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Effect of Various Combinations of Chickpea/Safflower Intercropping on Chickpea Yield and Yield Components

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Abstract – **An experiment with randomized complete block design including four replications and eight treatments was carried out in investigation field of Ferdowsi university of Mashhad to compare various combinations of safflower and chickpea intercropping. The treatments included A: strip intercropping, B: 100% overlapping, C: 66% overlapping, E: 34% overlapping, F: 83% overlapping, G: 17% overlapping, D: pure chickpea culture, H: pure safflower culture. Evaluation of yield and yield components of chickpea revealed that dry weight of vegetative parts, grain yield, biological yield, grain number per pod and pod number per stand were significantly influenced by the various combinations of cultivation regime, and the highest values for these traits were obtained in strip intercropping. The highest chickpea grain yield as 4600kg/ha was obtained in treatment A (strip intercropping); whereas the lowest grain yield as 1500 kg/ha was observed in the treatment E(34% overlapping). Evaluation of land equivalent ratio indicated that the highest LER (2.46) and the lowest LER (1.34) were achieved in treatment A (strip intercropping) and treatment E (row intercropping with 34% overlapping), respectively. Strip intercropping is recommended if chickpea is the main target of intercropping.**

Keywords – **Chickpea, Land Equivalent Ratio, Strip Intercropping, Safflower.**

I. Introduction

Increased agricultural production throughout the 20th century was due to over consumption of external inputs; however intensified agriculture has brought about some side effects such as soil erosion, environmental pollution by agricultural chemicals and over use of fertilizer, and emergence of chemical resistant pests and weeds. Variation of agronomic system has been proposed as a possible mechanism to eliminate some agricultural problems in modern countries (Khan et al, 2005). In developing countries, intercropping plays a vital role in food production and people life. In these countries, intercropping systems are usually managed traditionally by farmers in small farms (Banik et al, 2006).

Intercropping refers to cultivation of two or more crops planted simultaneously in the same land (Sarker et al, 2000). Intercropping is performed in low input and low fertile soils of tropic regions (Sabaghpour, 2005). Intercropping is preferred to monoculture as a result of superior yield due to better absorption of resources, and this is especially realized when cereals and legumes are planted together (Sachan and Uttam, 1992). Intercropping is carried out in many parts of the world due to its relative advantages including higher stability of yield, higher efficiency of land and labor use, and increase of crop ability to compete with weeds (Klindnt et al, 2007). Improving soil fertility due to increased nitrogen fixation rate by legume component is another advantage of intercropping. Most of the advantages of intercropping are obtained by application of legume species (Manjith et al, 2009). A major benefit of intercropping is increase of production per unit area compared to monoculture which is resulted from improved use of environmental factors such as light, water and soil-contained nutrition (Banik et al, 200).

Chickpea and safflower are two crops with large cultivation area in Iran which are mainly cultivated as monoculture. Investigation show that intercropping of these two crops belonging to Fabaceae and Asteraceae families results in increased crop yield, maximized resource consumption and enhanced productivity of cultivation system (Singh Rajesh, 2010). In this type of culture, cross-species competition is observed, in which two crops interact with each other. This competition involves aerial and subterranean plant organs which plays important role in structure and dynamism of plant populations in agricultural systems (Tiwari et al, 1992). In addition to weed control in intercropping, there are numerous reports on yield increase in this cultivation system. In many cases, intercropping of annual alfalfa (Medicago sp.) and barley has resulted in yield enhancement (Jeyabal and Kuppusway, 2001).

Khan (2005) reported increased biological yield of barley when the crop was intercropped with mung bean (Vigna radiate). reported increased forage yield in intercropping of barley and chickpea (Khan et al, 2005). Kushwaha et al (1987) reported that intercropping of broad bean (Faba vulgaris) and safflower increased total yield and decreased weed biomass (Kushwaha et al, 1987). Results reported by Singh and Mahesh (1993) suggest increase of yield in population of corn (Zea mays) and chickpea (Singh and Mahesh, 1993). In an investigation carried out by Mahfouz et al (2004) it was observed that intercropping of maize and chickpea influences many traits such as plant height, fresh weight, dry weight, yield and raw protein. Moreover, maize yield in intercropping with legumes was higher than that obtained in monoculture (Mahfouz and Migawer, 2004).

In most cases, one of the crops planted in intercropping system is a member of Fabaceae (legumes) family (Sabaghpour et al, 2005). Legumes occupy special place in intercropping due to their nitrogen fixation ability and chickpea is a legume that is widely cultivated in semi-arid regions. Chickpea (*Cicer aritinum* L.) is one of the major three legumes in west Asia and north Africa (Sabaghpour et al, 2005). Based on the statistics reported by Food and Agriculture organization (FAO), chickpea produce eight million tons of global legume production with cultivated area as 10.1 million hectares (FAO, 2005). Based on the same statistics, chickpea cultivation in Iran is about 700,000 hectares providing the global fourth place for the country after India, Pakistan and Turkey. Chickpea yield in Iran is 480kg/ha in average which is lower than the average global yield (746kg/ha), Asia (766kg/ha) and neighbor countries such as Turkey (915kg/ha) and Iraq (689kg/ha) (FAO, 2005).

Intercropping of oil crops with legumes can promote resource use efficiency compared to monoculture and improve the yield (Singh Rajesh et al, 2010). Among the crops, legumes have great ability in adaptation to cultivation pattern and can improve production capacity (Banik et al, 2006). Mahfouz and Migawer (2004) reported that intercropping of canola with chickpea has significant effect on yield components such as plant height, pod number, grain weight, biological yield and grain yield; planting ration of 75:25 (chickpea: canola) resulted in the highest yield and the highest LER (1.05).

Considering the importance of interaction and cross-species competition in intercropping, the present investigation was conducted to evaluate chickpea-safflower competition ability and to investigate yield and yield components in various combinations of intercropping.

II. Material and Methods

The experiment was carried out in investigational farm of faculty of agriculture of Ferdowsi University of Mashhad with latitude as northern 36° and 16’, and longitude of eastern 59° and 36’, and altitude of 985m above sea surface. The soil was of silt loam type. Average annual precipitation of Mashhad is 286mm and the maximum and minimum annual absolute temperature was 34°C and -27.8°C; respectively. According to Ambroget method, Mashhad climate is dry and cold. Before initiation of the investigation, four soil samples were prepared from 20cm depth and transferred to laboratory for determining physical and chemical properties of the farm soil. The soil had silt loam texture and the results of chemical analysis of the soil are presented in table1.

Table 1: Result of soil analysis in mashhad Ferdowsi University (2009-2010)

PH	EC (ds/m)	T.N.V %	N%	P (mg/kg)	K (mg/kg)	OC %
7/74	0/96	15	0/042	28	250	0/38

The experiment was carried out in the form of randomized complete blocks with four replications and eight treatments (including various arrangements of safflower and chickpea intercropping and monocultures of the two crops). The goal of the present study was a wide range of safflower/chickpea intercropping based on species ration and various arrangements including A: strip intercropping, B: 100% overlapping, C: 66% overlapping, E: 34% overlapping, F: 83% overlapping, G: 17% overlapping, D: chickpea monoculture, H: safflower monoculture.

The space between the plants on culture rows was 10cm, the rows were separated from each other with 50cm, 1m distance between the blocks, inter-plot space was 0.5m, margin:1m, and density of both species in all treatments was 20 plant per square meter.

Safflower and chickpea were sown on 20th Esfand of 1389 as dry farming. Culture depth in monoculture and intercropping was 10cm for both of the seeds. The length and width of each plot were 6m and 4m; respectively. Distance between plots and the space between the blocks were 0.5m and 1m; respectively. Culture lines were separated from each other by 0.5m, and the distance between the plants on culture line was 10cm. in the time of soil preparation, 200kg/ha of super ammonium phosphate fertilizer and 150k/ha urea fertilizer were applied. The first irrigation was performed one day after culture and the practice was repeated each 10 days. Irrigation was conducted by siphon. 40kg/ha of chickpea seed and 25kg/ha of safflower seed was applied in this experiment and thinning was carried out for chickpea at 4-leaf stage and for safflower at 2-leaf stage to obtain the desired density which was 20 plant per square meter for both of the crops. After full establishment, weeding was carried out in two steps including the first step approximately 35 days after sowing, and the second approximately 70 days after culture via hand weeding. Sampling for calculation of dry weight and leaf area index was performed from one square meter area with 15-day intervals. At the end of growth season to determine final yield of safflower and chickpea, chickpea was harvested on 5/4/90 except for treatment E which was harvested on 24/3/90; safflower was harvested in all treatments on 18/4/90.

Destructive sampling method was used to calculate growth indices in which, half of each plot was devoted to sampling. Sampling place of each plot was randomly selected meaning that a 25cmx25cm quadrate applied and the plants located within this area were harvested and transferred to laboratory.

Data obtained from sampling during and at the end of growth season were analyzed for dry matter, yield and yield components (grain, pod number, head number, and weight of 100 grains) and the mean values were compared using Duncan method. Probability level in all analyses was 5%. Data were analyzed using MSTAT-C software and the graphs were drawn by EXCEL software. Land equilibrium ratio index was used to compare various treatments regarding efficiency. Land equilibrium ration was estimated using the following formula:

$$LER = \sum_{0} \left(Y_I / Y" \right)$$

In which, Y stands for yield of a species (in area unit) in intercropping, and Y” denotes the yield of the same species (in area unit) in monoculture.

III. Results and Discussion

3.1. Grain number per plant

Mean comparison of grain number per chickpea plant indicated significant difference among the treatments, so that the highest number of grain was obtained in treatment

A (strip intercropping) with 25 grains per plant and the lowest number was achieved in treatment F (34% overlapping) with 11 grains per plant (table2).

Response of monoculture was similar to that of strip intercropping regarding this trait. It has been reported that reduction of soybean yield in intercropping was due to lower number of pod per plant and lower number of seeds per pod (Sarker et al, 2000). Tahir et al (2003) reported that by identical density of soybean in intercropping with sorghum, grain number in unit area was reduced compared to monoculture. Moreover, a positive and significant correlation was observed between grain number per unit area and grain yield. Manjiteh et al (2009) reported that pod number of bean in monoculture was higher than that of intercropping arrangement.

3.2. Pod number per plant

Pod number per plant is a component of chickpea yield which was influenced by various culture combinations. The highest number of pod per plant (11 pod) was observed in treatment A (strip intercropping), while the lowest number (5 pod) was obtained in treatment E (34% overlapping). Similar responses were observed in treatments C, F and regarding this trait with 8 pod per plant (table2).

Kumar et al (1987) observed no significant difference for umbel number per cumin plant in intercropping of cumin and lentil. In an investigation carried out by Zolfaghar et al (2000) on yield and yield components of soybean and sorghum in intercropping, it was observed that sorghum height had no significant influence on soybean grain weight but had effect on grain number per unit area; so that the grain number in soybeans intercropped with high sorghum pants was higher than that observed in soybean pants intercropped with dwarf sorghums. The authors reported that this increased grain number was due to increase in pod number per plant and grain number per pod.

3.3. 100 grain weight

Results showed that 100 grain weight of chickpea was significantly different in various treatments; which varied between 150 to 140gr (tabe2). The highest number of 100 grain weight (150gr) was observed in treatment D (monoculture chickpea) and treatment G (17% overlapping), while the lowest weight (140gr) was obtained in treatment C (68% overlapping)

Investigating soybean intercropping, upasani (1994) reported the highest 100 grain weight of soybean in high density. In higher densities, intra-species is reduced so more photosynthetic products are provided for seed and this procedure results in increase of soybean 100 grain weight. Mazaheri (1998) reported that sorghum 100 grain weight was not significantly different between monoculture and intercropping with soybean, though grain number in intercropping was higher than that of monoculture. Greater reduction of pod weight in row intercropping compared to strip cropping is due to stronger competition on resources such as light, water and nutrition in intercropping which indirectly influences grain number and weight and further reduces these components in row intercropping.

3.4. Grain yield

Mean comparison performed on chickpea grain yield indicated that there was significant difference between treatments A (strip culture) as 4600kg/ha and lowest grain yield was obtained in treatment E (38% overlapping) with 1500kg/ha Grain yield also decreased by reducing the overlap found that treatment of C (68% overlapping) with the 3500 kg/ ha D and F monoculture chickpea and 83% overlap) with a yield of 3000 kg / ha (table2).

Investigating wheat and vetch intercropping, Soetedjo et al (1998) reported no significant difference for grain yield between various intercropping treatments. In a study carried out on yield and yield components of soybean and sorghum intercropping, Mazaheri et al (1998) reported reduction of soybean yield which the authors attributed to lower number of pod number per plant, lower number of grains per pod and reduction of grain weight. The authors concluded that in strip intercropping of maize and soybean, marginal rows had 20-24% increase of maize yield and 10-15% increase of soybean yield. Sachan et al (1992) maintained that improved light absorption in square arrangement is the cause of increased maize yield. Investigating intercropping of maize and soybean, singh et al (2010) found out that the highest grain yield is achieved in moderate density of maize and high density of soybean.

Table 2: Mean comparison of yield and yield components of Safflower- chickpea in intercropping ratios

Planting Ratio	No. of Pod	No. of Grain	1000 Grain weight	Grain Yield ($kg.ha^{-1}$)	Biological Yield ($kg.ha^{-1}$)	Hervest Index ($kg.ha^{-1}$)
A: strip intercropping	11^{a}	25^{a}	145^{a}	4600^{a}	10800^{a}	45^{a}
B: 100% overlapping	8^{ab}	15^{ab}	145^{a}	2000^{ab}	8000^{ab}	30^{a}
C: 66% overlapping	7^{ab}	15^{ab}	140^{a}	3500^{ab}	8000^{ab}	45^{a}
E: 34% overlapping	5^{b}	10^{b}	140^{a}	1500^{b}	4600^{ab}	40^{a}
F: 83% overlapping	7^{ab}	15^{ab}	140^{a}	3000^{ab}	6500^{ab}	40^{a}
G: 17% overlapping	7^{ab}	14^{ab}	150^{a}	2000^{ab}	6500^{b}	40^{a}
D: chickpea monoculture	7^{ab}	15^{ab}	150^{a}	3000^{ab}	8000^{ab}	40^{a}

Means in each column, followed by similar letter(s) are not significantly different 5% probability level using LSD test

3.5. Biological yield

Biological yield any significant difference between treatment A (strip intercropping) and E (34% overlapping) has the highest biological function of treatment A with 10800 kg / ha , and the lowest yield in the treatment E with 4600 kg / ha and treatment of B (100% overlapping), C (68% overlapping) and D (monoculture chickpea) has biological yield of 8000 kg/ ha. Treatment F (83%

overlapping) and G (17% overlapping) with biological yield was 6500 kg/ha (Table 2) .

3.6. Harvest index

Based on the results of testing different treatments showed no significant difference in harvest index and yield 30% to 45 % of the treatments varied (Table 2) .

In a study conducted on barley and bean intercropping, Zolfaghar et al (2000) maintained that light, water and nutrition may be fully absorbed by the plant in intercropping and stored in various organs. This absorption has been attributed to difference in competition ability between economic organs and vegetative organs of the plants in intercropping.

3.7. Land equilibrium ration (LER)

LER values in all intercropping treatments were higher than 1; suggesting superiority of intercropping over monoculture of the two crops. The highest LER value was obtained in strip intercropping and the lowest one was observed in row intercropping with 66% overlapping (C) As can be seen from table 3, it is obvious that partial LER of safflower in strip intercropping and row intercropping with 34% overlapping was higher than 1. Investigating intercropping of cumin and lentil, Kumar et al (1987) reported the highest LER in row intercropping. LER value higher than 1 can be due to greater light consumption efficiency of intercropping compared to monoculture. Increased land equilibrium ratio in intercropping compared to monoculture has been reported by other authors, so that in general, LER of legumes is reduced when they are intercropped with non-legume species (Tahir et al, 2003). Investigating yield and yield components in maize/soybean strip cropping, Mahfouz et al (2004) concluded that LER was increased in intercropping; suggesting advantage of intercropping over monoculture. This is in agreement with the results obtained in the present investigation.

Table 3: LER (Land equilibrium ration) of Safflower-chickpea in intercropping ratios

Planting Ratio	LER (Total)	LER(chickpea)
A: strip intercropping	2.46	1.07^{a}
B: 100% overlapping	1.78	0.97^{b}
C: 66% overlapping	2	0.97^{b}
E: 34% overlapping	1.34	1.14^{a}
F: 83% overlapping	1.77	0.96^{b}
G: 17% overlapping	1.71	0.99^{ab}

Sabaghpour et al (2005) reported that LER was greater than 1 in all patterns of intercropping of maize and bean. In a study conducted on cumin and chickpea intercropping it was observed that partial LER of chickpea was not higher than 1 in any of the treatments and chickpea was not positively affected by intercropping with cumin.

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