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COMPARISON OF ORGANIC AND TRADITIONAL PRODUCTION SYSTEMS IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

Yield and yield components, and protein content of chickpea (*Cicer arietinum* L.) were compared in traditional and organic production systems since organic farming has many advantages on environment, animal and human health over traditional production systems. In the study, organic production system, green manure, farmyard manure and effective microorganisms and their combinations were tested as six treatments. Seed yield and some yield components were found higher in the traditional production system than those of organic production systems. The highest protein content was obtained in green manure and farmyard manure applications. Among the organic production systems, green manure and farmyard manure applications could be strongly recommended for organic chickpea producer since the highest seed yields with 2729 in 2007 and 3838 kg ha^{-1} in 2008 were found in green manure + farmyard manure treatment among the organic production systems.

Keywords: chickpea; farmyard manure; green manure; organic production; traditional production; yield

INTRODUCTION

In modern industrial agriculture, high productivity capacity in plants depends on new productive cultivars, mineral fertilizers, pesticides, growth regulating materials, and some other agronomical practices. Although these inputs have resulted in high yield and production increase, unconscious and uncontrolled usage of them have also caused serious problems concerning human and environmental health such as contamination of the soil and groundwater. Especially pesticides, chemical fertilizers, and hormones disturb the natural balance and human health. Researchers have developed various production techniques to prevent these adverse effects. Several alternative production systems have been developed and organic farming system has been approved and accepted as the a reliable farming model among these systems in many countries (Bettiol et al., 2004). With organic farming, it is possible to produce food of a better quality, healthier, and more nutritious than those of produced with the conventional counterparts (Warman and Haward, 1998). Therefore, in recent years, use of organic food has increased in parallel with the increased interest in the environmental protection and safe foods in the developed countries (Caliskan, 2007).

Generally, yield of crops-grown organically are lower than those of the conventionally grown crops (Warman and Haward, 1998) due to malnutrition of plants and effects of diseases and pests. Accordingly, use of organic manures including green manure, farm yard manure, effective microorganisms (EM) composts derived from various wastes are important factors to maintain and improve soil fertility for a sustainable crop production (Ashiona et al., 2006; Javaid, 2006; Talgre et al., 2012).

Legume crops are grown not only as part of the human diet but also for improving soil fertility. As a legume, chickpea (*Cicer arietinum* L.) is considered as one of the most important grain legumes in the world (Namvar et al., 2011). It is also an important crop in Turkey according to sowing area and production (Sepetoglu et al., 2008; Ozalkan et al., 2010; Cagirgan et al., 2011; Toker et al., 2012). On the basis of FAO statistical database, chickpea production area occupied 446.218 ha and produced 530.634 tons in Turkey in 2010 (FAOSTAT, 2012). Chickpea is a major food legume and an important source of protein in many countries. It is used in crop rotation (Sahin and Gecit, 2006) and has atmospheric nitrogen fixation ability (Jain et al., 1999) and play an important role in the maintenance of soil fertility (Gunes et al. 2006) and also widely used as green manure (Mohammadi et al., 2010a). In addition, it especially could play a key role in organic cropping systems (Mohammadi et al., 2010a). Cereals and grain legumes share a 15.3% of organic agriculture production in Turkey (Caliskan, 2007).

Organic chickpea with production of 3614 t is the second most important legume crop after the lentil in Turkey (Anonymous, 2012a).

The purpose of this study was to evaluate the individual or mixture characteristics of different organic manures such as green manure, farmyard manure and effective microorganism (EM) in organically grown chickpea and also to compare them with traditional grown chickpea.

MATERIALS AND METHODS

Field study and experimental arrangements

A field experiment was conducted at the Mustafa Kemal University, in Hatay (36° 39' N, 36° 40' E; 83 m above sea level) located in the Eastern Mediterranean region of Turkey in the 2006-2007 and the 2007-2008 growing seasons. In the experiment, six organic production systems, which were consisted of the sole and combined usage of green manure (GM), farmyard manure (FYM) and Effective Microorganisms (EM), were compared with a traditional production system in chickpea production. According to organic production system in Turkey (Anonymous, 2012b), the experimental area had not been cultivated for five years before starting this experiment. The FYM was obtained from the experimental farm of the Faculty of Agriculture, Animal Science Department and the application rate of the FYM was 30 tons ha^{-1} which was applied a week before sowing. As green manure, common vetch (*Vicia sativa* L.) was sown and incorporated with soil at the flowering stage in each year. EM solution consisted of mixed culture of beneficial microorganism including a predominant population of lactic acid bacteria (*Lactobacillus* sp.), yeast (*Saccharomyces* sp.) and a small proportion of photosynthetic bacteria (*Rhodopseudomonas* sp.). EM is available in a dormant state and requires activation before application. Activation involved the preparation of a solution containing one part basic EM + 1 part of sugar solution + 20 parts water by volume. The activation was kept away from direct sunlight for 3 days. The activated EM solution was dissolved in water in a ratio of 1:1000 and applied to soil seven days before sowing. During the course of the experiment, foliar applications of activated EM were carried out at V6 and R4 growth stages at a dilution of 1:300. The mineral fertilizers urea and diammonium phosphate (DAP) were used as source of nitrogen (30 kg N ha^{-1}) and phosphorus (60 kg P ha-^{1}), respectively. Half of dose of N and all of the P were distributed and incorporated thoroughly into the soil at sowing. The remaining N was applied at two equal doses at the 6-8 leave and flowering stages. The soil (0-40) was Clayey and some chemical and physical properties of experimental area and FYM were given in Table 1. The field trial was arranged in a Randomized Complete Block Design with three replications. Each plot has 99 m^2 areas (9.9 m x 10 m) and consisted of 66 rows 0.15 m apart. The traditional growing plots were formed nearly 200 m away from organic production plots. Chickpea seeds (cv Cevdetbey 98) were sown on December 19 in 2007 and on December 31 in 2008. The pre-sowing herbicide trifluralin (α,α,α-trifliofo-2,6-dinitro-N,N-dipropyl-p-toluidine) was applied to soil at the rate of 2000 cc ha^{-1} and standard local cultivation practices were applied in the traditional farming system. Synthetic herbicides or insecticides were not used in the organic plots; weeds were controlled by hand during the growing period. The daily climatic data were recorded. Air temperature, humidity and precipitation data of the experimental site were presented in Table 2.

Table 1. Chemical characteristics of soil and farmyard manure used in the experiment

	E.C (mS cm^{-1})	pH	$CaCO_3$ (%)	OM (%)	N (%)	P (mg kg^{-1})	K (mg kg^{-1})
Soil	1.0	7.8	21.7	17.3	0.13	322.8	287.3
FYM	38.5	8.7	39.0	55.0	2.35	5800.0	26000.0

FYM: Farmyard manure; OM: organic matter

Table 2. Monthly rainfall, temperature and relative humidity during the growing period of 2007 and 2008

	Mean Temperature (°C)		Rainfall (mm)		Relative humidity (%)	
	2007	2008	2007	2008	2007	2008
December	8.4	8.6	6.5	210.1	70.8	67.1
January	7.6	5.6	109.4	126.1	70.1	55.8
February	10.6	9.5	198.8	127.9	77.0	59.9
March	13.9	16.5	130.4	109.5	66.4	62.2
April	15.9	14.6	124.2	27.3	64.6	65.2
May	22.6	20.9	32.7	87.2	68.5	68.2
June	25.6	25.9	4.4	21.3	63.5	63.1

Plots were harvested on 27 June in 2007, and on 1 July in 2008. The morphological characteristics such as plant height (cm), first pod height (cm), number of branch per plant, number of pod per plant and harvest index (%) were recorded on twenty plants, selected randomly from each plot before harvest. Then plots were harvested by hand and threshed by using a threshing machine. After harvest, seed yield (kg ha^{-1}) and 100-seed weight (g) were determined for each treatment. Seed protein content was determined using a micro-Kjeldahl digest procedure (AOAC, 2005).

Statistical Analysis

Data obtained for the traits were statistically analyzed using the ANOVA technique for Randomized Complete Block Design according to the general linear model procedure described in the Statistical Analysis System (SAS Institude 1996). The means were compared by the Duncan's multiple range test (Steel and Torrie, 1997).

RESULTS AND DISCUSSION

Yield and yield components

Yield and yield components of chickpea plants grown under conventional and organic production systems based on the two experimental years were given in Tables 3 and 4. The ANOVA results indicated that the year x treatment interactions were significant for all evaluated traits except protein content. Hence the results for each year were presented and discussed separately. The results obtained from the variance analysis indicated that treatments had statistically significant effects on all of studied traits except for plant height, number of branches per plant in 2007 and 100-seed weight in 2008.

Plant height is an important morphological trait for chickpea and it was significantly influenced by the applications of various organic treatments in 2008 (Table 3). The highest plant height was recorded in traditional production system in both years (71.5 and 62.1 cm in 2007 and 2008). Organic production system without any supplement had high plant height (71.2 cm) in 2007, whereas green manure + farmyard manure application and EM application had high plant height mean (55.1 cm) in 2008 (Table 3).

Table 3. The mean values and ANOVA results for plant and yield characteristics of chickpea grown under the traditional and organic production systems in 2007 and 2008

Treatment	Plant height (cm)		First pod height (cm)		Number of branches per plant		Number of pods per plant	
	2007	2008	2007	2008	2007	2008	2007	2008
Traditional	71.5 a	62.1 a	36.0 c	26.7 b	3.5 ab	5.1 a	39.6 b	99.0 a
Organic	71.2 a	52.6 c	38.5 ab	27.2 b	3.3 bc	1.2 c	38.9 b	55.5 e
FYM	69.4 ab	53.9 bc	39.4 a	28.1 ab	3.4 ab	1.3 c	44.7 a	62.2 cd
EM	69.7 ab	55.1 b	35.7 c	29.5 a	3.3 abc	1.6 c	35.5 d	57.9 de
GM	66.7 b	54.4 b	37.4 bc	23.9 c	3.3 bc	4.7 a	36.2 cd	62.5 cd
GM + EM	69.3 ab	54.3 bc	37.4 bc	24.7 c	3.1 c	4.1 b	34.4 d	66.9 c
GM + FYM	67.9 ab	55.1 b	38.1 ab	24.5 c	3.6 a	4.9 a	37.8 bc	89.6 b
Mean	69.4	55.4	37.5	26.4	3.4	3.3	38.2	70.5
LSD (%5)	4.3	1.8	1.7	2.0	0.3	0.6	2.1	5.2
ANOVA								
Treatment MS	8.8ns	29.0**	5.2**	12.9**	0.06ns	9.74**	34.9**	853.4**
T x Year MS	12.60**		10.37**		4.72**		427.71**	
CV (%)	3.5	1.8	2.6	4.2	4.3	10.4	3.1	4.2

FYM: Farmyard manure, GM: Green manure, EM: Effective microorganism, MS: Mean square
*,**: F-test significant at p <0.05, and p <0.01, respectively. ns: not significant.

Mean first pod height was affected by the production systems. However, number of branches per plant was not affected by the production systems in 2007. Farmyard manure application had the highest first pod height with 39.4 cm in 2007, and effective microorganism (EM) application had the highest first pod height with 29.5 cm in 2008. In the 2008 growing season, plant development and branch formation were poor and the average of first pod height was 26.4 cm which was lower than the first pod height (37.5 cm) of the previous year. The highest number of branches per plant was obtained in the traditional production system. Regarding to organic applications, the green manure + farmyard manure combination had the best results for first pod height in both years (3.6 and 4.9 in 2007 and 2008). On the average, number of branches per plant obtained in 2007 was less than that of obtained in 2008. Pod number per plant could be the responsible trait for yield change (Toker and Cagirgan, 2004) under the conventional and organic production systems in the two years of study. In 2008, pod number per plant was higher than that of in 2007 in the traditional system. Pod number per plant seemed to be highly influenced by change in cultural and environmental conditions.

The 100-seed weight and the harvest index of chickpea grown under the traditional and organic production systems are shown in Table 4. One hundred seed was not affected by the production systems in 2008. The average of 100-seed weights were different between 2007 and 2008 growing seasons such as 47.1 g and 46.3 g in 2007 and 2008, respectively. The 100-seed weight was higher for the traditionally grown chickpea than those of organic production systems in 2008. The highest 100-seed weight was obtained from the green manure application in 2007, contrary to the traditional production system in 2008 (Table 4). There were major harvest index differences between production systems. The highest harvest index was obtained in green manure treatments in both years. The highest harvest index value (40.4%) was found in the green manure + farmyard manure combination in the first year. In the second year, the highest harvest index value (41.2%) was obtained from the green manure + farmyard manure application. The GM + EM combination (40.8%) and the traditional model (39.3 %) have followed it. The organic production system without any supplement and sole EM application resulted in the lowest harvest index and followed by sole FYM treatment in both years (Table 4).

Table 4. The mean values and ANOVA results for yield, yield components and protein content of chickpea grown under the traditional and the organic production systems in 2007 and 2008.

Treatment	100-seed weight (g)		Harvest index (%)		Protein content (%)		Seed yield (kg ha^{-1})	
	2007	2008	2007	2008	2007	2008	2007	2008
Traditional	46.8 b	48.1 a	38.3 ab	39.3 b	20.4 d	20.4 cd	2972 a	4002 a
Organic	45.2 c	46.0 ab	28.2 d	29.3 d	20.1 d	20.1 d	1538 f	1830 e
FYM	47.9 ab	46.0 ab	30.0 cd	29.4 d	21.4 b	20.8 bcd	2468 d	2133 d
EM	47.1 ab	46.9 ab	28.6 d	29.3 d	20.6 cd	20.6 bcd	1891 e	1926 e
GM	48.3 a	45.8 b	32.1 c	36.4 c	21.1 bc	21.1 bc	2462 d	2430 c
GM + EM	47.1 ab	45.3 b	37.4 b	40.8 ab	21.5 b	21.4 b	2590 c	2843 b
GM + FYM	47.7 ab	46.0 ab	40.4 a	41.6 a	22.3 a	22.6 a	2729 b	3838 a
Mean	47.1	46.3	33.6	35.1	21.1	21.0	2379	2715
LSD (%5)	1.4	2.2	2.3	2.0	0.7	0.8	12.2	18.2
ANOVA								
Treatment MS	3.1**	2.5 ns	76.3**	97.0**	1.8**	2.1**	7396.9**	23792.5**
T x Year MS	3.28*		4.17*		0.09		440772.10**	
CV (%)	1.6	2.7	3.9	3.2	1.8	2.3	2.9	3.8

FYM: Farmyard manure, GM: Green manure, EM: Effective microorganism, MS: Mean square
*,**: F-test significant at p <0.05, and p <0.01, respectively. ns: not significant.

Seed yields of chickpea grown under the traditional and organic production systems are shown in Table 4. The means of seed yield for the production systems were significantly different. The mean seed yields were 2379 kg ha^{-1} and 2715 kg ha^{-1} in 2007 and 2008, respectively. Generally, seed yields in 2008 were higher than those of in 2007 due to favorable climatic conditions during the second year. In 2007, germination and crop growth were better at the start, but high temperatures were adversely affected during the flowering and pod initiation stages. Furthermore, total rainfall during second year (709.3 mm) was higher than the first year (606.4 mm). Islam (2012) also observed that growth and yield of chickpea were better during the cropping season of higher rainfall due to abundant supply of moisture when crop was grown under rainfed conditions. Chickpea seed yields were higher for the traditional system in both years. The results also showed that the means of seed yield was 2972 and 4002 kg ha^{-1} in the traditional system in 2007 and 2008, respectively. Chemical fertilizers used in the conventional production system caused more yield and yield component in both years. Chemical fertilizers are essential in the traditional agriculture, since they provide essential plant nutrients. Essential plant nutrient elements are considered a prerequisite for the enhanced plant development (Sahin and Gecit, 2006; Rosculete et al., 2010; Namvar et al., 2011). The lowest seed yield was obtained from the organic production system without organic and inorganic fertilizer application in both years (Table 4). In general, chickpea seed yield and yield components were lower in the organic production systems. These results are in agreement with the results of Vadavia et al. (1991) and Rosculete et al. (2010). They reported that seed yield and yield components of chickpea were increased with application of mineral fertilization. The low yields of organic production approach were generally attributed to the differences between organic and traditional production practices, particularly due to crop rotations, methods of controlling weeds and pathogens and fertilization practices. Green and farm yard manures were found to be more effective on crop growth, seed yield and yield components of chickpea. Green manure improves organic materials of soil, enriches soil nitrogen content, and transforms nutrients into the absorbable form, so the seed yield and yield components increases (Fageria, 2007; Mohammadi et al., 2010b). Furthermore, potential benefits of green manure are reduced in nitrate leaching risk and lower fertilizer usage in the succeeding crops. However, influence of green manure might depend on soil, crop, environment to environment, type of green manure crop, and management techniques (Fageria, 2007). Besides, green manure crops are also known to increase soil N and availability of P for the following crop. Astier et al. (2006) studied the effects of two different green manure plants (vetch and oat) on yield of maize. They reported that green manure had a significant effect on maize grain yield, N and P uptakes. Astier et al. (2006) concluded that vetch provided more yield than oat. Furthermore, the application of farm yard manure improves physical conditions of the soil, provides energy for activity of microorganisms, increases nutrient supply and improves the efficiency of macro elements (Ashiono et al., 2006; Khan et al., 2009). Yaduvanshi et al. (2003) reported that the application of N, P, K and their combination with green manure and farmyard manure significantly increased the rice yield. They also resulted in increase of soil N, P, K and organic C, and reduced soil pH. In our study, farmyard manure application was also significantly affected plant growth and seed yield, but the green manure + farmyard manure applications were found to be more effective seed yield and quality in organic chickpea production. Also, farmyard manure applications increased the efficiency of green manure. Similar results were reported by Vadavia et al. (1991) and Tolanur and Badanur (2003) in chickpea and Astier et al. (2006) in maize.

In this study, application of effective microorganisms (EM) alone did not increase the seed yield significantly (Table 4). On the contrary, the applications of EM combined with green manure were found to be more effective on plant growth and seed yield. In earlier studies, there were conflict reports in regard to the effect of EM application on plant growth, seed yield and yield parameters. Some researchers have reported that the application of the EM had increased plant growth and yield (Javaid, 2006). Similarly, Daly and Stewart (1999) reported that application of EM to onion, pea and sweet corn increased yields by 29%, 31% and 23%, respectively. In contrast, some other researchers have reported that the effect of EM on plant growth and yield was negative or no effects (Daiss et al., 2008). However, some studies also demonstrated that the negative effects of EM could be overcome by repeated applications of the EM (Javaid, 2010).

Protein content

The means of protein content for different treatments were given in Table 4. The seed protein content ranged from 20.1 to 22.6%, and differences between protein content of organic and traditional chickpea treatments were significant in both years (Table 4). In general, high seed protein contents were obtained in the organic production systems as compared to the traditional production system. The highest protein content was also obtained from the green manure + farmyard manure application, followed by the green manure + effective microorganisms (GM + EM) in both years (Table 4). The lowest protein content (20.1 %) in two years was obtained from organic production without any fertilizer application. It was also determined that seed protein contents were higher in the organic production systems combined with green manure than those of the other production systems. Similar findings regarding positive effects of green manuring on seed protein content of chickpea were also reported by Williams and Singh (1986) and Mohammadi et al. (2010a).

CONCLUSION

Results of this study clearly indicated the effects of the traditional and organic production systems on growth, yield and yield components of chickpea cv. Cevdetbey 98. The traditional production system had the highest seed yield in 2007 (2972 kg ha^{-1}) and in 2008 (4002 kg ha^{-1}). In the organic production systems, the highest seed yields (2729 and 3838 kg ha^{-1} in corresponding years, respectively) were obtained from green manure + farmyard manure treatment. Therefore, the green manure and farmyard manure applications could be recommended in a organic chickpea production.

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