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# EFFECT OF INTERCROPPING ON GROWTH AND YIELD IN WHEAT-LENTIL AND WHEAT-CHICKPEA INTERCROPPING SYSTEM AT DIFFERENT PLANTING CONFIGURATIONS

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**ABSTRACT**

Das AK, Khaliq QA, Haider ML (2011) Effect of intercropping on growth and yield in wheat-lentil and wheat-chickpea intercropping system at different planting configurations. *J. Innov. Dev. Strategy* 5(3), 125-137.

This intercropping experiment was planned under the concept of cereal-legume intercropping system to find out the planting configurations effect on the growth and yield of component crops under wheat-lentil and wheat-chickpea intercropping system. During the experiment the data on growth and yield parameters of the component crops were recorded under sole cropping and intercropped conditions. From 10 days after emergence (DAE) destructive sampling for growth analysis was done at 15 days interval. The total dry matter (TDM) accumulation, crop growth rate (CGR) and relative growth rate (RGR) was recorded higher under sole cropping condition in all the component crops compared to those under intercropping condition. The growth and yield parameters were significantly influenced by the crop combination and planting configurations. Among the intercropping treatments, in wheat-chickpea intercropping, these growth parameters were found higher at 2:2 planting configuration. But in wheat-lentil intercropping these growth parameters were recorded higher at 3:1 planting configuration. Plant height, tillers plant$^{-1}$, spikes hill$^{-1}$, spikelets spike$^{-1}$, grains spike$^{-1}$ and grain yield in wheat were the highest in the sole cropping wheat. Hundred seeds weight was increased under intercropping condition. Wheat equivalent yield was highest in wheat-lentil intercropping at 1:1 row ratio. Number of branches plant$^{-1}$, pods plant$^{-1}$, seeds pod$^{-1}$ and grain yield in lentil was also the highest in sole cropping lentil. Intercropping increased the plant height and seed size in lentil. The highest lentil equivalent yield was recorded in wheat-lentil intercropping at 1:1 row ratio. Branches plant$^{-1}$, pods plant$^{-1}$, seeds pod$^{-1}$ and grain yield was the highest in sole cropping chickpea. Plant height and seed size was increased under intercropping condition. Chickpea equivalent yield was the highest in wheat-chickpea intercropping at 2: 2 row ratio.

***Key words:*** *intercropping, planting configuration, growth, days after emergence, yield, equivalent yield, total dry matter (TDM), crop growth rate (CGR), relative growth rate (RGR)*

## 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. The plants from 0.5 linear meters in each plot were collected at 15days interval starting from 10 DAE to 100 DAE for growth analysis. Then the plant materials were oven dried at $70^0$C for 72 hours and final dry weights were recorded. Data on other yield parameters were recorded from 10 randomly selected plants from each plot. Yield of crop was calculated from 4m$^2$ demarcated areas from the experimental plots. The plot size was 5 m × 4 m and the experiment was laid out in RCBD design with 4 replications.

## RESULTS AND DISCUSSION

### *Plant height in wheat*

Plant height is an important morphological character that acts as a vital indicator of availability of growth resources in its vicinity. Plant height of the component crop is an important trait for selecting the crop for intercropping. It influences the resource utilization efficiency of the component crops. In the intercropping system plant height was influenced by the plant density and row ratio of the component crops. Plant height in wheat at maturity across the different row ratio with legumes and sole crop varied significantly (Table 1). The tallest plants (100.37 cm) were recorded in wheat grown under sole crop ($T_1$) condition, however, the plant height of wheat sole crop condition was statistically similar to the plant heights of wheat under wheat - lentil at 2:2 row ratio ($T_6$), wheat - chickpea at 2:2 row ratio ($T_7$), wheat - lentil at 3:1 row ratio ($T_8$) and wheat - chickpea at 3:1 row ratio ($T_9$). In the intercropped condition the plant height in wheat was reduced irrespective of crop combination and the row ratio. The tallest plant height in wheat (92.77 cm) was observed in the intercropped combination under wheat - chickpea at 2:2 ($T_7$) and wheat - chickpea at 3:1 row ratio ($T_9$) but these were statistically similar to the plant height of wheat in all other treatments except in sole wheat ($T_1$). These results indicated that intercropping affected the plant height in wheat in a narrow scale. In another cereal-legume experiment in combination with maize and 14 bean genotypes Sood and Sood (2001) also found decreased plant height in maize under intercropping condition. Plant height in wheat was found to be decreased by different intercropping treatments comprising of chickpea, lentil and rapeseed under rainfed condition (Khan *et al.* 2005).

### *Tillers plant$^{-1}$ in wheat*

Number of tillers plant$^{-1}$ in wheat was found to be decreased significantly due to the variation in cropping system and planting configurations (Table 1). The highest number (3.28) of tiller was found in sole wheat ($T_1$) which was statistically similar to that of wheat - chickpea at 2:2 row ratio ($T_7$). The lowest number of tiller (2.65) was recorded in wheat - chickpea at 1:1 row ratio ($T_5$) which was statistically similar to the number of tillers in wheat - lentil at 1:1 row ratio ($T_4$), wheat lentil at 2:2 row ratio ($T_6$), wheat - lentil at 3:1 row ratio ($T_8$) and wheat - chickpea at 3:1 row ratio ($T_9$).

Table 1. Plant height, number of tillers plant$^{-1}$, number of spikes hill$^{-1}$, number of spikelets spike$^{-1}$, number of grains spike$^{-1}$ and length of spike in wheat as influenced by the intercropping with lentil and chickpea at different row ratios

| Treatment | Plant height (cm) | Number of tillers plant$^{-1}$ | Number of spikes hill$^{-1}$ | Number of spikelets spike$^{-1}$ | Number of grains spike$^{-1}$ | Length of spike (cm) |
|---|---|---|---|---|---|---|
| $T_1$ | 100.37 | 3.28 | 2.71 | 13.62 | 23.00 | 11.37 |
| $T_4$ | 82.16 | 2.75 | 1.91 | 12.84 | 18.25 | 10.59 |
| $T_5$ | 85.23 | 2.65 | 2.22 | 12.24 | 19.50 | 10.58 |
| $T_6$ | 92.14 | 2.92 | 2.02 | 10.94 | 19.50 | 10.53 |
| $T_7$ | 92.77 | 3.28 | 2.18 | 13.87 | 21.00 | 10.94 |
| $T_8$ | 92.28 | 2.77 | 2.06 | 13.44 | 18.00 | 10.71 |
| $T_9$ | 92.77 | 2.77 | 2.28 | 11.37 | 21.00 | 10.71 |
| LSD $_{(0.05)}$ | 10.51 | 0.27 | 0.28 | 1.20 | 2.12 | NS |
| CV % | 7.76 | 9.49 | 8.63 | 7.73 | 7.12 | 6.36 |

NS = Not significant

$T_1$ = 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 ratios), $T_7$ = Wheat - chickpea (2:2 row ratio), $T_8$ = Wheat - lentil (3:1 row ratio), $T_9$ = Wheat - chickpea (3:1 row ratio)

### *Spikes hill$^{-1}$ in wheat*

Variations were observed in number of spikes hill$^{-1}$ as influenced by the variation in cropping system and planting configuration under intercropped condition (Table 1). The highest number of spikes (2.71) was found in sole wheat ($T_1$), which was statistically different from all other treatments The lowest number of spikes hill$^{-1}$(1.91) was recorded in wheat - lentil at1:1 row ratio ($T_4$) and it was statistically similar to that in wheat - lentil at 2:2 row ratio ($T_6$), wheat - chickpea at 2:2 row ratio ($T_7$) and in wheat - lentil at 3:1 row ratio ($T_8$). Under intercropped condition the highest number of spikes hill$^{-1}$ was recorded in wheat - chickpea at 3:1 row ratio, however this was statistically similar to that in the wheat - chickpea at 1:1 row ratio ($T_5$), wheat - lentil at 2:2 row ratio ($T_6$), wheat - chickpea at 2:2 row ratio ($T_7$) and wheat - lentil at 3:1 row ratio ($T_8$). This result revealed that variation in number of spikes hill$^{-1}$ significantly decreased due to intercropping with lentil and chickpea.

### *Spikelets spike$^{-1}$ in wheat*

In wheat variations were recorded in number of spikelets spike$^{-1}$ due to the variation in the planting configuration under intercropping systems (Table 1). The highest number (13.87) of spikelets spike$^{-1}$ were found

in wheat - chickpea at 2:2 row ratio ($T_7$), which was statistically similar to that of sole wheat ($T_1$) and wheat - lentil at 1:1 row ratio ($T_4$). The lowest number of spikelets spike$^{-1}$ (10.94) was in wheat - lentil at 2:2 row ratio ($T_6$) and it was statistically similar to that of wheat - chickpea at 2:2 row ratio ($T_5$) and wheat chickpea at 3:1 row ratio ($T_9$).

***Grains spike$^{-1}$ in wheat***

Cropping system and planting configuration significantly reduced the number of grains spike$^{-1}$ under intercropping system in wheat (Table 1). The highest number of grains spike$^{-1}$ (23.00) was found in sole wheat ($T_1$), which was statistically similar with those of wheat - chickpea at 2:2 row ratio ($T_7$) and wheat chickpea at 3:1 row ratio ($T_9$). The lowest number of grains spike$^{-1}$ (18.00) was recorded in wheat - lentil 3:1 row ratio ($T_8$) which was statistically similar to that of wheat- lentil in 1:1 row ratio ($T_4$) and wheat lentil in 2:2 row ratios ($T_6$). Similarly Khan *et al*. (2005) in wheat legume intercropping experiment found that number of grains spike$^{-1}$ significantly decreased under different intercropping treatments.

***Length of spike in wheat***

Variation in length of spike in wheat was found statistically insignificant due to the variation in cropping system and the planting configuration under intercropping condition (Table 1). The longest spike was 11.37 cm in sole wheat ($T_1$) and the shortest (10.53 cm) in wheat - lentil intercropping at 2:2 row ratios ($T_6$). These variations in spike length in wheat due to the variation in planting configuration were found in conformity with the findings of Khan *et al*. (2005).

***Seed size in wheat***

Seed size in wheat varied significantly due to the variation and the planting configuration under intercropping system (Table 2). The 100- seed weight of wheat was the highest (4.26 g) in wheat - chickpea intercropping at 2:2 row ratio ($T_7$) and it was statistically similar to that of wheat - lentil at 1:1 row ratio ($T_4$) and wheat - chickpea at1:1 row ratio ($T_5$). The hundred seed weight was the lowest in sole wheat ($T_1$) but statistically similar to those of all the treatments except in the wheat - chickpea at 2:2 treatments ($T_7$), which indicated that the seed size in wheat in $T_7$ was superior to that of other treatments. In an intercropping experiment of rice associated with green gram, black gram and pigeon pea, the thousand seed weight of legumes was found to be influenced (Mandal *et al*. 2000) by different intercropping systems. Halub *et al.* (2000) also reported that 100-seed weight significantly increased when wheat was intercropped with legume.

Table 2. Seed size, grain yield, wheat equivalent yield and harvest index in wheat as influenced by intercropping with lentil and chickpea at different row ratios

| Treatment | 100-seed weight (g) | Grain yield (kg ha$^{-1}$) | Wheat equivalent yield (kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| $T_1$ | 3.60 | 3707 | 3707 | 47.40 |
| $T_4$ | 3.87 | 2651 | 4065 | 43.10 |
| $T_5$ | 3.91 | 2762 | 3321 | 46.23 |
| $T_6$ | 3.78 | 2780 | 3652 | 50.24 |
| $T_7$ | 4.26 | 3256 | 3388 | 47.26 |
| $T_8$ | 3.67 | 3318 | 3921 | 48.11 |
| $T_9$ | 3.67 | 3193 | 3534 | 50.07 |
| LSD $_{(0.05)}$ | 0.40 | 400 | 433 | NS |
| CV % | 7.03 | 7.96 | 7.98 | 10.88 |

$T_1$ = 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 wheat***

Grain yield in wheat was found to be varied significantly with the variation in planting configuration (Table 2). 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 2). 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).

***Harvest index in wheat***

Variation in harvest index of wheat was found to be statistically insignificant due the variation in cropping system and planting configuration (Table 2). The highest (50.24%) was recorded in wheat - lentil at 2:2 row ratio ($T_6$) and the lowest (43.11%) in wheat - lentil at 1:1 row ratio ($T_4$). Halub *et al*. (2000) reported the higher harvest index in wheat under intercropped condition compared to sole crop of wheat.

***Plant height in lentil***

Plant height in lentil varied significantly due to the variation in cropping system and planting configuration in intercropping system (Table 3). The height of lentil plant was 39.81 cm in sole cropping system ($T_2$) and it was the lowest compared to that of intercropping system. It was statistically different than those of other treatments. In intercropping system the highest plant height (45.86 cm) was recorded in wheat - lentil at 1:1 row ratio ($T_4$) and it was statistically similar to that of $T_6$ and $T_8$ treatment. The lowest plant height was 43.77 cm, found in wheat - lentil intercropping at 3:1 row ratio ($T_8$). Inter cropping increased the plant height of lower-story crop. Difference in the height of cowpea genotypes was reported by Robertson *et al*. (2000) when intercropped with maize. The increase in plant height in soybean was attributed to the decrease in red to far- red light ratio as result of preferential absorption of red light by the plants (Morgan and Smith, 1981). Such change in spectral balance increased internodes elongation process (Kretchmer *et al*. 1977) and increased the plant height in soybean when intercropped with maize.

***Branches plant$^{-1}$ in lentil***

Number of branches plant$^{-1}$ in lentil was found to be influenced significantly by the variation in cropping system and the planting configurations (Table 3). The highest number of branches plant$^{-1}$ (7.48) was found in sole lentil ($T_1$) and it was statistically different from those of other treatments. Under intercropped condition the highest number of branches plant$^{-1}$ was in wheat - lentil intercropping at 1:1 row ratio ($T_4$), which was statistically similar to those of wheat - lentil at 2:2 row ratio ($T_6$) and wheat - lentil at 3:1 row ratio ($T_8$). It indicated that intercropping and planting configuration influenced the number of branches plant$^{-1}$. Sood and Sood (2001) reported that number of branches plant$^{-1}$ in soybean, being a genotypic trait the coefficient of variation was higher under the intercropping system.

Table 3. Plant height, number of branches plant$^{-1}$, number of pods plant$^{-1}$, number of seeds pod$^{-1}$, 100- seed weight, grain yield and equivalent yield in lentil as influenced by the intercropping with wheat at different row ratio

| Treatment | Plant height (cm) | Number of branches plant$^{-1}$ | Number of pods plant$^{-1}$ | Number of seeds pod$^{-1}$ | 100 -seed weight (g.) | Grain yield (kg ha$^{-1}$) | Lentil equivalent yield (kg ha$^{-1}$) | HI |
|---|---|---|---|---|---|---|---|---|
| $T_2$ | 39.81 | 7.48 | 39.83 | 2.51 | 1.60 | 934 | 934 | 19.83 |
| $T_4$ | 45.86 | 4.65 | 24.05 | 1.46 | 1.80 | 188 | 1413 | 24.72 |
| $T_6$ | 44.37 | 4.8 | 31.83 | 1.32 | 1.78 | 252 | 1293 | 23.91 |
| $T_8$ | 43.77 | 4.48 | 24.73 | 1.27 | 1.83 | 272 | 1252 | 27.30 |
| $LSD_{(0.05)}$ | 3.83 | 0.96 | 5.80 | 0.31 | .008 | 65 | 145 | 4.875 |
| CV % | 5.51 | 11.25 | 12.03 | 11.93 | 5.23 | 9.88 | 8.90 | 12.20 |

$T_2$ = Sole lentil, $T_4$ = Wheat - lentil (1:1 row ratio) $T_6$ = Wheat - lentil (2:2 row ratio), $T_8$ = Wheat - lentil (3:1 row ratio)

***Pods plant$^{-1}$ in lentil***

In lentil number of pods plant$^{-1}$ was found to be influenced significantly by the variation in cropping system and the planting configurations under intercropped condition (Table 3). The highest number of pods plant$^{-1}$ was (39.83) found in sole lentil ($T_2$) and it was statistically different from those of other treatments. Under intercropped condition the highest number of pod (31.83) was found in wheat - lentil intercropping at 2:2 row ratio ($T_6$) which was statistically different from other treatments. The lowest number (24.05) of pods plant$^{-1}$ was found in wheat - lentil intercropping at 1:1 row ratio ($T_4$) and it was statistically similar to that of wheat - lentil at 3:1 row ratio ($T_8$). Similarly pods plant$^{-1}$ in bushbean was found to be affected by intercropping with maize (Amankwa *et al*. 1977; Atuahene *et al.* 2004). In maize - cow pea inter cropping pods plant$^{-1}$ decreased significantly (Ndakidemi and Dakora, 2007). Due to shading by the taller component there occurs flower and pod dropping which ultimately causes lower number of pods plant$^{-1}$ in bushbean (Osumi *et al*. 1998).

***Seeds pod$^{-1}$ in lentil***

Number of seeds pod$^{-1}$ in lentil was found to be influenced by the variation in cropping system and planting configurations (Table 3). The highest number (2.51) of seeds pod$^{-1}$ was found in sole lentil and it was statistically different from that of other treatments. Under intercropped condition the highest number (1.46) of seeds pod$^{-1}$ was in wheat - lentil intercropping at 1:1 row ratio ($T_4$) which was statistically similar to that of wheat- lentil at 2:2 ($T_6$) and at 3:1 row ratio ($T_8$). The lowest number of seeds pod$^{-1}$ was in $T_8$ treatment. Similar result was found in maize - bushbean intercropping system where the cropping system significantly affected the number of seeds pod$^{-1}$ (Atuahene *et al.* 2004). Number of seeds pod$^{-1}$ in grain legumes assumed as a genetic trait but it may be modified under changed growing environment. In another experiment it was reported that reduction in production of photo-assimilates under prolonged shading of maize might result in the lowest number of seeds pod$^{-1}$ in soybean (Egli and Yu, 1991).

***Seed size in lentil***

Seed size in lentil varied significantly with the variation in cropping system and planting configuration under intercropped condition (Table 3). The hundred seed weight was the highest (1.83g) in wheat - lentil intercropping at 3:1 row ratio ($T_8$) and it was statistically similar to that of wheat - lentil at 1:1($T_4$) and at 2:2 row ratio ($T_6$). The weight of hundred seeds was the lowest in sole lentil ($T_2$). Similar trend was found in intercropping of rice with green gram, black gram and pigeon pea. Mandal *et al*. (2000) reported that 1000-seed weight in legumes increased in different intercropping systems. It might be due to the reason that lower number of seeds pod$^{-1}$ in intercropped lentil received comparatively higher amount of assimilate.

***Grain yield in lentil***

Grain yield in lentil varied significantly with the variation in cropping system and the planting configuration under intercropping system (Table 3). 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 and 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 3). 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 ratio ($T_6$). 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).

***Harvest index in lentil***

The harvest index in lentil under different intercropping treatments varied significantly with the variation in planting configuration (Table 3). The highest harvest index (27.30%) was found in wheat - lentil intercropping at 3:1 row ratio ($T_8$) and it was statistically similar to wheat - lentil at 1:1 row ratio ($T_4$) and wheat - lentil at 2:2 row ratios ($T_6$). The lowest value of harvest index (19.83%) was recorded in sole lentil ($T_2$) and it was statistically similar to that in $T_6$. Similarly Halub *et al*. (2000) found the significant effect of plant configuration on harvest index in gram when intercropped with wheat.

***Plant height in chickpea***

Significant variation in plant height in chickpea due to the variation in cropping system and planting configuration was not found (Table 4). Difference in the height of cowpea genotypes was reported by Robertson *et al.* (2000) when intercropped with maize. The increase in plant height in soybean was attributed to the decrease in red to far- red light ratio as result of preferential absorption of red light by the plants (Morgan and Smith, 1981). Such change in spectral balance increased internodes elongation process (Kretchmer *et al.* 1977) and increased the plant height in soybean under intercropping system.

***Branches plant$^{-1}$ in chickpea***

Number of branches plant$^{-1}$ varied significantly with the variation in cropping system and planting configurations under intercropping system (Table 4). The highest number of branches plant$^{-1}$ (5.50) was found in the chickpea under sloe cropping ($T_3$) and it was statistically different from that in other treatments. Under intercropped condition the number of branches plant$^{-1}$ in chickpea was 4.35 in wheat - chickpea at 2:2 row ratio ($T_7$) and it was statistically similar to that in wheat - chickpea at 3:1 row ratio ($T_9$). The lowest number of

branches plant$^{-1}$ was found in wheat - chickpea at 1:1 row ratio ($T_5$) and it was statistically different from that in other treatments. Sood and Sood (2001) reported that number of branches plant$^{-1}$ in soybean being a genotypic trait the coefficient of variation was higher under the intercropping system.

Table 4. Plant height, number of branches plant$^{-1}$, number of pods plant$^{-1}$ and number of seeds pod$^{-1}$ in chickpea as influenced by intercropping with wheat at different row ratios

| Treatment | Plant height (cm) | Number of branches plant$^{-1}$ | Number of pods plant$^{-1}$ | Number of seeds pod$^{-1}$ |
|---|---|---|---|---|
| $T_3$ | 50.07 | 5.50 | 23.80 | 2.08 |
| $T_5$ | 56.79 | 3.13 | 13.55 | 1.19 |
| $T_7$ | 54.85 | 4.35 | 17.13 | 1.37 |
| $T_9$ | 55.05 | 3.88 | 13.88 | 1.20 |
| $LSD_{(0.05)}$ | NS | 0.66 | 1.85 | 0.25 |
| CV% | 5.65 | 9.75 | 6.92 | 10.52 |

$T_3$ = Sole chickpea, $T_5$ = Wheat - chickpea (1:1 row ratio), $T_7$ = Wheat - chickpea (2:2 row ratio), $T_9$ = Wheat - chickpea (3:1 row ratio)

***Pods plant$^{-1}$ in chickpea***

Number of pods plant$^{-1}$ in chickpea varied significantly with the variation in cropping system and planting configuration (Table 4). The highest number of pods plant$^{-1}$ (23.80) was found in sole chickpea ($T_3$) and it was statistically different from that in other treatments. Under intercropped condition the highest number of pods plant$^{-1}$(17.13) was found in wheat - chickpea at 2:2 row ratio ($T_7$) and it was statistically different from other treatments. The lowest number of pod plant$^{-1}$ (13.55) was recorded in wheat - chickpea 1:1 row ratio ($T_5$) and it was statistically similar to that in wheat - chickpea at 3:1 row ratio ($T_9$). In maize - cowpea intercropping pods plant$^{-1}$ and seeds pod$^{-1}$ in cowpea decreased significantly (Ndakidemi *et al.* 2007). Due to shading by the taller component there occurs flower and pod dropping which ultimately causes lower number of pods plant$^{-1}$ in bushbean (Osumi *et al*. 1998).

***Seeds pod$^{-1}$ in chickpea***

The number of seeds pod$^{-1}$ in chickpea varied significantly with the variation in cropping system and planting configuration under intercropping system (Table 4). The highest number of seeds pod$^{-1}$ (2.08) was recorded in sole chickpea ($T_3$) and it was statistically different from that in other treatments. In the intercropping systems the highest number of seeds pod$^{-1}$ was recorded in wheat - chickpea intercropping at 2:2 row ratio ($T_7$) and it was statistically similar to that in wheat - chickpea at 1:1 row ratio ($T_5$) and at 3:1 row ratio. Similar result was found in maize - bean (*Phaseolus vulgaris* L.) intercropping system where the cropping system significantly affected the number of seeds pod$^{-1}$(Atuahene *et al.* 2004). Number of seeds pod$^{-1}$ in grain legumes is assumed as a genetic trait but it may me modified under changed growing environment. Reduction in production of photo - assimilates under prolonged shading of maize resulted in the lowest number of seeds pod$^{-1}$ in soybean (Egli and Yu, 1991).

***Seed size in chickpea***

Hundred seed weight in chickpea was found to be influenced by the variation in cropping systems and the planting configurations under intercropped condition (Table 5). The hundred seed weight was the lowest (12.38 g) in sole chickpea ($T_3$) which was statistically different from that in other treatments. Among the intercropping treatments in wheat - chickpea at 2:2 row ratio ($T_7$) the 100-seed weight was the highest (14.24g) but statistically similar to the 100-seed weight in chickpea in the treatments $T_5$ and $T_8$. Mandal *et al.* (2000) reported that the thousand seed weight in mungbean, blackgram and pigeon pea increased when intercropped with rice.

***Grain yield in chickpea***

Grain yield in chickpea varied significantly with the variation in cropping system and the planting configuration under intercropping system (Table 5). 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 5). 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 ($T_5$).

Table 5. Hundred seed weight, grain yield, equivalent yield and harvest index in chickpea as influenced by intercropping with wheat at different row ratios

| Treatment | 100-seed weight (g) | Grain yield (kg $ha^{-1}$) | Equivalent yield (kg $ha^{-1}$) | Harvest index |
|---|---|---|---|---|
| $T_3$ | 12.38 | 840 | 840 | 28.32 |
| $T_5$ | 13.83 | 279 | 1655 | 20.54 |
| $T_7$ | 14.24 | 368 | 1764 | 29.38 |
| $T_9$ | 13.86 | 170 | 1719 | 18.67 |
| LSD $_{(0.05)}$ | 0.89 | 77 | 126 | 2.52 |
| CV% | 6.10 | 11.72 | 5.30 | 6.50 |

$T_3$ = Sole chickpea, $T_5$ = Wheat - chickpea (1:1 row ratio), $T_7$ = Wheat - chickpea (2:2 row ratio), $T_9$ = Wheat - chickpea (3:1 row ratio)

***Harvest index in chickpea***

Harvest index in chickpea varied significantly with the variation in cropping system and planting configuration under intercropping system (Table 5). The highest harvest index (29.38%) was recorded in wheat - chickpea intercropping at 2:2 row ratios ($T_7$) and it was statistically similar to that of sole chickpea ($T_3$). The lowest harvest index (20.54%) was in wheat - chickpea at 1:1 row ratio ($T_5$) and it was statistically similar to the harvest index (18.67%) of chickpea in wheat - chickpea intercropping at 3:1 row ratio ($T_9$). Halub *et al*. (2000) found the variation in harvest index under intercropped condition compared to the sole cropping of wheat.

***Total dry matter accumulation in wheat***

Total dry matter accumulation in wheat was influenced by the cropping system and the planting configuration under intercropping system (Fig. 1). At the early stage of crop growth the rate of dry matter accumulation was almost in similar pace. After 25 DAE, there was a sharp rise in accumulation of dry matter and the differential rate of dry matter accretion became evident. Throughout the whole period the sole cropping of wheat ($T_1$) maintained the highest rate of dry matter accumulation. Among the intercropping treatments the rate of dry matter accumulation in wheat was higher in wheat - chickpea at 2:2 row ratio ($T_7$). The lowest level of dry matter accumulation in wheat was recorded in wheat - lentil intercropping at 1:1 row ratio ($T_4$).

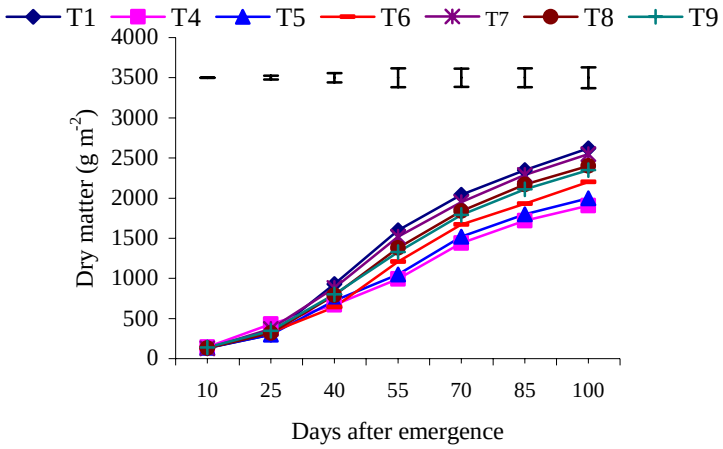


Fig.1. Total dry matter accumulation in wheat at different days after emergence as influenced by intercropping with lentil and chickpea at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

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

***Total dry matter accumulation in lentil***

Dry matter accumulation in lentil varied significantly due to the variation in cropping system and the planting configuration under intercropped condition (Fig. 2). From 10 DAE on wards lentil maintained a higher rate of dry matter accumulation in sole cropping ($T_2$) than in intercropping system. In intercropping the higher rate of dry matter accumulation was recorded in lentil under wheat – lentil intercropping at ratio 3:1 ($T_8$). The lowest rate of dry matter accumulation in lentil was found in wheat - lentil intercropping at 1:1 row ratio ($T_4$).

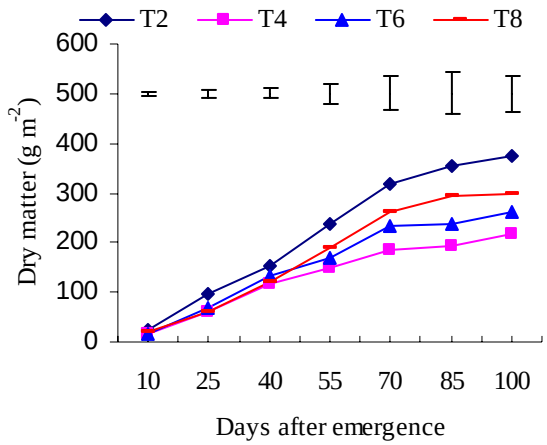


Fig. 2. Total dry matter accumulation in lentil at different days after emergence as influenced by intercropping with wheat at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

$T_2$ = Sole lentil, $T_4$ = Wheat - lentil (1:1), $T_6$ = Wheat - lentil (2:2), $T_8$ = Wheat - lentil (3:1)

***Total dry matter accumulation in chickpea***

Dry matter accumulation in chickpea varied with the variation in cropping system and the planting configuration under intercropping system (Fig. 3). From 40 DAE onward there was a distinct difference in the rate of dry matter accumulation in chickpea under different cropping systems and planting configurations. The rate of dry matter accumulation was higher in chickpea grown as sole crop ($T_3$). Under intercropped condition the rate of dry matter accumulation in chickpea was superior in wheat – chickpea intercropping at 2:2 row ratios ($T_7$). The rate of dry matter accumulation in chickpea was the lowest in wheat – chickpea intercropping at 1:1 row ratio ($T_5$). In the intercropping treatments of wheat - chickpea at 3:1 ratio ($T_9$), the rate of dry matter accumulation in chickpea was close to that in the treatment $T_7$.

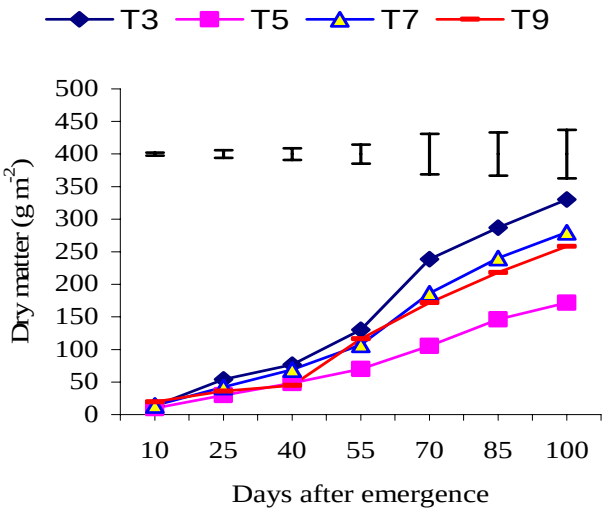


Fig. 3. Total dry matter accumulation in chickpea at different days after emergence as influenced by intercropping with wheat at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

$T_3$ = Sole chickpea), $T_5$ = Wheat - chickpea (1:1), $T_7$ = Wheat - chickpea (2:2), $T_9$ = Wheat - chickpea (3:1)

***Crop growth rate in wheat***

Crop growth rate (CGR) in wheat varied due to the variation in cropping system and planting configuration under intercropping system (Fig. 4). The crop growth rate was higher in wheat in sole cropping system ($T_1$). There was distinct difference in the CGR under different planting configurations. Among the intercropping treatments, the CGR in wheat was higher in wheat - chickpea intercropping at 2:2 row ratios ($T_7$). The CGR was lowest in the wheat – chickpea intercropping at 1:1 row ratio ($T_5$). In intercropping of wheat – lentil intercropping at 2:2 row ratios ($T_6$) CGR of wheat was close to that in $T_7$. Irrespective of intercropping and planting configuration, the CGR in wheat reached its peak at 70 DAE and gradually decreased with the increase in age of the wheat crop.

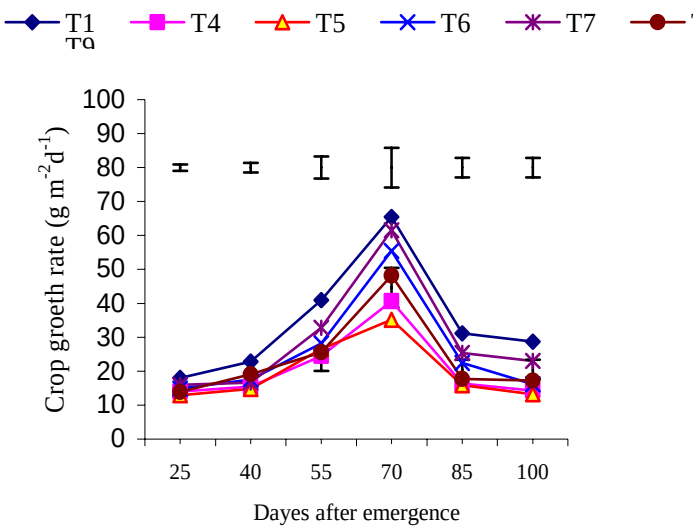


Fig. 4. Crop growth rate in wheat at different days after emergence as influenced by intercropping with lentil and chickpea at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

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

***Crop growth rate in lentil***

The crop growth rate in lentil varied significantly due to the variation in cropping system and the planting configuration under intercropping system (Fig. 5). The CGR was higher in sole lentil ($T_2$) throughout the growth period. Under the intercropping system the CGR in lentil was found higher in wheat - chickpea at 3:1 row ratio ($T_8$). The rate of CGR was the lowest in wheat - lentil intercropping at 1:1 row ratio ($T_4$). The CGR in lentil attained its peak at 70 DAE and declined sharply thereafter.

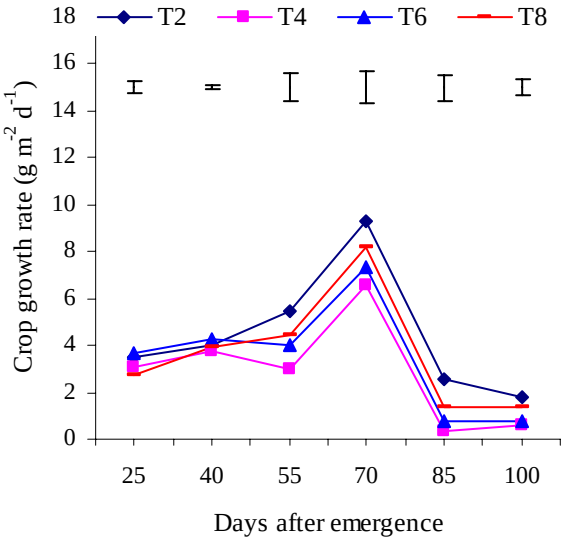


Fig. 5. Crop growth rate in lentil at different days after emergence as influenced by intercropping with wheat at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

$T_2$ = Sole lentil, $T_4$ = Wheat - lentil (1:1) $T_6$ = Wheat - lentil (2:2), $T_8$ = Wheat - lentil (3:1)

***Crop growth rate in chickpea***

The crop growth rate in chickpea was influenced significantly by the variation in cropping system and planting configuration under intercropping system (Fig. 6). The crop growth in chickpea was higher in sloe cropping system ($T_3$). After 40 DAE the CGR increased sharply and CGR decreased thereafter. Under the intercropping system the CGR in chickpea was the highest in wheat - chickpea intercropping at 2:2 row ratios ($T_7$). In intercropping wheat - chickpea at 1:1 row ratio ($T_5$) the CGR was close to that in the treatment $T_7$. The lowest was obtained in wheat - chickpea intercropping at 3:1 row ratio ($T_9$).

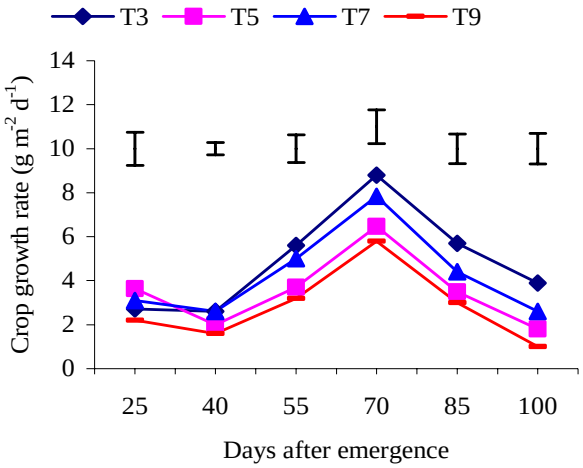


Fig. 6. Crop growth rate in chickpea at different days after emergence as influenced by intercropping with wheat at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

$T_3$ = Sole chickpea, $T_5$ = Wheat - chickpea (1:1), $T_7$ = Wheat - chickpea (2:2), $T_9$ = Wheat - chickpea (3:1)

***Relative growth rate in wheat***

Relative growth rate (RGR) in wheat was influenced by the variation in cropping system and the planting configuration under intercropping system (Fig. 7). After 55 DAE the RGR in wheat decreased gradually with the advancement of growth stages. The highest level of RGR was maintained by wheat under sole cropping ($T_1$). Under the intercropped condition in different planting configurations with lentil and chickpea the RGR of wheat in wheat - chickpea intercropping at 2:2 row ratios ($T_7$) maintained the higher level throughout the whole growth period. Next to it the RGR in wheat in wheat - lentil at 2:2 row ratio ($T_6$) was close to that in the treatment $T_7$. The lowest level of RGR was found in wheat when grown in wheat - lentil intercropping at 1:1 row ratio ($T_4$).

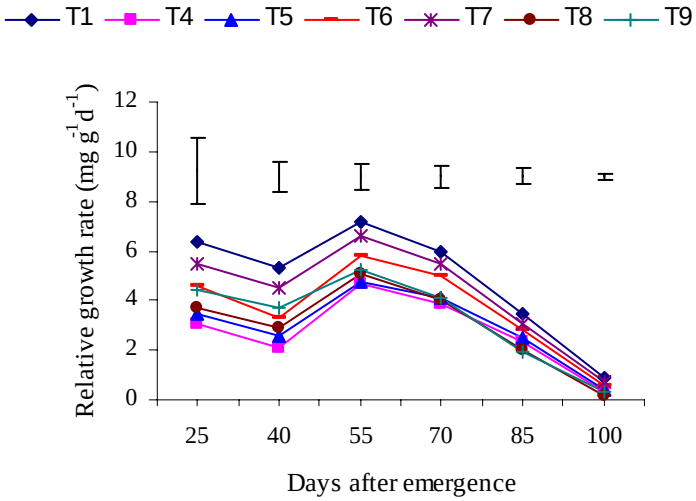


Fig. 7. Relative growth rate in wheat at different days after emergence as influenced by intercropping with lentil and chickpea at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

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

***Relative growth rate in lentil***

Relative growth rate (RGR) in lentil was influenced by the cropping system and the planting configurations when intercropped with wheat (Fig. 8). From 40 DAE onwards the rate of RGR decreased with the advancement of plant age. During the whole growth period the RGR of lentil grown under sole cropping system maintained the superior level. Under the intercropped condition the RGR in lentil at 3:1 row ratio ($T_8$) also maintained a superior level similar to that in wheat - lentil at 2:2 row ratios ($T_6$). The lowest level of RGR in lentil was maintained in wheat - lentil intercropping at 1:1 row ratio ($T_4$).

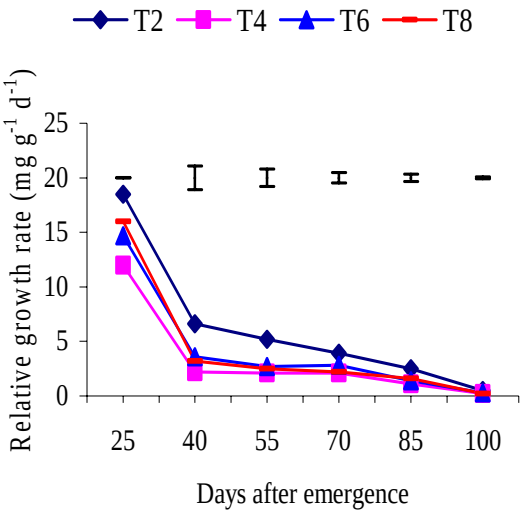


Fig. 8. Relative growth rate in lentil at different days after emergence as influenced by intercropping with wheat at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

$T_2$ = Sole lentil, $T_4$ = Wheat - lentil (1:1) $T_6$ = Wheat - lentil (2:2), $T_8$ = Wheat - lentil (3:1)

***Relative growth rate in chickpea***

The relative growth rate (CGR) of chickpea was influenced by the variation in cropping system and the planting configurations under different intercropping systems (Fig. 9). The RGR in chickpea both in sole crop and different intercropping treatments maintained almost similar pattern of decrease from the 40 DAE to the later stages of growth. The RGR in sole cropping system ($T_3$) was found superior to that in the other intercropping treatments. Among the intercropping treatments, the RGR in chickpea in wheat - chickpea at 2:2 row ratios ($T_7$) showed the maximum rate of RGR throughout the whole growth period. The RGR in chickpea in wheat - chickpea intercropping at 3:1 row ratio ($T_9$) was close to that in $T_7$. The lowest rate of RGR was recorded in wheat - chickpea 1:1 at row ratio ($T_5$).

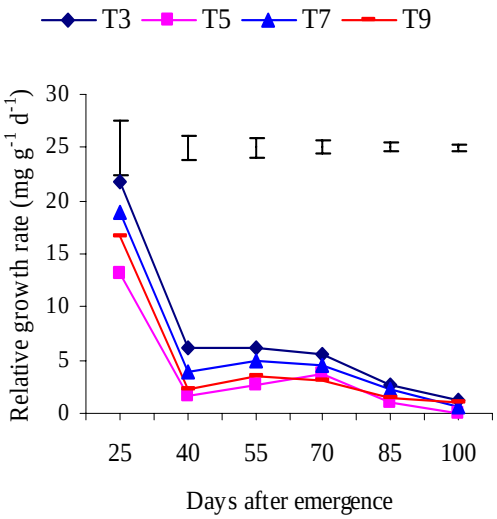


Fig. 9. Relative growth rate in chickpea at different days after emergence as influenced by intercropping with wheat at different row ratios. Vertical bars indicate LSD $_{(0.05)}$

$T_3$ = Sole chickpea), $T_5$ = Wheat - chickpea (1:1), $T_7$ = Wheat - chickpea (2:2), $T_9$ = Wheat - chickpea (3:1)

## CONCLUSION

Planting configurations significantly influenced the yield in component crops. In the intercropping system yield in main crop should be the best consideration for the producer. So the equivalent yield of the main crop under consideration is one of the vital points to be considered during the selection of component crops under intercropping system. Considering the findings of this experiment in case of wheat-lentil inter cropping system 1:1 row ratio should be maintained to get highest wheat equivalent yield but to get the highest chickpea equivalent yield 2:2 row ratio should be maintained in wheat- chickpea intercropping system.

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