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EVALUATION OF YIELD AND YIELD COMPONENTS CHICKPEA (*CICER ARIETINUM* L.) IN INTERCROPPING WITH SPRING BARLEY (*HORDEUM VULGARE* L.)

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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 compelet 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 - inputcropping systems. One of the most popular intercropping practicesis 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.,*

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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 (Maingi *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 word 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 cropor 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 pestin crop production. Hauggaard-Nielsen *et al.* (2009) showed that, pea + barley intercropping is a relevant cropping strategy to adopt when trying to optimize N_2 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 N_2 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 seed-bed 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 20thApril. The density for barley and chickpea were 350 and 60 seeds/m^2, respectively. Two cultivar of chickpea (Desi and Kabuli) were used in this study. The experimental design was a randomized complete block with 13 treatmeants and three replicates. The treatmeants 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 treatmeants was 2.4 m×4 m. The row spacing was 20 cm and spacing between blocks was 2 m. Treatmeants 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

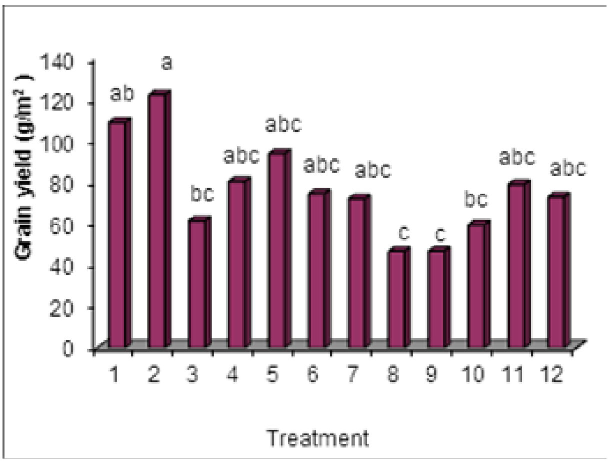
Grain yield of chickpea

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/m^2) 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/m^2) and 46.51 (g/m^2), 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 abscission 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 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

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

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



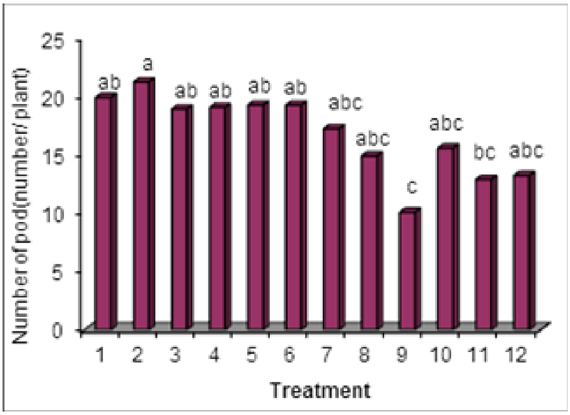
Treatments:

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/m^2) 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) mobserved increasing number of pods because of raising to ratio of bean-mongo in intercropping oat/bean-mongo.



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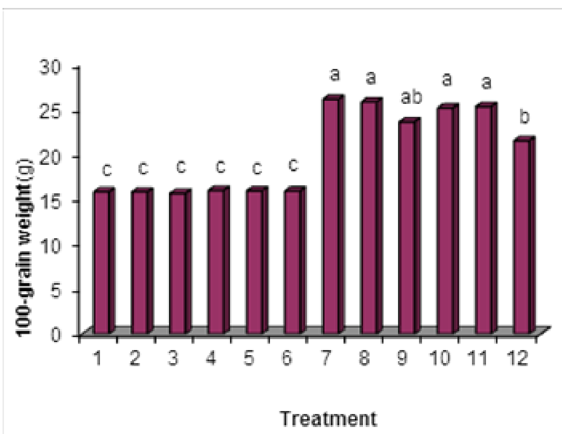
7. Sole Kabuli Chickpea
8. 1B:1KC
9. 2B:1KC
10. 3B:1KC
11. 2B:2KC
12. 3B:2KC

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



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8. 1B:1KC
9. 2B:1KC
10. 3B:1KC
11. 2B:2KC
12. 3B:2KC

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

100-Grain weight of chickpea

The effect of planting pattern was significant on 100-grain weight ($p<0.01$). Compaired 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

Variable	NP	NB	PL	100GW	PP	BY	HI	PY
GY	0.588**	-0.159	-0.237	-0.297	-0.445**	0.724**	0.684**	0.956**
PY	0.493**	-0.106	-0.007	-0.071	-0.185	0.725**	0.603**	
HI	0.392*	-0.327	-0.515**	-0.386*	-0.623**	0.081		
BY	0.566**	-0.068	0.031	-0/053	-0.147			
PP	-0.489**	0.342*	0.838**	0.800**				
100GW	-0.328*	0.323	0.765**					
PL	-0.274	0.323						
NB	-0.016							

*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/m^2), HI= Harvest index (%), PY= Protein yield (%), GY= Grain yield (g/m^2).

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

Variable	NP	100 GW	PP	Correlation coefficients with yield
NP	0.480	-0.025	0.133	0.588**
100 GW	-0.157	0.079	-0.218	-0.297
PP	-0.234	0.063	-0.273	-0.445**

**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.

REFERENCES

Adeniyan O.N., Akendes S.R., Balongun M.O., Saka J.O., 2007 - Evaluation of crop yield of African yam bean, maize and kenaf under intercropping systems. American-Eurasian J, Agic, Environ, Sci, 1:99-102.

Ahlawat I.P.S., Gangaiah B., Ompal S., 2005 - Production potential of chickpea (*Cicer arietinum*) based intercropping systems under irrigated conditions. Indian Journal of Agronomy 50(1): 27–30.

Ali M., 1993 - Wheat-chickpea intercropping under late sown condition. Journal of Agricultural Science Cambridge 121: 141-144.

Anil J.P., Phipps R.H., Miller F.A., 1998 - Temperate intercropping of cereals for forage: Review of potential for growth and utilization with particular reference to the UK. Grass and Forage Sci. 53: 301-317.

Banik P., Midya A., Sarkar B.K., Ghose S.S., 2006 - Wheat and chickpea intercropping systems in on additive experiment: Advantages and weed smothering. European Journal of Agronomy 24: 325-332.

Carr P., Martin G.B., Caton J.S., Poland W.W., 1998 - Forage and nitrogen yield of barley - pea and oat - pea intercrops. Agron. J. 90:79-84.

Chemeda F., 1997 - Effects of planting pattern, relative planting date and intra-row spacing on haricot bean/maize intercrop. African Crop Sci. J 5:15-22.

Contreras-Govea F.E., Muck R.E., Armstrong K.L., Albrecht K.A., 2009 - Nutritive value of corn silage in mixture with climbing beans. Anim. Feed. Sci. Tech.150: 1-8.

Daryaei F., Chaichi M.R., Aga Alikhani M., 2009 - Forage yield and quality in chickpea/barley intercropping. Journal of Agricultural Science 2:11-19.

Dhima K.V., Lithourgidis A.S., Vasilakoglou I.B., Dordas C.A., 2007 - Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crops Res. 100: 249-256.

Gardiner T.R., Craker L.E., 1979 - Development and light interception in a bean-maize intercropping. Agronomy Abstract. 102.

Ghaley B.B., Hauggaard-Nielsen H., Høgh-Jensen H., Jensen E.S., 2005 - Intercropping of wheat and pea as influenced by nitrogen fertilization. Nutr. Cycl. Agroecosyst. 73: 201–212.

Hashemi Dezfoli A., Koocheki A., Banayan Aval M., 1995 - Maximizing crop yields. Jahad Mashad University, 286 p.

Hansen W.R., Shibles R.M., 1978 - Seasonal log of flowering and podding activity of yield - grown soybean. Agronomy Journal. 70:47-50.

Hauggaard-Nielsen H., Gooding M., Ambus P., Corre-Hellou G., Crozat Y., Dahlmann C., Dibet A., Vonfragstein P., Prister A., Monti M., Jensen E.S., 2009 - Pea-barley intercropping for efficient symbiotic

N2-fixation, soil N acquisition and use of other nutrients in European organic cropping systems. Field Crops Res. 113: 67-71.

Hiremath S.M., Hosmani M.M., Chittapur B.M., 1991 - Performance of safflower (*Carthamus tinctorius*) + chickpea (*Cicer arietinum*) intercropping systems. Indian Journal of Agronomy 36(3), 407-409.

Jandaghi R., 2005 - Evaluation of water stress effect on forage and seed yield in chickpea - barley intercropping system. MSc Thesis in agronomy, Azad University, Saveh Unit.

Javanmard A., Nasab A.D.M., Javanshir A., Moghaddam M., Janmohammadi H., 2009 - Forage yield and quality in intercropping of maize with different legumes as double cropped. J. Food Agr. Environ. 7:163-166.

Lesoing G.W., Francis A.C., 1999 - Strip intercropping effects on yield and yield components of corn, grain sorghum, and soybean. Agronomy Journal 91:804-813.

Lithourgidis A.S., Vasilakoglou I.B., Dordas C.A., Yiakoulaki, M.D. 2006 - Forage yield and quality of commen vetch mixtures with oat and triticale in two seeding ratios. Field Crop Res. 99: 106-113.

Lithourgidis A.S., Dhima K.V., Vasilakoglou I.B., Dordas C.A., Yiakoulaki M.D., 2007 - Sustainable production of barley and wheat by intercropping common vetch. Agron. Sustain. Dev. 27: 95-99.

Lithourgidis A.S., Dordas C.A., Damalas C.A., Vlachostergios D.N., 2011 - Annual intercrops: an alternative pathway for sustainable agriculture. Australian Journal of Crop Sci 4: 396-410.

Maingi M.J., Shisanya A.C., Gitonga M.N., Hornetz B., 2001 - Nitrogen fixation by common bean (*Phaseolus vulgaris* L.) in pure and mixed stands in semi arid South East Kenya. European J. Agron. 14: 1-12

Manjunatha B.L., 2007 - Physiological basis of seed hardening in chickpea (*Cicer arietinum* L.) MSc. Agriculture University of Agricultural Sciences, Dharwad, 94 p.

Mandal B.K., Dasgupta S., Ray P.K., 1986 - Yield of wheat, mustard and chickpea grown as sole and intercrops with four moisture regimes. Indian Journal of Agricultural Sciences 56(8), 577–583.

Musaana M.S., 1979 - Heritability of and environmental influence on major yield and agronomic characters of pigeon peas. MSc Thesis, Makerere University, Kampala, Uganda.

Ndakidemi P.A., Dakora F.D., 2007 - Yield component of nodulated cowpeas and maize pants grown with exogenous phosphorus in different cropping system. Aus. J. Exp. Agric. 47: 583-589.

Sharma R.K., Bangar K.S., Sharma S.R., Gwal H.B., Verma I.D., 1993 - Studies on intercropping of pulses in spring planted sugarcane. Indian Journal of Pulses Research 6(2), 161–164.

Singh D.K., Yadav D.S., 1992 - Production potential and economics of chickpea (*Cicer arietinum*) -based intercropping systems under rainfed condition. Indian Journal of Agronomy 37(3), 424–429.

Singh R., Joshi B.S., Singh S., 1982 - Correlation studies in cowpea. Tropical Grain Legume Buletin. 26:3-5.

S'Ozdemir A., 1996 - Path coefficient analysis for yield and its components in chickpea. International Chickpea and Pigeon pea. Newsletter 3:19-21.

Thakur N.S., Pannase S.K., Sharma R.S., 2000 - Production potential of gram (*Cicer arietinum*) - based intercropping systems under rainfed condition. Indian Journal of Agronomy 45(3), 534–539.

Thwala M.G., Ossom E.M., 2004 - Legume-maize association influences crop characteristics and yield. 4th International Crop Science Congress. 26 Sep-01 Oct. 2004, Brisbane, Australia.

Thobatsi T., 2009 - Growth and yield responses of maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) in an intercropping system. MSc. Agric. (Agronomy). University of Pretoria.

Tuna C., Orak A., 2007 - The role of intercropping on yield potential of common vetch (*Vicia sativa* L.)/oat (*Avena sativa* L.) cultivated in pure stand and mixture. Journal Agricultural and Biological Science. 2:14-19.

Vandermeer J., 1989 - The ecology of intercropping. Cambridge University Press, Cambridge, UK.

Vasilakoglou I.B., Dhima K.V., Lithourgidis A.S., Eleftherohorinos I., 2008 - Competitive ability of winter cereal - common vetch intercrops against sterile oat. Exp Agri 44:509-520.

Yolcu, H., Dasci M., Tan M., 2009a - Evaluation of annual legumes and barley as sole crops and intercrop in spring frost conditions for animal feeding: I. Yield and quality. J. Anim. Veterin. Adv. 8:1337-1342.

Yolcu, H., Polat M., Aksakal V., 2009b - Morphologic, yield and quality parameters of some annual forages as sole crops and intercropping mixtures in dry conditions for livestock. J. Food Agric. Environ. 7:594-599.

Yücel D.O., Anlarsal A.E., Yücel C., 2006 - Genetic variability, correlation and path analysis of yield, and yield components in chickpea (*Cicer arietinum* L.). Turk J. Agric. For. 30:183-188.