ABSTRACT. Intercropping is considered for increasing and stability of yield per average unit. In order to evaluate the effect of barley/chickpea intercrop, a study was carried out in the research field of Faculty of Agriculture, Maragheh University, in 2009 as randomized complete block design, with three replicates, with row replacement series. Treatments included different combinations (1:1, 2:1, 3:1, 2:2 and 3:2 row ratios of barley:chickpea) and their monocultures. Results indicated that the highest yield was obtained from combination of one row barley and one row Desi chickpea. The highest number of pods was obtained, also, in combination of one row barley and one row Desi chickpea. There was a significant difference among treatments including Desi chickpea and Kabuli chickpea 100-grain weight that its Kabuli chickpea was more. The correlation coefficient analysis indicated that number of pods per plot had the highest positive relationship and protein percentage had the highest negative relationship with yield per plot. The path coefficient analysis showed that the number of pods had the highest direct effect on yield percentage via the number of pods.

Key words: Intercrop combination; Barley/Chickpea intercrop; Correlation coefficient; Path analysis.

INTRODUCTION

Intercropping is an old cropping practice, possibly as old as the settled agriculture, and is widespread especially in low-input cropping systems. One of the most popular intercropping practices is the cultivation of mixtures of certain annual legumes with cereals (Yolcu et al., 2009a, 2009b; Lithourgidis et al., 2011). Intercropping can provide numerous benefits to cropping systems through increasing total yield and land use efficiency (Dhima et al., 2007); improving yield stability of cropping systems (Lithourgidis et al.,...
2006); enhancing light, water, and nutrient use (Lithourgidis et al., 2007); improving soil conservation (Anil et al., 1998) and controlling weeds, insects, or diseases (Vasilakoglou et al., 2008). Moreover, intercropping can facilitate mechanical harvest, whereas legumes in mixtures with cereals can improve the quality of forage (Javanmard et al., 2009; Contreras - Govea et al., 2009). If a legume is grown in association with another crop, commonly a cereal, the N nutrition of the associated crop may be improved by direct N transfer from the legume to the cereal (Maangi et al., 2001). Therefore, productivity, normally, is potentially enhanced by the inclusion of a legume in the cropping system. Chickpea (Cicer arietinum L.) has an important role in feeding humanity. Amongst the annual seed crops it ranks 14th in terms of area and 16th in production. According to Food and Agriculture Organization (FAO) statistics for 1996-2005, the chickpea area averaged nearly 11 million hectares world wide (1.2% of total crop area) and production was slightly more than 8 millions tonnes (0.34%). However, amongst pulse crops, chickpea has consistently maintained a much more significant status, ranking second in area (15.3% of total) and third in production (14.6%). Chickpea provides a high quality protein, mainly, to the people in developing countries and it can play a key role to alleviate protein-energy malnutrition (Manjunatha, 2007). Also, barley (Hordeum vulgare L.) is one of the major crops in the world for both food and feed. Traditionally, these species are grown as sole crops. Monocultures often can not fully utilize available space and resources (soil resources and light), but two species, intercropped together, can use space and resources more efficiently where they occupy different niches. When the niches are similar, species compete intensity for resources. However, environmental changes made by one species may provide benefits to the associated species, for example by N fixation, and these are referred to as facilitation interactions (Vandermeer, 1989). Intercropping of barley and chickpea improves use of plant growth resources complementary, i.e. species do not compete precisely for the same niches (Hauggaard-Nielsen et al., 2009). Sharma et al. (1993) reported high returns when chickpea, pea or French bean were intercropped with spring-planted sugarcane in Madhya Pradesh, India. In Karnataka, the yield of chickpea intercropped with safflower was similar to that of sole-crop chickpea (Hiremath et al., 1991). Chickpea/safflower row ratios of 2:1, 3:1 and 3:2 gave the highest total yields. In Madhya Pradesh, Thakur et al. (2000) demonstrated that chickpea + safflower intercropping in 3:1 and 6:2 row ratios was superior to pure stands of either crop components and to chickpea + mustard and chickpea + linseed. Chickpea yield was adversely affected by intercropping with Indian mustard, barley and linseed in New Delhi (Ahlawat et al., 2005). Chickpea
yield increased as the proportion of chickpea in the mixture increased from 2:1 to 4:1. Sole Indian mustard productivity, as measured in chickpea-equivalent yield (CEY), was highest, followed by chickpea + Indian mustard (2:1). Chickpea + linseed and sole chickpea recorded similar CEY. The recommended intercropping systems based on relative crowding coefficient were chickpea + barley in all row proportions and chickpea + linseed in 3:1 and 4:1 row proportions. Chickpea + mustard in 4:1 row proportion gave the highest net return over a 2-year period in Faizabad, India (Singh and Yadav, 1992). Chickpea as sole crop or mixed (1:1) with barley, mustard or wheat was the least profitable. Mandal et al. (1986) found that wheat + chickpea intercropping was most efficient with one irrigation application in terms of land-equivalent ratio, relative crowding coefficient and economic return. Banik et al. (2006) concluded that intercropping wheat and chickpea increase total productivity per unit area, improve land use efficiency and suppress weeds, a menacing pest in crop production. Hauggaard-Nielsen et al. (2009) showed that, pea + barley intercropping is a relevant cropping strategy to adopt when trying to optimize N₂ fixation inputs to the cropping system. Ghaley et al. (2005), in intercropping of wheat and pea, concluded that, intercropping increased total dry matter (DM) and N yield, grain DM and N yield, grain N concentration, the proportion of N derived from symbiotic N₂ fixation, and soil N accumulation. The aim of this work was to assess the effect of intercropping barley + chickpea on yield and yield components of chickpea.

**MATERIALS AND METHODS**

Field experiment was conducted at the Experimental Field of the Faculty of Agriculture (latitude 37°23’N, longitude 46°16’E, altitude 1485 m), University of Maragheh, Maragheh, Iran, in 2008-2009 growing season. Composite soil samples for each block were taken before planting from 0 to 30 cm deep for chemical analysis of pH, organic matter, available P and N and texture (clay, silt and sand). Soil texture was sandy-loam, with pH 7.54 and 0.32% organic matter. The seedbed was well prepared through two perpendicular plowing and removing residual of the previous crop and weeds. Prior to planting, seeds were treated with benomyle at 0.2% (wt/wt) in order to protect them from soil-borne pathogens. The planting date was 20th April. The density for barley and chickpea were 350 and 60 seeds/m², respectively. Two cultivar of chickpea (Desi and Kabuli) were used in this study. The experimental design was a randomized complete block with 13 treatments and three replicates. The treatments included monoculture of chickpea (Desi and Kabuli) and barley as well as ten combinations (1:1, 2:1, 3:1, 2:2 and 3:2 row ratios of barley:chickpea) of barley-chickpea intercropping. The placement series was used for intercropping. The experimental plots size for monoculture and intercropping treatments was 2.4 m×4 m. The row spacing was 20 cm and spacing between blocks was 2 m. Treatments were separated by a 1 m buffer zone. At the
harvest, six middle rows were harvested for both sole and intercropping barley and chickpea plots. At harvest time, 10 plants of chickpea were harvested randomly and used for determination of yield and yield components, including number of pod per plant, 100-seed weight and number of grain in each pods. Grain yield was determined by total seed mass after threshing. The path analysis was used to partition the simple correlation into direct and indirect effects, which influence yield, taking the yield as effect and all the other components as the possible causes. Data were analyzed with and Duncan’s multiple test applied for mean comparisons.

RESULTS AND DISCUSSION

Grain yield of chickpea

The results of analysis of variance for chickpea traits as RCB design are referred to in Table 1. The effect of planting pattern was significant on grain yield of chickpea, number of pods and 100-grain weight. Maximum grain yield (122.16 g/m²) was obtained from the treatment of one row of barley and one row of Desi chickpea, compared with other treatments, especially 2:1 barley-Kabuli chickpea ratio and 1:1 barley-Kabuli chickpea ratio, as reflected in Fig. 1. From the intercropping treatment 1B:1DC was obtained amount 109 unit, more higher yield compared with sole cropping Desi chickpea. In present experiment, treatment 1B:1DC was preferable to 1B:1KC ratio, with mean comparison 122.16 (g/m²) and 46.51 (g/m²), respectively; on the other hand, the best combination respect to grain yield for chickpea was 1B:1DC ratio. Different genotypes behave differently under different cropping systems and may also vary in their ability to compete with barley for growth resources in addition to the shading effect (Thobatsi, 2009). Chemeda (1997) also, found that different bean genotypes differ in their grain yield. The reduction chickpea yield in some of intercropping treatments, due to reduced interception and transmission of light in the lower canopy, resulting in etiolated growth and poor pod setting (Ali, 1993). This probably resulted in the abscession of flowers, therefore, reducing yield. Ali (1993) concluded that chickpea was completely overshadowed by wheat in the 3:1 row ratio arrangement and, consequently, the light transmission at its lower canopy was only 7% of the total intercepted light. Yield reduction under intercropping could be associated with the competition effect by component crops for nutrients, moister and space (Adeniyan et al., 2007). Carr et al. (1998) reported that intercropping reduced grain yield of lentil (Lens culinaris Medik.) by 87 to 95%. Similar results were also found by Chemeda (1997) with maize-bean intercropping and Thawala and Ossom (2004) with maize-groundnut intercropping. Jandaghi (2005) concluded that the highest yield obtained from chickpea monoculture followed by barley-chickpea (1B:1C) intercropping. The chickpea grain yield increased with increasing rows of barley and this position was higher.
EVALUATION OF CHICKPEA / BARLEY INTERCROPPING

in Desi chickpea than Kabuli chickpea. Also, Daryaei et al. (2009) reported that, in intercropping, the lowest forage yield of chickpea related to 2B:1C ratio about 95% lower than sole cropped chickpea. Mostly, grain yield in pulse influence by number of pods and number of seed in pod. In present study, number of pods was significant, thereby it has been affected on grain yield.

Table 1 - Analysis of variance of barley - chickpea intercropping for all traits under study

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean squares</th>
<th>Grain yield</th>
<th>Number of pod</th>
<th>100-Grain weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replicate</td>
<td>2</td>
<td>1696/93</td>
<td>178/748</td>
<td>1/999</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>11</td>
<td>1580/91*</td>
<td>35/084*</td>
<td>66/1878**</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>22</td>
<td>819/98</td>
<td>16/921</td>
<td>3/9677</td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td>37/47</td>
<td>24/55</td>
<td>9/88</td>
<td></td>
</tr>
</tbody>
</table>

*and ** Significant at the 0.05 and 0.01 probability level, respectively.

Treatments:
1. Sole Desi Chickpea
2. 1:1 (Barley:Desi Chickpea)
3. 2B:1 DC row ratio
4. 3B:1DC
5. 2B:2DC
6. 3B:2DC
7. Sole Kabuli Chickpea
8. 1B:1KC
9. 2B:1KC
10. 3B:1KC
11. 2B:2KC
12. 3B:2KC

Figure 1 - Grain yield (g/m²) chickpea under different cropping systems. Values with the same letter were not significantly different.

Number of pods in chickpea
As appeared in Fig. 2, comparison mean indicated that the highest number of pods related to 1B:1DC row ratio. The other treatments placed in a same level. The number of pods decreased with increasing rows in barley. The lowest number of pods (10.06) observed in intercropping 2B:1KC row ratio. As likely intercropped combination one by one barley and Desi chickpea could be made the best canopy structure. Ndakidemi and Dakora (2007) reported a reduction in cowpea number of pods per plant under intercropping, compared to sole cropping. Because of positive
correlated yield with number of pods, it seems that decreasing of number of pods causes yield reduction; due to enhancing interspecific competitive between crops for utilization of available resource in intercropping. Gardiner and Craker (1979), in their study about intercropping corn/bean, reported that yield reduction of bean was been due to decreasing in number of pods. Also, Tuna and Orak (2007) observed increasing number of pods because of raising to ratio of bean-mongo in intercropping oat/bean-mongo.

**Figure 2 - Number of pod (number/plant) chickpea under different cropping systems.** Values with the same letter were not significantly different.

**Figure 3 - 100-grain weight (g) chickpea under different cropping systems.** Values with the same letter were not significantly different.

**Treatments:**
1. Sole Desi Chickpea
2. 1:1 (Barley:Desi Chickpea)
3. 2B:1 DC row ratio
4. 3B:1DC
5. 2B:2DC
6. 3B:2DC
7. Sole Kabuli Chickpea
8. 1B:1KC
9. 2B:1KC
10. 3B:1KC
11. 2B:2KC
12. 3B:2KC
100-Grain weight of chickpea

The effect of planting pattern was significant on 100-grain weight (p<0.01). Compared mean in Fig. 3 showed that 100-grain weight had no significant difference between pure stand Desi chickpea and intercropped with barley, but in contrast to sole cropped Kabuli chickpea and it’s the others intercropped treatments had a significant difference and it was lower. The 100-grain weight of Kabuli chickpea in combination 3B:2KC was lower than sole cropped and its others combinations. As likely, in this population ratio, plants shading resulted in reduction of photosynthetic materials and thus cause of decreasing in 100-grain weight. A significant difference observed between 100-grain weight of Desi chickpea and Kabuli chickpea which could be due to genotype difference of two plants so it influenced by environment less. Kabuli chickpea produces grains weight more than 26 g and Desi chickpea is producer of grains less than 26 g (Hashemi Dezfoli et al., 1995). Hansen and Shibles (1978) has noticed that differences in number of pods and 100-grain weight influence by environment less, but controlled genetically. Chemeda (1997) did not find any significant difference between sole and intercropped beans on 100 grain mass but there were differences among different genotypes. Also, Lesoing and Francis (1999) reported a direct relationship between 100-grain weight and number of pods with yield.

Path analysis of yield in chickpea

Correlation coefficient

The results of the simple correlation between grain yield and yield components of chickpea is presented in Table 2. The grain yield per plant exhibited a significant positive correlation with grain yield and the number of pods. Similar observations were reported by Sing et al. (1982) and Musaana (1979), on cowpea, and S'Ozdemir (1996), on chickpea. These results suggested that any positive increase in such traits will accelerate GY per plant.

Table 2 - Simple correlation coefficients of traits in chickpea

<table>
<thead>
<tr>
<th>Variable</th>
<th>NP</th>
<th>NB</th>
<th>PL</th>
<th>100GW</th>
<th>PP</th>
<th>BY</th>
<th>HI</th>
<th>PY</th>
</tr>
</thead>
<tbody>
<tr>
<td>GY</td>
<td>0.588</td>
<td>-0.159</td>
<td>-0.237</td>
<td>-0.297</td>
<td>-0.445</td>
<td>0.724</td>
<td>0.684</td>
<td>0.956</td>
</tr>
<tr>
<td>PY</td>
<td>0.493</td>
<td>-0.106</td>
<td>-0.007</td>
<td>-0.071</td>
<td>-0.185</td>
<td>0.725</td>
<td>0.603</td>
<td></td>
</tr>
<tr>
<td>HI</td>
<td>0.392</td>
<td>-0.327</td>
<td>-0.515</td>
<td>-0.386</td>
<td>-0.623</td>
<td>0.081</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BY</td>
<td>0.566*</td>
<td>-0.068</td>
<td>0.031</td>
<td>-0.053</td>
<td>-0.147</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>-0.489</td>
<td>0.342</td>
<td>0.838</td>
<td>0.800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100GW</td>
<td>-0.328</td>
<td>0.323</td>
<td>0.765</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>-0.274</td>
<td>0.323</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NB</td>
<td>-0.016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*and ** Significant at the 0.05 and 0.01 probability level, respectively.

NP= Number of pods/plant (number/plant), NB= Number of branch/plant (number/plant), PL= Plant length (cm), 100 GW=100-grain weight (g), PP= Protein percentage (%), BY= Biological yield (g/m²), HI= Harvest index (%), PY= Protein yield (%), GY= Grain yield (g/m²).
Significant and negative relationship was found between GY and PP, whereas positive relationships were found between GY and NP, GY and BY, GY and HI, GY and PY. The high positive correlation between GY and NP indicated that number of pods contribute to yield. However, there was a negative correlation between protein percentage and yield.

The main purpose of breeders is increase in chickpea yield. Yield and its components are multigenic traits, which are strongly influenced by the environment and other factors both known and yet to be identified (Yücel et al., 2006). To this end, emphasis should be given to the development of intercropped chickpea with suitable plant to raise complementarity and thus to improve yield.

Path coefficient analysis

In order to determine the relationships between yield and the other examined traits, path correlation coefficients were calculated. The path coefficients were partitioned into direct and indirect effects by using grain yield as a dependent variable. Direct and indirect effects are given in Table 3.

The path coefficient analysis based on grain yield as a dependent variable revealed that number of pods exhibited positive direct effect. Compared to the simple correlation analysis, path analysis chickpea yield and its components demonstrated that the number of pods exerted the highest direct influence but it had a negative and small indirect effect, via 100-grain weight and protein percentage, with 0.48 , -0.025% and -0.133%, respectively. Finally, correlation and path coefficient analysis indicated that the number of pods was the major contributor to yield. Hence it could be exploited more confidently for crop improvement. Conversely, protein percentage had a negative and great effect on yield, which via negative indirect effect of the number of pods emphasized, then had a negative effect on yield.

This study suggests that a good selection for yield improvement should be based on number of pods in chickpea.

Table 3 - The direct, indirect and % contribution of various traits to grain yield per plant in chickpea

<table>
<thead>
<tr>
<th>Variable</th>
<th>NP</th>
<th>100 GW</th>
<th>PP</th>
<th>Correlation coefficients with yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP</td>
<td>0.480</td>
<td>-0.025</td>
<td>0.133</td>
<td>0.588**</td>
</tr>
<tr>
<td>100 GW</td>
<td>-0.157</td>
<td>0.079</td>
<td>-0.218</td>
<td>-0.297*</td>
</tr>
<tr>
<td>PP</td>
<td>-0.234</td>
<td>0.063</td>
<td>-0.273</td>
<td>-0.445**</td>
</tr>
</tbody>
</table>

**Significant at the 0.01 probability level.
CONCLUSIONS

The chickpea and barley were found to be advantageous increasing grain yield in chickpea. According to the data obtained from this research, the best results in terms of grain yield were taken from 1B:1DC row ratio. Also the results of the simple correlation between grain yield and yield components of chickpea is showed that the grain yield exhibited a significant positive correlation with the number of pods. Hence it could be exploited more confidently for crop improvement.

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