wheat (T_1) and it was significantly different from those of others treatments. The lowest yield of wheat (2651 kg ha^{-1}) was found in wheat - lentil at 2:2 row ratio (T_4) and it was statistically similar to that of wheat - chickpea at 1:1 (T_5) row ratio and wheat – lentil at row ratio 2:2 (T_6). Statistically similar yield of wheat was recorded in wheat - lentil at 1:1 row ratio (T_4), wheat - lentil row ratio of 3:1 (T_8) and wheat- chickpea row ratio 3:1 (T_9). These results indicated that wheat gave the superior yield in sole cropping system compared to the intercropping system. Decreased yield in intercropped wheat was

found in an intercropping experiment with mustard (Dwivedi *et al.* 1998). Lal *et al.* (1998) also found decreased grain yield in wheat in an intercropping experiment of wheat with chickpea, lentil and mustard.

Wheat equivalent yield

Wheat equivalent yield varied with the variation in cropping systems and the planting configurations (Table 1). The highest wheat equivalent yield was found in wheat - lentil at 1:1 row ratio (T_4) and it was statistically similar to that of wheat - lentil at 2:2 row ratio (T_6) and wheat - lentil 3:1 row ratio (T_8). The lowest wheat equivalent yield (3321 kg ha^{-1}) was found in wheat - chickpea at 1:1 row ratio (T_5) and it was statistically similar to those of wheat - lentil at 1:1 row ratio (T_6), wheat - chickpea at 2: 2 row ratio (T_7) and wheat - chickpea at 3:1 row ratio T_9. Here the wheat - lentil intercropping showed the superior wheat equivalent yield as the market price of lentil was unusually high in the market, which has been reflected in wheat equivalent yield in wheat – lentil intercropping system. In another experiment wheat equivalent yield was found higher in intercropping system than in sole cropping (Sarma and Sarma, 1998).

Table 1. Grain yield, equivalent yield in wheat, lentil and chickpea as influenced by intercropping system at different row ratios

Treatment	Grain yield in wheat (kg ha^{-1})	Wheat equivalent yield (kg ha^{-1})	Grain yield in lentil (kg ha^{-1})	Lentil equivalent yield (kg ha^{-1})	Grain yield in chickpea (kg ha^{-1})	Chickpea equivalent yield (kg ha^{-1})
T_1	3707	3707				
T_2	-	-	934	934		
T_3	-	-	-	-	840	840
T_4	2651	4065	188	1413	-	-
T_5	2762	3321	-	-	279	1655
T_6	2780	3652	252	1293	-	-
T_7	3256	3388	-	-	368	1764
T_8	3318	3921	272	1252	-	-
T_9	3193	3534	-	-	170	1719
LSD $_{(0.05)}$	400	433	65	145	77	126
CV (%)	7.96	7.98	9.88	8.90	11.72	5.30

T_1 = Sole wheat, T_2 = Sole lentil, T_3 = Sole chickpea, T_4 = Wheat - lentil (1:1 row ratio), T_5 = Wheat - chickpea (1:1 row ratio), T_6 = Wheat - lentil (2:2 row ratio), T_7 = Wheat - chickpea (2:2 row ratio), T_8 = Wheat - lentil (3:1 row ratio), T_9 = Wheat - chickpea (3:1 row ratio)

Grain yield in lentil

Grain yield in lentil varied significantly with the variation in cropping system and the planting configuration under intercropping system (Table 1). The highest yield (934 kg ha^{-1}) was recorded in sole lentil (T_2) and it was statistically different from that of other treatments. Under intercropped condition the highest yield (272 kg ha^{-1}) was recorded in wheat - lentil intercropping at 3:1 row ratio and it was statistically similar to that of wheat - lentil at 1:1 row ratio (T_4). Similarly in maize - soybean inter cropping system the grain yield in legumes was found to be decreased significantly by intercropping treatments (Halikatti and Berrader, 1998; Carruthers *et al.* 2000). Maize when intercropped with black gram the grain yield of black gram decreased significantly (Upasani *et al.* 2000). The yield in common bean was also decreased when intercropped with maize (Maingi *et al.* 2000).

Lentil equivalent yield

Lentil equivalent yield in wheat - lentil intercropping system varied with the variation in planting configurations (Table 1). Under intercropped condition the highest equivalent yield (1413 kg ha^{-1}) was found in wheat - lentil at 1:1 row ratio and it was statistically similar to that of wheat - lentil intercropping at 2:2 row ratios (T_6). The lowest lentil equivalent yield (1252 kg ha^{-1}) was in wheat - lentil at 3:1 row ratio but statistically similar to that in wheat - lentil at 2:2 row ratio. Similarly the bushbean equivalent yield was found superior in intercropping with maize (Islam *et al*. 2002).

Grain yield in chickpea

Grain yield in chickpea varied significantly with the variation in cropping system and the planting configuration under intercropping system (Table 1). The highest yield (840 kg ha^{-1}) was obtained from sole chickpea (T_3) and it was statistically different from that in other intercropping treatments. Among the intercropping treatments the highest yield (368 kg ha^{-1}) was achieved from wheat - chickpea at 2:2 row ratios (T_7) and it was statistically different from all other treatments. The lowest yield was 170 kg ha^{-1} found in wheat - chickpea 3:1 row ratio (T_9) it was also statistically different from those in other treatments. In wheat - chickpea intercropping at 1:1 row ratio the yield of chickpea was 279 kg ha^{-1}, and it was statistically different from that in other treatments. Similarly chickpea yield was found higher in sole cropping compared to the intercropped yield (Pawer and Karle, 1999).

Chickpea equivalent yield

Chickpea equivalent yield varied due to the variation in cropping system and the planting configuration under intercropping system (Table 1). The equivalent yield in chickpea was the highest (1764 kg ha^{-1}) in wheat - chickpea intercropping at 2:2 row ratio (T_7), but it was statistically similar to that in other intercropping treatments and different from that in sole chickpea (T_3). In sole cropping (T_3) the yield in chickpea was 840 kg ha^{-1}. Among the intercropping treatments the lowest chickpea equivalent yield (1655 kg ha^{-1}) was recorded in wheat- chickpea at 1:1 row ratio (T_5).

Land equivalent ratio

The land equivalent ratio (LER) is the main index of intercropping advantage. It represents the land required for sole cropping to produce the total yield produced by the component crops in intercropping. The value of LER greater than 1 indicates an overall biological advantage of intercropping. The LER values varied significantly due to the variation in cropping system and the planting configuration under intercropping system (Table 2). The highest value of LER (1.46) was recorded in wheat - chickpea at 2:2 row ratios (T_7). The lowest LER (0.96) was found in wheat- chickpea at 1:1 row ratio (T_5) indicating the inefficiency of the intercropping system. Next to the treatment T_7 the wheat - lentil at 2:2 row ratio (T_6) achieved the higher LER (1.23). In other treatments the values of LER were found more than unity also. Similarly, Sarawgi *et al.* (1999); Sharma *et al.* (1998) reported from India the highest LER values under intercropping of wheat with chickpea at 2:2 row ratio.

Table 2. The land equivalent ratio, staple land equivalent ratio, actual yield loss and the intercropping advantage as influenced by different intercropping systems and planting configurations

Treatment	LER	SLER	AYL	IA
T_4	1.18	1.29	0.43	-24.48
T_5	0.96	1.56	0.74	-5.32
T_6	1.23	1.49	0.17	-27.45
T_7	1.46	1.69	0.81	2.41
T_8	1.07	1.18	-0.07	-26.16
T_9	1.19	1.23	-0.10	-17.64
SE (±)	0.08	0.1	0.2	6.17
$LSD_{(0.05)}$	0.18	0.21	0.42	13.15

T_4 = Wheat - lentil (1:1 row ratio), T_5 = Wheat - chickpea (1:1 row ratio), T_6 = Wheat - lentil (2:2 row ratio), T_7 = Wheat - chickpea (2:2 row ratio), T_8 = Wheat - lentil (3:1 row ratio), T_9 = Wheat - chickpea (3:1 row ratio)

Staple land equivalent ratio

Reddy and Chetty (1984) proposed the concept of staple land equivalent ratio (SLER) as an extension of LER where the primary objective was to produce a fixed yield of one component (staple crop), usually the cereal and some yield of legume, the one of the basic objectives of cereal- legume intercropping system. The SLER values were found to be varied due to the variation in intercropping system and the planting configuration (Table 2). The SLER values recorded in all the treatments of this experiment were more than unity indicating the suitability in crop combination under the concept of cereal-legume intercropping system. The highest value of SLER (1.69) was found in wheat- chickpea at 2:2 row ratio (T_7) indicating the best combination in cereal-legume intercropping system under consideration. The lowest value of SLER (1.23) was recorded in wheat - chickpea intercropping at 3:1 row ratio (T_9).

Actual yield loss

In evaluating the intercropping efficiency the concept of actual yield loss (AYL) and intercropping advantage (IA) was proposed by Banik (1996). The positive or negative sign of AYL score gives a quantitative assessment regarding advantage or disadvantage under any intercropping situation. The AYL scores varied with the variation in cropping system and the planting configuration under the intercropping system (Table 2). Among the intercropping treatments wheat - lentil at 3:1 (T_8) and wheat - chickpea 3:1 row ratio (T_9) scored negative values indicating the disadvantage of this crop combination and planting configuration. Among the other treatments of intercropping the wheat - chickpea at 2:2 row ratio (T_7) scored the highest positive value (0.81) indicating the best crop combination and planting configuration in the intercropping situation under consideration. The AYL value (0.74) in wheat - chickpea at 1:1 row ratio (T_5) was also advantageous and found close to the highest value (0.81) in T_7 treatment. Similarly the intercropping advantage was measured by calculating the AYL in mustard - legume intercropping at different planting configurations by Banik *et al.* (2000), who found the AYL value 0.44 at 1:1 row ratio. Dhima *et al.* (2007) conducted a wheat-common vetch intercropping experiment and evaluated the intercropping advantage by using the AYL and reported a similar trend as it was recorded in the present experiment.

Intercropping advantage

The intercropping advantage (IA) is an indicator of the economic feasibility of intercropping system where the negative sign indicates the disadvantage and the positive sign indicates the advantage of the system. In the present experiment it varied with the variation in cropping system and the planting configuration. All the intercropping treatments were found disadvantageous except wheat - chickpea at 2:2 row ratio (T_7). The highest positive value (2.41) of IA was recorded in treatment T_7 indicating the best economic feasibility of intercropping of wheat with chickpea at 2:2 row ratio (Table 2). In mustard-legume intercropping experiment Banik *et al.* (2000) expressed the IA as a new index of intercropping efficiency and evaluated the experiment by this index. They reported an IA value of 2.89 in mustard - lentil intercropping at 1:1 row ratio and declared the intercropping system economically feasible one. Dhima *et al.* (2007) conducted wheat - common vetch intercropping experiment and evaluated it by using IA index and reported a similar trend as it was found in the present experiment.

Competitive ratio

Competitive ratio (CR) indicates the ability of competition of one component crop over another under intercropped condition. The CR value over unity indicates the component as a good competitor while less than unity as a poor competitor when grown in association (Jedel *et al.* 1998). The CR varied significantly with the variation in crop combination and planting configuration. The highest CR value in wheat was (4.49) found in wheat - chickpea at 1:1 row ratio (T_5). Wheat in T_9 (wheat - chickpea 3:1 row ratio) showed the lowest (2.13) CR value. The higher values of CR in T_4 and T_5 treatments indicated that wheat was more competitive at 1:1 row ratio in combination either with lentil or with chickpea (Table 3). Similar trends in (CR) for the cereals like barley, wheat and oat were reported by Dhima *et al.* (2007) in a cereal - legume intercropping experiment in association with common vetch. In all the treatments the CR of wheat was more than unity that indicates its superior ability of competition with lentil and chickpea. The CR of lentil and chickpea was found less than unity in all the planting configurations. It revealed that these legumes are poor competitors in association with wheat. Difference in CR was the highest (4.27) in wheat - chickpea at 1:1 row ratio (T_5) indicating differential competitive ability and the lowest 1.66 in wheat - chickpea at 3:1 row ratio (T_9) reflecting the comparatively similar competitive ability for resources. In wheat - chickpea intercropping at 2:2 row ratio (T_7) the difference between the competitive ratios of the component crops was 2.96 and may be considered as moderate competitor of each other for growth resources.

Table 3. Competitive ratio and aggressivity of wheat, lentil and chickpea under different planting configurations in intercropping system

	Competitive ratio (CR)			Aggressivity	
Treatment	Wheat	Legume	Difference	Wheat	Legume
T_4	4.40	0.23	4.17	1.52	-1.52
T_5	4.49	0.22	4.27	1.73	-1.73
T_6	3.49	0.29	3.2	1.20	-1.20
T_7	3.26	0.3	2.96	1.48	-1.48
T_8	2.29	0.44	1.85	0.75	-0.75
T_9	2.13	0.47	1.66	0.68	-0.68
SE (±)	0.5	0.05	0.55	0.22	0.22
$LSD_{(5\%)}$	1.07	0.11	1.08	0.46	0.46

T_4 = Wheat - lentil (1:1 row ratio), T_5 = Wheat - chickpea (1:1 row ratio), T_6 = Wheat - lentil (2:2 row ratio), T_7 = Wheat - chickpea (2:2 row ratio), T_8 = Wheat - lentil (3:1 row ratio), T_9 = Wheat - chickpea (3:1 row ratio)

Aggressivity

Aggressivity determines the difference in competitive ability of the component crops in intercropping association. The positive sign indicates the dominant component and the negative sign indicates the dominated component. Higher numerical values of aggressiveness denote greater difference in competitive ability as well as bigger difference between actual and expected yield in both crops (Billore *et al.* 1992). In wheat - lentil and wheat - chickpea intercropping system the variations were found due to the variation in planting configuration (Table 3). In all the treatments wheat was found to dominate the legume component. The highest positive value (1.73) of aggressivity in wheat was recorded in wheat - chickpea at 1:1 row ratio (T_5). Next to it the value (1.52) of aggressivity in wheat was superior in wheat - lentil at 1:1 row ratio (T_4) and close to that in T_5 treatment. The legumes in all the planting configurations showed negative value. From these results it was revealed that the legumes, lentil and chickpea were dominated by wheat, irrespective of the planting configurations.

Table 4. Cost of cultivation, gross return, net return and benefit cost ratio of wheat - lentil, wheat - chickpea intercropping system at different planting configurations and the corresponding sole cropping

Treatments	Cultivation cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	Net return (Tk ha^{-1})	Benefit cost ratio (BCR)
T_1	40112	74150	34038	1.85
T_2	33038	74775	41737	2.26
T_3	32110	50454	18344	1.57
T_4	41120	85345	44225	2.07
T_5	41000	72008	31008	1.76
T_6	40400	79410	36310	1.96
T_7	40580	79129	34549	1.95
T_8	40100	81459	41359	2.03
T_9	40200	74093	33893	1.84
$SE_{(\pm)}$	1761.09	4888	3825	0.09
$LSD_{(5\%)}$	3934.89	10296	7869	0.2

T_1 = Sole wheat, T_2 = Sole lentil, T_3 = Sole chickpea, T_4 = Wheat - lentil (1:1 row ratio), T_5 = Wheat - chickpea (1:1 row ratio), T_6 = Wheat - lentil (2:2 row ratio), T_7 = Wheat - chickpea (2:2 row ratio), T_8 = Wheat - lentil (3:1 row ratio), T_9 = Wheat + Chickpea (3:1 row ratio)

Price:
Wheat- 20 Tk kg^{-1}, lentil-80Tk kg^{-1} and chickpea-60 Tk kg^{-1}

Economic evaluation

The monetary advantages obtained from different cropping system and the planting configuration varied significantly and indicated a definite gain from intercropping system. The gross return in all the intercropping system was found superior to that in the corresponding sole cropping (Table 4). Among the intercropping systems the gross returns were higher in wheat - lentil intercropping than in the wheat - chickpea-intercropping system. Under intercropping system the highest gross return (85345 Tk ha^{-1}) was obtained from the wheat - lentil at 1:1 row ratio (T_4) and the lowest (72008 Tk ha^{-1}) from wheat - chickpea intercropping at 1:1 row ratio (T_5). In case of net return similar trend was observed. The corresponding sole cropping gave the relatively lower net return than the intercropping system. The highest net return (44225Tk ha^{-1}) was obtained from wheat - lentil at 1:1 row ratio (T_4) and the lowest net return (31008Tk ha^{-1}) was obtained from wheat - chickpea at 1:1 row ratio (T_5). In case of benefit cost ratio (BCR) higher value was obtained also from the cropping system having the lentil as a component due to its higher price. The BCR was highest (2.26) in sole lentil (T_2). Among the wheat - chickpea intercropping system the highest value (1.95) of BCR was recorded in wheat - chickpea at 2:2 row ratio (T_7) and the lowest (1.76) was in wheat - chickpea at 1:1 row ratio (T_5). Saraf *et al*. (2001) found wheat - pea intercropping at 1:1 row ratio profitable with BCR of 2.75. Under the concept of cereal-legume intercropping, maize was intercropped with field bean at different planting configurations. After economic analysis the highest BCR was found 1.87 at 2:2 row ratios among all the planting configurations and declared as a profitable cereal-legume intercropping cropping system (Pandita *et al.* 2000).

CONCLUSION

Intercropping efficiencies varies significantly with the variation in crop combination and planting configurations. The experiment revealed that land equivalent ratio (LER). Staple land equivalent ratio (SLER), actual yield loss (AYL) and intercropping advantage (IA) were recorded higher in the wheat-chickpea intercropping at 2:2 row ratio indicating efficient intercropping efficiencies.

REFERENCES

Aiyer AKYN (1949) Mixed cropping in India. *Indian J. Agric. Sci.* 19, 439.

Anjaneyulu VR, Singh SP, Pal M (1982) Effect of competition free period and technique and pattern of pearl millet planting for growth and yield of mungbean and total productivity in soil for pearl millet and pearl millet/ mungbean intercropping system, *Indian J. Agron.* 27(3), 219–226.

Banik P (1996) Evaluation of wheat (*Triticum aestivum*) and legume intercropping under 1:1 and 2:1 row replacement series system. *J. Agron. Crop Sci.* 176, 289-294.

Banik P, Sasmal T, Ghosal PK, Bagchi DK (2000) Evaluation of mustard (*Brassica campestris* Var. Toria) and legume intercropping under 1:1 and 2:1 row-replacement series systems. *J. Agron. and Crop Sci.* 185, 9-14.

Banik KC (1997) Maize - legume intercropping for North Central Plateau of Orissa. Legume Res. 20(3/4), 218-220.

Billore SD, Singh K, Bargale M (1992) Competition functions of wheat (*Triticum aestivum*) - linseed (*Linum usitatissimum*) inter cropping grown under different fertility levels. *Indian J. Agron.* 37, 415-419.

Carruthers K, Prithiviraj B,.Cloutier D, Martin RC, Smith DL (2000) Intercropping corn with soybean, lupin and forages: yield components responses. *European J. Agron.* 12(2), 103-115.

Dhima KV, Lithourgidis AS, Vasilakoglou IB, Dordas CA (2007) Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crops Res. 100(2/3), 249-256.

Dwivedi DK, Sah AK, Dubey J, Thakur SS, Singh SJ, Pandey IB (1998) Intercropping of mustard with irrigated wheat. *J. Res. Birsa Agricultural University*. 10(2), 183-184.

Elangovan R (1980) Studies of rainfed black soil areas in the North East Moonsoon Season. M.Sc. (Ag) thesis. Tamil nadu Agric. University, Coimbatore, India.

Frappel BD (1979) Competition in vegetable crop communities. *J. Aust. Inst. Agric. Sci.* 45, 211-217.

Gilchrist CAM (1965) Analysis of competition experiments. Biometrics. 21, 975 – 985.

Halikatti SI, Banarasilal (1998) Production potentiality of as influenced by planting configuration, mulching and grain legume in intercropping. *Karnataka J. Agril. Sci.* 11(4), 883-888.

Harper JL (1977) Populatio biology of plants. Academic Press. Newyork.

Islam MN, Haque MM, Hamid A, Mondal MH, Karim MA, Ahmed JU (2002) A Ph.D dissertation on competitive interference and productivity in maize bush bean intercropping system. Department of Agronomy Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur.

Jedal PE, Helm JH, Burnett PA (1998) Yield, quality and stress tolerance of barley mixtures in central Albetra. *Can. J. Plant Sci.* 78, 429-436.

Lal RB, Verma AK, Ahuja KN (1998) Intercropping of oilseed and pulses crops in wheat (*Triticum aestivum*) under fertilizer and water-constraint situations. *Indian-J. Agron*. 43(2), 253-255.

Lyman JK, Sanders JH, Mason SC (1986) Economics and risk in multiple cropping. Pp.250-266. Francis (Ed) Multiple Cropping Systems. Macmillan Publishing Company, NewYork.

Maingi JM, Shisanya CA, Gitonga NM, Hornetz B (2000) Nitrogen fixation by common bean (*Phaseolus vulgaris* L.) in pure and mixed stands in semi arid south east Kenya. *European J. Agron*. 14(1), 1-12.

Mayers RJK, Foale MA (1980) Row spacing and population density in Australian grain sorghum production. *J. Aust. Inst. Agric. Sci.*46, 214-220.

Palaniappan SP (1980) Cotton based intercropping system for Coimbatore region. *Madras Agric. J.* 67, 71.

Pandita AK, Shah MH, Bali AS (2000) Effect of row ratio in cereal - legume intercropping systems on productivity and competition functions under Kashmir condition. *Indian J. Agron*. 45(1), 48-53.

Pawar GG, Karle AS (1999) Relative performance of different chickpea based intercropping systems on grain yield and monetary return. *Indian J. Pulse Res.*. 12(2), 257-259.

Reddy MN, Chetty CKR (1984) Staple land equivalent ratio for assessing yield advantage from intercropping. Expt. Agric. 20, 171- 177.

Saraf RK, Kuramvanshi SM, Pathak RK, Kamdeo KN (2001) Production potential of wheat and pea under mixture and intercropping system. *Ann. Agril. Res.* 22(4), 468-470.

Sarawgi SK, Tripathi RS (1999) Research note: Nitrogen management in wheat- chickpea intercropping system. *Madras Agril. J.* 86(717), 465-467.

Sarma HK, Sarma CK (1998) Performance of different wheat (*Triticum aestivum* L.) based intercropping systems under irrigated condition. *Indian J. H. Farm.*. 11(1/2), 24-26.

Sharma VM, Chakor IS, Manchanda AK (1998) Effect of maize (*Zea mays*) based legume intercropping on growth and yield attributes of succeeding wheat (*Triticum aestivum*) and economics. *Indian J. Agron.* 43(2), 231-236.

Spitters CJT (1983) An alternative approach to analysis of mixed cropping experiments: Estimation of competition effects. *Neth. J. Agric. Sci.* 3, 1-11.

Upasani RR, Singh MK, Thakur R, Verma UN, Pal SK (2000) Plant density and fertilizer management of blackgram intercropping system. *J. Res., Birsa Agril. University*. 12(2), 229-231.

Willey RW, Osiru DSO (1972) Studies on mixture of maize and beans (*Phaseolus vulgaris*) with particular reference to plant population. *J. Agril. Sci.*32, 221-232.

Willey RW, Rao MR (1980) A competitive ratio for quantifying competition between intercrops. Expt. Agric. 16, 117-125.