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Comparison of open-field and protected banana cultivation for some morphological and yield features under subtropical conditions

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Abstract

Banana production in Turkey is located well beyond subtropical banana production zones. However, banana is the only tropical fruit produced commercially in both open-field and greenhouse conditions. Recently the area under greenhouse production has started to expand, partly because production costs are covered by harvesting fruit in same year as planting. This popularity has also led to improved greenhouse technology being used for banana production. In this research, the effects of open-field and greenhouse production systems on some of the morphological (number of leaves, pseudostem circumference, pseudostem height, bunch stalk circumference), phenological features (fruit maturation length), and yield components (number of hands, number of fingers per bunch) were determined. In addition, the effects of production systems on physicochemical features of banana were investigated. Similar cultural measures were applied in both cultivation systems except for bunch covering. Among the morphological features, number of leaves, pseudostem circumference and pseudostem height were found to be higher under greenhouse conditions than those in open field cultivation. Fruit maturation length was shorter in greenhouse-produced banana by about 25 days, compared to that observed in open-field cultivation. Yield components were also found to be better in greenhouse-produced banana as compared with open field production, with average bunch weight of 40 kg in greenhouse-produced banana versus 27 kg in banana produced under open-field conditions. Physical fruit parameters were found to be better for greenhouse-produced fruits compared to those observed in open-produced fruits while soluble solids contents did not differ in both production conditions. The results of this research clearly showed that some yield and fruit quality components were found to be superior when produced in a greenhouse production system compared to that observed in open field production system and no wind damage, naturally, was observed in greenhouse.

Keywords: AAA genome, Dwarf Cavendish, plastic greenhouse, productivity, fruit quality.

INTRODUCTION

The major banana-growing areas of the world are geographically situated between 20°N and 20°S latitudes. This area is extended with subtropical banana production zone to 30°N and 30°S (Stover and Simmonds, 1987). In Turkey, banana-growing areas are located in the Mediterranean coastal strip at 36°N latitude (Gubbuk et al., 2010). This latitude is well beyond even subtropical banana production zones, making banana the only tropical fruit commercially produced in Turkey, in both open-field and greenhouse (plastic greenhouse) conditions. The reasons may be underlined as lesser production than more due to consumer demand, profitable yet stable price and moderately high banana import tariffs, than to any production constraints. Local importers pay very high custom duties (over 100%) for

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imported bananas, so banana retail prices remain high, which makes local banana production a very attractive and profitable enterprise (Gubbuk and Pekmezci, 2004).

Presently, total annual Turkish banana production is 270,501 t, and production area has increased to 5,838 ha (Anonymous, 2015) while local demand (domestic consumption) for bananas is over 400,000 t. Therefore, to meet consumer demand, Turkey has to import nearly 200,000 t bananas. Greenhouse banana production area is expanding moderately. Promoting domestic banana production may serve to completely meet consumer demand in the near future.

The leading reasons behind this popularity of banana production under a protected environment (greenhouse)in Turkey include early covering of production costs by harvesting fruit in same year of planting, and higher fruit yield and quality compared to that obtained under open-field conditions (Galan-Sauco et al., 1998; Eckstein et al., 1998; Gubbuk and Pekmezci, 2004).Another advantage of protected cultivation is that minimum temperature and relative humidity are higher than in open conditions.

The yield and some quality parameters in banana grown in open-field and under protected conditions have been previously investigated (Galan-Sauco et al., 1998; Eckstein et al., 1998; Gubbuk and Pekmezci, 2004). However, there is no comparative study reported on the effects of production systems on physicochemical features of banana after ripening. Galan-Sauco et al., (1998) have reported20% heavier bunches and annual yields on banana produced with protected cultivation compared to banana produced in open conditions in the Canary Islands. Eckstein et al. (1998) has also found that protected cultivation increased banana yield by 28% (71 t ha^{-1}, 56 t ha^{-1}, and protected Vs open-field, respectively) in experimental plantation carried on in South Africa. Gubbuk and Pekmezci (2004) have reported huge yield differences, with 53% for banana produced in protected (65 t ha^{-1}) and open-field (42.8 t ha^{-1}) in Turkey.

In this research, the effects of open-field and greenhouse production systems on some morphological (number of leaves, pseudostem circumference, pseudostem height, bunch stalk circumference), phenological features (fruit maturation length) and yield components (number of hands, number of fingers per bunch) were evaluated. Also, the effects of production systems on physicochemical features of banana were investigated.

MATERIALS AND METHODS

The study was carried out using the Dwarf Cavendish cultivar between 2007 to 2008 in Alanya, Antalya (locations: open-field -altitude 50 m, latitude 36°28'N; protected cultivation -altitude 10 m, latitude 36°28'N). A plastic-covered and metal-framed greenhouse with 5 meter gutters and a 7.5 m roof height was used in the experiment. Plant density was1800 plants/ha in both cultivation systems. Temperature and relative humidity were measured using a data logger (HOBO) greenhouse monitoring system during the experimental period. Mean annual minimum/maximum/average temperatures in the open-field cultivation and under the protected cultivation were16/26/20°C and 15/33/23°C, respectively. Annual minimum/maximum/average relative humidity in the open-field cultivation and under the protected cultivation was 47/82/66% and 54/88/75%, respectively. A double line drip-irrigation system was installed for each row. The important soil properties were as follows: pH 7.6, 8.3% lime content, loamy texture, with 3.1% organic matter. Irrigation and fertilization were uniformly applied as per normal recommended practices (Pekmezci, et. al., 1998). Pseudostem circumference (20 cm above the soil level), pseudostem height, total leaf number (at shooting stage), days from shooting to harvest, bunch stalk circumference (5 cm above the first hand), hand and finger numbers, finger circumference (at the center of first, middle and last hands of fingers), finger length (from end to end in a straight line) and bunch weight, were determined at harvesting time according to Gubbuk and Pekmezci (2004). Finger weights (before and after ripening), peel

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thickness, fruit firmness, peel ratio (peel (g)/whole fruit (g) X100)) and soluble solid content were also determined. The experiment was established with 3 replications, using five plants each for morphological parameters and 10 fruits for physical and chemical parameters.

RESULTS AND DISCUSSION

Values of all the examined morphological features were found to be higher in protected cultivation (Table 1). Mean pseudostem height was higher in protected cultivation (2.32 m) than that found in open-field (2.11 m). Average pseudostem circumference was 78.19 cm in open-field and 84.58 cm in protected cultivation. The total leaf number was found to be higher in protected cultivation (28.52) than in open-field (27.43). All the examined yield parameters were found statistically significant between two cultivation systems (Table 2). It was found that numbers of hands and fingers per bunch and weight of bunches were higher in protected cultivation compared to that found in open-field, while the period from shooting to harvest was 25 days shorter in protected cultivation (Table 2). Similar results have been reported in previous studies (Galan-Sauco et al., 1998; Eckstein et. al., 1998; Kwach et al., 2000; Gubbuk et. al., 2004). We assume that these results were due to the more suitable environmental conditions within the protected cultivation system such as temperature, humidity and non-wind conditions compared to that observed in open field condition.

Table 1. The effect of cultivation system on stem height, pseudostem circumference and total leaf number

Cultivation system	Pseudostem height (m)	Pseudostem circumference (cm)	Total leaf number
Open-field	2.11 b*	78.19 b	27.43 b
Protected cultivation	2.32 a	84.58 a	28.52 a
$LSD_{\%5}$	0.069	1.757	0.834

**Mean comparisons were significantly different at the 5% level according to the LSD test (P≤0,05).

Table 2. The effect of cultivation system on bunch stalk circumference, hand number, finger number, bunch weight, from shooting to harvest.

Cultivation system	Bunch stalk circumference (cm)	Hand number	Finger number	Bunch weight (kg)	Days from shooting to harvest
Open-field	26.51	11.62 b*	244.43 b	26.99 b	152.83 a
Protected cultivation	27.68	12.72 a	296.56 a	40.43 a	127.90 b
$LSD_{\%5}$	NS**	0.465	11.872	1.420	3.328

*Mean comparisons were significantly different at the 5% level according to the LSD test (P≤0,05).
**NS, indicate non-significance

Finger circumference and length were also significantly different between both cultivation systems (Table 3). These were measured as 11.04 cm and 19.19 cm in open-field and 11.89 cm, and 20.75 cm in protected cultivation, respectively. As a consequence, finger weights were found to be different before and after ripening between the two growing systems (Table3). Peel thickness was another fruit parameter affected by cultivation system. It was thinner in protected cultivation leading a higher pulp-to-peel ratio and a heavier fruit

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finger compared to that determined from open field cultivation (Table 4). Values for all fruit physical features were found higher in protected cultivation with non-significant values from peel to-pulp ratio and fruit pulp firmness. These results were similar to that reported by Gubbuk and Pekmezci (2004).Fruit weight decreased after ripening in both cultivation systems. Peel thickness and fruit firmness was found higher in protected cultivation, while peel ratio of whole fruit and soluble solid content were not affected. Arvanitoyannis and Mavromatis (2009) reported that the physicochemical (pH, texture, vitamin C, ash, fat, minerals) and sensory properties of banana fruits were correlated with the genotype and growing conditions. These results suggest that protected area had enhanced the growing period by favouring again the environmental conditions since fruit developmental period takes place in cold and harsh winter conditions.

Table3. The effect of cultivation system on finger circumference, finger length and finger weight before and after ripening.

Cultivation system	Finger Circumference (cm)	Finger Length (cm)	Finger weight Before ripening (g)	Finger weight after ripening (g)
Open-field	11.04 b*	19.19 b	122.28 b	82.82 b
Protected cultivation	11.89 a	20.75 a	145.80 a	110.35 a
$LSD_{\%5}$	0.651	0.823	1.211	4.416

*Mean comparisons were significantly different at the 5% level according to the LSD test ($P \leq 0{,}05$).

Table4. The effects of cultivation system on peel thickness, fruit firmness, peel to pulp ratio and soluble solid content.

Cultivation system	Peel Thickness (mm)	Fruit firmness (kg/cm^2)	Peel ratio (%)	Soluble Solid content (%)
Open-field	2.03 b*	0.96 b	37.45	18.88
Protected cultivation	2.35 a	1.38 a	35.37	19.09
$LSD_{\%5}$	0.123	0.073	NS.**	NS.**

*Mean comparisons were significantly different at the 5% level according to the LSD test ($P \leq 0{,}05$).**NS, indicate non-significance

CONCLUSIONS

The results presented here suggest that bananas grown under protected cultivation were superior to those grown in open-field cultivation for many of the qualitative and quantitative parameters.

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