Comparison yield and yield components of *Capsicum annuum* L. under organic and conventional farm management

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Abstract

Organic agriculture has become increasingly important in recent years due to concerns about the environmental impacts of conventional farming practices and the need for sustainable and healthy food production. Pepper is a widely used spice all over the world, its organic production not only reduces the negative environmental impacts of conventional agricultural practices, but also makes it a healthier choice for consumers who are concerned about the potential health risks associated with chemical inputs. This study aimed to compare the production of Dalkani variety of *Capsicum annuum* under organic and conventional cropping systems in different crop densities (5, 7 and 10 plant.m^{-2}). The experiment was carried out in 2021 at Ferdowsi University of Mashhad based on a randomized complete block design with three replications. During the growing season and in the harvesting stages, plant growth characteristics, yield and yield components were measured. The results showed that conventional and organic cultivation systems did not have significant differences in most plant growth traits, but the effect of density was significant. The highest yield of fruit and seeds was observed at the density of 10 plant.m^{-2} in the conventional farm. The maximum (25.77 ± 4 t.ha^{-1}) and minimum (14.94 ± 5 t.ha^{-1}) fruit yield were observed at the density of 10 plant.m^{-2} in the conventional and 5 plant.m^{-2} in the organic farm, respectively. The results showed that the organic cultivation of the studied pepper variety can have competitive yields compared to conventional farming under a well-managed agriculture.

***Keywords*:** CGR, Leaf area index, Physiological parameters, Yield

1. Introduction

Organic agriculture has become increasingly important in recent years due to concerns about the environmental impact of conventional farming practices and the need for sustainable and healthy food production. Organic agriculture is a holistic approach to farming that aims to produce healthy and nutritious food in an environmentally friendly way. It focuses on enhancing soil health, biodiversity, and ecological balance, while reducing the use of synthetic inputs like pesticides and fertilizers (Abu-Zahra, 2016). Organic farming methods rely on natural processes and sustainable practices that avoid harmful chemicals and respect the environment. Pepper (*Capsicum annuum* L.) is a vegetable and spice that is rich in vitamins and minerals and has a vibrant color and a distinct flavor. It is widely consumed around the world and covers a large area of agricultural lands (Barchenger et al., 2022). Therefore, organic pepper production can have positive effects on soil health and biodiversity, as well as improve the quality of the products. On the other hand, organic paprika pepper can command a higher price in the marketplace, which can be beneficial for farmers who are able to sell their products at a premium price. Additionally, organic farming methods can help to reduce input costs over the long term, which can improve the profitability of the farm.

Therefore, the main objectives of this study were to compare the yield and yield components of pepper under organic and conventional cropping systems, and to evaluate the influence of crop density on these traits.

2. Materials and Methods

Field study

The field experiment was conducted in two separated farms at the Agricultural Research Station of Ferdowsi University of Mashhad (FUM), Iran (located at 36°15′ N, 59°28′ E, with 985 m altitude), in 2021 under organic and conventional farming systems. The organic one had been cultivated for more than nine years under national organic standards. The physio-chemical characteristics of the soil of both farms are presented in Table 1.

Cultivation was based on transplanting. So, we used plastic nursery trays with 170 cells for preparation of seedlings. Pepper seeds (*Capsicum annuum* L.) var. Dalkani were cultivated in a mixture of 50% peat moss, 20% perlite and 30% cocopeat in the first of March and were kept under greenhouse conditions until the transfer of seedlings to the fields.

Land preparation of farms were conducted before planting of seedlings on April 19. The plantation was done in 1.1m row spacing with three different plant densities including 5, 7 and 10 plants.m^{-2} density. The density was selected based on previous studies and consulting with local agricultural experts and seed suppliers of the location. First irrigation was done simultaneously with transplanting and then irrigation schedule was done in 5- or 7-day intervals. During the growing season, weeding was done manually in both fields.

Table 1. The soil physical and chemical properties of experimental field before planting.

Farm	Soil texture	K (mg/kg)	P (mg/kg)	N (%)	EC (dS/m)	pH	oc (%)	om(%)
Organic	Silt loam	138.4	34.2	53	1.42	7.36	1.01	1.75
Conventional	Silt loam	217.9	63.8	64	1.26	7.25	0.64	1.11

* EC: Soil electrical conductivity (dS m^{-1})

The field experiment was consisted of a randomized complete block design with 3 plant density levels arranged in three blocks in each farm. The effect of plant density and field management on physiological parameters of plants including height, wet and dry weight of plant, number of flowers and number of fruits per plant, wet and dry weight of fruits were evaluated two weeks after transplanting at 14-day intervals. The dry matter was determined after drying the plant material at 72◦C for 24 hours. Measurement of pepper leaf area index (LAI) were done by a leaf area meter (Model LI-3000, LI-ORInc., Lincoln, NE).

The crop growth rate (CGR) was calculated by means of the following equation (Eq.1):

Eq. 1: $CGR = {W_2 - W_1}/{SA\ (t_2 - t_1)}$

Where W_1 and W_2 are total plant dry matter (TDM) in g at the beginning and end of an interval, t_1 and t_2 are the corresponding days, and SA is the soil area in m^2 occupied by the plants at each sampling.

Data analysis

Statistical analysis was conducted based on GLM procedure using Minitab ver.20, and means were compared by Fisher's LSD test. The data of plant parameters under field conditions were analyzed based on mixed blocks analysis of the Randomized Complete Block Design with nested field effect in the replication.

3. Results and Discussion

Plant height

Based on the results of this study, it was found that in both organic and conventional farms, the plant height of paprika peppers had a sharp rising trend 42 days after transplanting. The maximum (50.33 ± 1.52 cm) and minimum (44.77 ± 1.07 cm) height of pepper plants were measured in 5 and 10 plants.m^2 in organic and conventional farms, respectively (Figure 1a). Data analysis showed that although increasing density had a significant effect on the decline in plant height ($p = 0.02$; $F_{2,8} = 6.46$), there was no significant difference between organic and conventional farms in this trait ($p = 0.25$; $F_{1,8} = 1.84$).

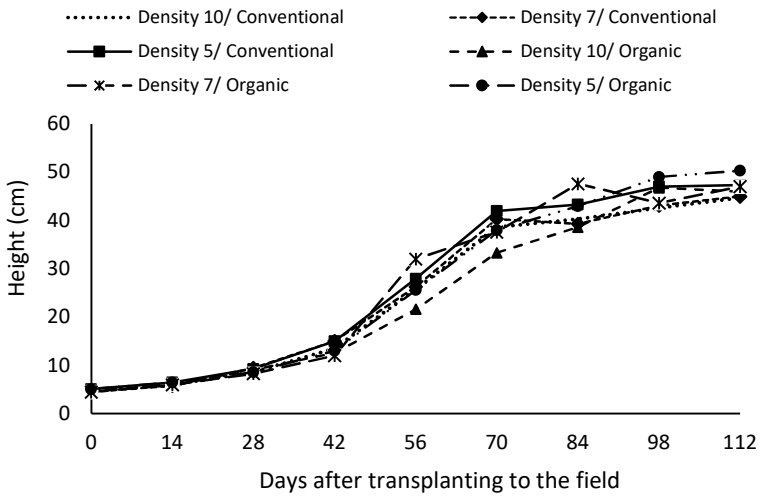

Fig 1. Changes in pepper plant height after transplanting to conventional and organic field.

Previous studies have examined how plant density and fertilization affect the growth and yield of different crops. For example, Salau et al. (2016) reported that hot pepper plants grown with 40 cm distance on the rows had the highest height and yield, compared to other distances. Ibrahim et al. (2022) also found that cotton plants with 40 cm distance on the row had significantly higher height and seed yield than those with smaller distances. Similarly, Shahsavari (2012) and Maleki et al. (2018) showed that decreasing row distance increased the height of red castor plant (*Ricinus communis* L.) and hyssop plant (*Thymbra spicata* L.), respectively. However, Nasto et al. (2009) observed that reducing plant density (from 11.1 to 2.6 plants per square meter) decreased the height of pepper plants.

In addition, in comparison to conventional farming, organic farming has been found to have varying effects on plant height in different crops. For instance, a study on sweet corn showed that the height of the plant in organic cultivation was higher than in conventional cultivation, but the difference was not significant (Fahrurrozi, et al., 2021). On the other hand, a study on eight wheat genotypes in Saudi Arabia found that the plant height in the conventional farming system was higher than in the organic farming system (AL-Ghumaiz, 2014).

Leaf area index

Results indicated that the highest leaf area index (LAI) in the conventional farm was observed 98 days after transplanting at a density of 10 plants.m^2, while the lowest LAI at this sampling date was related to the density of 5 plants.m^2. A decreasing trend in the LAI was observed in all densities after 98 days of transplanting (Figure 2). Similarly, in the organic farm, the maximum and minimum LAI were observed in densities of 10 and 5 plants.m^2, respectively. There was no significant difference between the organic and conventional farms in this trait, while the effect of density was significant.

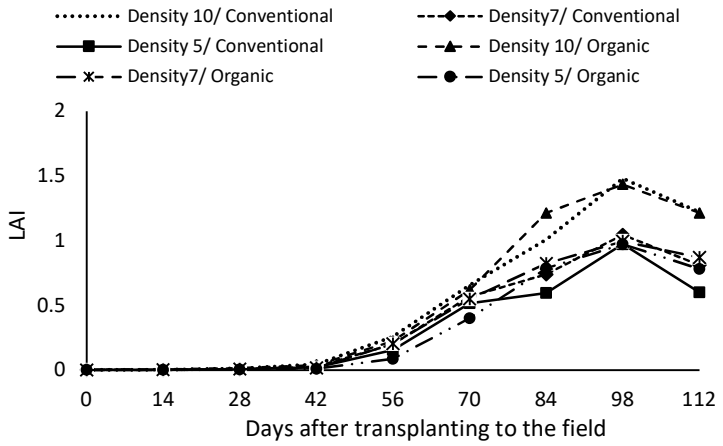

Fig 2. Leaf area index changes in pepper plants after transplanting to conventional and organic field.

Previous studies have shown that plant density per square meter affects the leaf area index (LAI), which is a measure of the total leaf area per unit ground area. For example, Soleymani (2017) and Li et al. (2019) reported that LAI increased with plant density from 8 to 12 plants per square meter in sunflower plants. Moreover, Vahedi et al. (2022) observed that higher plant density and smaller row distance resulted in higher LAI in quinoa plants. Similarly, Derogar et al. (2014) noted that LAI increased with plant density in different lentil cultivars. However, the current study did not find any significant difference in LAI between conventional and organic farms. This contrasts with a previous study by Ronga et al. (2015), who reported that LAI was lower in organic farming than in conventional farming for tomato cultivars in the Mediterranean region.

The current study did not find any significant difference in LAI between conventional and organic farms. This contrasts with a previous study by Ronga et al. (2015), who reported that LAI was lower in organic farming than in conventional farming for tomato cultivars in the Mediterranean region. LAI is a measure of the total leaf area per unit ground area, and it reflects the photosynthetic capacity and water use efficiency of plants. The difference in LAI between organic and conventional farming may depend on the crop type, the soil quality, the climatic conditions, and the management practices. Therefore, more studies are needed to compare the effects of organic and conventional farming on LAI and other physiological traits of different crops in different regions.

CGR

The study showed that the plant growth rate in the conventional farm followed a similar pattern in all three densities, as shown in Figure 3. The plant growth rate reached its peak 98 days after transplanting, and then declined gradually. The highest growth rate was achieved at a density of 10 plants.m^2, while the lowest growth rate was recorded at a density of 5 plants.m^2. The same trend was observed in the organic farm, where the

growth rate was highest at 10 plants.m^2 and lowest at 5 plants.m^2 (Figure 3). The plant growth rate is an indicator of the biomass accumulation and productivity of the crop. The difference in growth rate between different densities may be related to the competition for light, water, and nutrients among the plants.

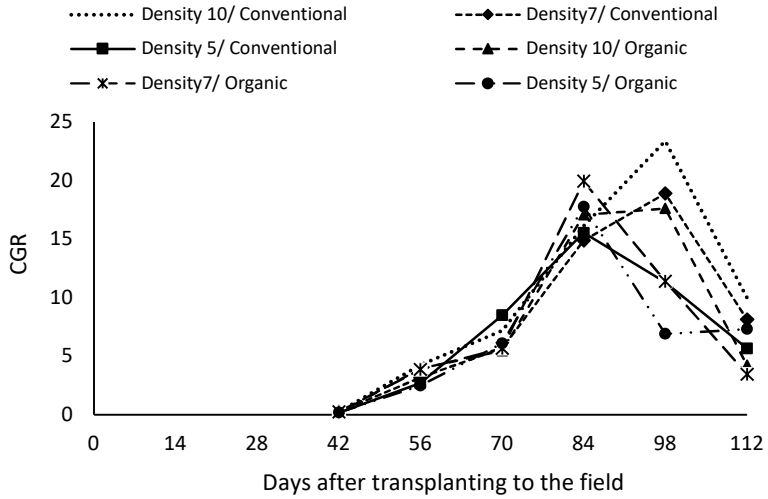

Fig 3. Crop growth rate changes in pepper plants after transplanting to conventional and organic field.

In a study by Vahedi et al. (2022), they investigated how different cultivation densities affected the yield components of quinoa plants. They found that decreasing the density significantly reduced the growth rate of the plants. LAI is a measure of the total leaf area per unit ground area, and it reflects the plant's ability to intercept light for photosynthesis (Mendoza-Pérez et al., 2017). The growth rate of a crop is an indicator of its biomass accumulation and productivity, and it depends on various factors such as light, temperature, nutrients, and water availability. In our experiment, we observed a decrease in crop growth rate (CGR) towards the end of the growing season, which could be due to several reasons. One possible reason is the limited availability of nutrients in the soil, which can restrict the plant's growth potential. Another possible reason is the temperature fluctuation, which can affect the plant's metabolism and development. In our experiment, we noticed a drop in temperature towards the end of the growing season. The length of the day can also influence CGR, as shorter days can reduce the amount of light available for photosynthesis. Finally, many plants undergo senescence towards the end of the growing season, which is the natural process of aging and dying. This can lead to a decline in CGR as the plant approaches the end of its life cycle. Therefore, the decrease in CGR towards the end of the growing season is likely due to a combination of these factors, which can all affect the plant's growth rate. Our results show a direct relationship between CGR and LAI, as higher LAI leads to higher CGR.

Fruit yield per hectare

The effect of plant density on fruit yield per hectare in conventional and organic farms is shown in Figure 4. The results indicate that the conventional farm had higher fruit yield than the organic farm, and that the highest yield per hectare was achieved at a density of 10 plants per m^2, while the lowest yield per hectare was obtained at a density of 5 plants per m^2. The lower yield in organic farming could be due to several factors, such as lower soil fertility. The results also show that increasing plant density increases fruit yield per hectare in both conventional and organic farms, which could be related to the higher leaf area index (LAI) at higher densities. Higher LAI can result in higher photosynthesis and biomass production, which can lead to higher fruit yield. This is in agreement with previous studies that have found a positive relationship between LAI and fruit yield in pepper plants (Nasto et al., 2009). Therefore, the results suggest that plant density and farm type are important factors that affect the fruit yield of pepper plants.

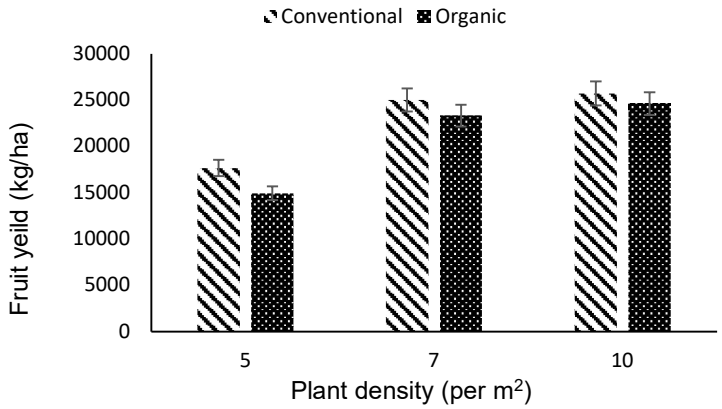

Fig 4. Pepper fruit yields different planting densities in conventional and organic fields.

Previous studies have reported lower yield in organic farming compared to conventional farming for different crops, such as tomato, raspberry, and paprika. For example, Frias-Moreno (2019) reported that organic raspberry yield (4.12 tons per hectare) was lower than conventional raspberry yield (2.15 tons per hectare) in Mexico. The lower yield in organic farming could be due to several factors, such as lower soil fertility, higher pest and disease pressure, lower water availability, and lower plant density.

The effect of plant density on fruit yield has also been studied for different crops, such as paprika and pepper. Campo et al. (2001) observed that increasing plant density increased paprika fruit yield.

4. Conclusion

In this study, we compared the effect of plant density on the growth and yield of paprika pepper plants in conventional and organic farms. Although we found that the

conventional farm had higher fruit yield per hectare than the organic farm, the organic cultivation of the studied pepper variety can have competitive yields compared to conventional farming under a well-managed agriculture. We also found that the highest fruit yield per hectare was achieved in the highest density. These results suggest that plant density is an important factor that influences fruit yield, as it affects the leaf area index (LAI), which is a measure of the total leaf area per unit ground area. Higher LAI can result in higher photosynthesis and biomass production, which can lead to higher fruit yield.

Pepper is a spice and vegetable that is widely used in cuisines around the world. It is produced by organic and conventional farming methods, which have different effects on the yield and quality of the crop. Organic farming is a sustainable and environmentally friendly approach that avoids synthetic inputs and promotes soil health and biodiversity. However, Organic farming also faces some challenges that require careful planning and management. Some of these challenges are pest and disease control, soil fertility, weed management, certification and regulations, market demand and competition, and weather and climate change. Most of these challenges can be overcome by applying good agricultural practices and using appropriate organic inputs and methods.

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مقایسه عملکرد و اجزای عملکرد *Capsicum annuum* L. در دو نظام کشت رایج و ارگانیک

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چکیده

در سال های اخیر به دلیل نگرانی در مورد اثرات زیست محیطی شیوه های کشاورزی رایج و نیاز به تولید پایدار و سالم مواد غذایی، کشاورزی ارگانیک اهمیت فزاینده‌ای یافته‌است. در این میان فلفل یک ادویه پرکاربرد در سراسر جهان است که تولید ارگانیک آن نه تنها اثرات منفی زیست محیطی فعالیت های کشاورزی رایج را کاهش می‌دهد، بلکه آن را به انتخاب سالم تری برای مصرف کنندگانی تبدیل می کند که نگران خطرات بالقوه سلامتی مرتبط با نهاده های شیمیایی هستند. این مطالعه با هدف مقایسه تولید فلفل رقم دلکنی در نظام‌های کشت ارگانیک و رایج و در تراکم های مختلف (۵، ۷ و ۱۰ بوته در متر مربع) در سال ۱۴۰۰ در مزرعه تحقیقاتی دانشگاه فردوسی مشهد در قالب طرح بلوک های کامل تصادفی در سه تکرار اجرا شد. در طول فصل رشد و طی مراحل برداشت، خصوصیات رشدی گیاهان، عملکرد و اجزای عملکرد اندازه گیری شدند. نتایج نشان داد که در دو مزرعه کشت رایج و ارگانیک در اکثر صفات اندازه گیری شده تفاوت معنی‌داری مشاهده نشد، اما اثر تراکم معنی‌دار بود .بیشترین عملکرد میوه (۴ ± ۲۵/۷۷ تن در هکتار) در تراکم ۱۰ بوته در متر مربع در مزرعه رایج و کمترین مقدار (۵ ± ۱۴/۹۴ تن در هکتار) در تراکم ۵ بوته در مترمربع در مزرعه ارگانیک مشاهده شد. به طورکلی نتایج نشان داد که کشت ارگانیک رقم فلفل مورد مطالعه می تواند عملکرد رقابتی در مقایسه با کشاورزی معمولی تحت یک کشاورزی مدیریت شده داشته باشد.

واژه‌های کلیدی: خصوصیات فیزیولوژیک، سرعت رشد گیاه، شاخص سطح برگ، عملکرد