

## Agronomic evaluation of new Cavendish banana cultivars for growing in different protected cultivation areas in Turkey

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### **Abstract**

**Protected cultivation (in greenhouses) is an effective cropping system to produce bananas in Turkey and much more profitable than open-field conditions. 'Grand Nain' is the most popular cultivar grown in greenhouses in Turkey, but it may be possible to increase yield and fruit quality, and subsequently grower incomes, by testing new cultivars. The objective of this study was to evaluate in subtropical conditions the performance of five new Cavendish cultivars ('CV 902', 'Jobo, MA13', 'Williams' and 'MA13') previously selected in open-field tropical conditions, compared to 'Grand Nain' (control). All new Cavendish cultivars were introduced in Turkey from VITROPIC SA, France. All cultivars were produced by in-vitro micropropagation of meristems, and then deflasked and grown in nurseries to 25 cm for planting. The trials were undertaken in three different locations (Alanya, Anamur and Bozyazı/Turkey) in greenhouses. Various parameters were recorded over two crop cycles including: stem circumference, stem height, total leaf number, bunch stem circumference, number of hands and finger per bunch, finger length and circumference at harvest and bunch weight. The Bozyazı location showed better performance in many aspects of plant growth compared to the other two sites. 'Williams' had on average the highest pseudostem circumference and height but also the highest bunch weight (50.27 kg). The bunch weight of 'MA13' and 'CV 902' was 47.65 kg and 42.66 kg, respectively, whereas the control ('Grand Nain') and 'Jobo' had a lower bunch weight. Cultivars 'Williams', 'MA13' and 'CV 902' were more productive than 'Grand Nain' in greenhouse conditions. In addition, no somaclonal variations were observed in any of the three experimental locations. These results suggest that the new selections have potential to provide higher yields in Turkey in protected cultivation, providing higher returns to growers, compared to local selections.**

**Keywords:** *Musa* spp., adaptation, protected cultivation, yield, quality

### **INTRODUCTION**

Bananas are grown mainly under tropical conditions. However, bananas are also grown subtropical conditions in countries including Australia, Egypt, Israel, Morocco, South Africa, Spain and Turkey. Due to global warming, banana production potential has increased in the subtropical climate. Banana production areas are increasing in Turkey, even in areas without subtropical tropical conditions. Banana production is located only in the coastal Mediterranean region, where the northern areas are protected by the high-altitude Taurus Mountains. Alanya and Gazipaşa, districts of Antalya province, and Anamur and Bozyazı, districts of Mersin province, are the most important banana-growing locations in Turkey (Gubbuk et al, 2017). As banana production is very profitable in Turkey, banana growing has expanded in recent years towards other towns in the coastal regions including Antalya (Kumluca, Finike and Manavgat districts), Mersin (Erdemli), Adana (Yumurtalık), Hatay (İskenderun) and Muğla (Fethiye) provinces. The total banana-growing area in Turkey has increased by >30% between 2013-2017, to 6,821 ha in 2017, with a total production of

369,009 tonnes (Anonymous, 2017). In the last 7 years, most banana production expansion, in terms of both area and production quantity, has been in protected cultivation.

Subtropical conditions are characterized by low winter temperatures, a large difference between day and night temperatures, high and low temperature extremes in summer and winter (temperature fluctuation), and low rainfall which is often poorly distributed to seasons (Smith et al., 1998). Therefore, protected cultivation can be recommended in subtropical conditions to prevent temperature fluctuation and to reduce frost and wind damage to banana. Besides temperature, cultivar choice can also have a profound effect on yield and quality in banana production. The main cultivar grown in Turkey is 'Dwarf Cavendish'. However, bunch shape and short fingers limit production potential of this cultivar in subtropical areas. There are many studies on the evaluation of cultivars for their performance in different subtropical conditions. Galan Sauco et al. (1998) evaluated five banana cultivars ('Eylon', 'Zelig', 'Gal', '19-39' and 'Chinese Cavendish') in the Canary Islands, and found 'Zelig' and 'Chinese Cavendish' suitable for commercial cultivation in the Canary Islands. Eckstein et al. (1998) examined the performance of different Cavendish banana cultivars, such as 'Williams', 'Chinese Cavendish' and 'Grand Nain Israel', in both open-field and greenhouse cultivation in South Africa. 'Grand Nain Israel' and 'Williams' were superior to 'Chinese Cavendish' in terms of cultivar performance in both open-field and greenhouse cultivation. Nuno et al. (1998) evaluated the adaptation of cultivars 'Grand Nain', 'Williams', 'Zelig', 'Eylon' and 'Chinese Cavendish' in Madeira Island, and found that 'Grand Nain' had the highest yield and pseudostem height. A similar study on the evaluation of performance of five banana cultivars ('Valery', 'Lacatan', 'Giant Cavendish', 'Dwarf Cavendish' and 'Green Red') in South Western Kenya found 'Valery' and 'Giant Cavendish' most suitable for cultivation due to their high yield, good taste and strong pseudostems (Kwach et al., 2000).

Previously, our group compared the performance of some Cavendish cultivars (AAA) under open-field and plastic greenhouse conditions (Gubbuk, 2004). We found that yield and quality of 'Williams' and 'Grand Nain' were superior to 'Dwarf Cavendish' in greenhouse conditions. However, more studies comparing cultivars are required to determine the benefits for Turkish growers. The objective of the present study was to evaluate the agronomic performance of some newly introduced banana cultivars under plastic greenhouse conditions in Turkey.

## **MATERIAL AND METHODS**

The study was carried out in 2006-2008 in Alanya province, Antalya, and in Anamur and Bozyazı province, Mersin. The experiment was carried out in two ratoon crops. Average mean yearly minimum/maximum temperatures in the greenhouse were recorded as 13/30°C, and the relative humidity was 70-90% for all locations. The greenhouse structure was made of steel, with the top height and height from the gutter approximately 5.50 meters and 4.5 meters. The greenhouse was covered in polyethylene (200 micron thickness and UV+IR added) and was ventilated from the sides and the top. The greenhouses were not heated during the trial.

Cultivars 'Williams', 'MA13', 'Jobo' and 'CV 902' were used as experimental material, with 'Grand Nain' as control. The experimental materials were introduced from VITROPIC SA Company. All plant materials were propagated via meristem culture. Plant spacing was 3 x 1.8 m (1,850 plant/ha).

Depending on the location, the soil pH was between 7.0-7.4, the calcium content was 3.2-4.3%, the texture was loam, and the organic matter content was 3.0-5.0%. Irrigation and fertilization were uniformly applied as per normal recommended practices (Pekmezci et al., 1995).

The observations focused on the following traits: pseudostem circumference (20 cm above the soil level), pseudostem height, total number of leaves (at bunching stage), bunch stalk circumference (5 cm above the first hand), finger weight, 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. These traits were recorded at harvest according to Pekmezci et al. (1998).

The experiment was laid out in a completely randomized factorial design with three replicates per treatment (10 plants for morphological features and 10 fruits for pomological features for each replicate). Data were analysed by analysis of variance (ANOVA) using the SAS software. Means were separated using LSD multiple range test at 0.05 levels.

## RESULT AND DISCUSSION

Except for total number of leaves, all traits showed significant differences ( $P < 0.05$ ) among cultivars and locations (Table 1-7). In addition, cultivar by location interactions also affected these traits significantly ( $P < 0.05$ ) (Tables 1-7). These interactions were important ( $P < 0.05$ ) for pseudostem and height circumferences, bunch stalk circumference, hand number, finger circumference and length, and bunch weight.

Pseudostem circumferences were statistically different according to cultivars and locations. 'Williams' had the greatest stem circumference (89.28 cm) and 'Grand Nain' control (82.89 cm) had the lowest. On average, significant differences ( $P < 0.05$ ) for pseudostem height was observed among locations, the tallest pseudostems were found in Bozyazı (3.19 m) followed by Anamur (2.87 m).

Table 1. Pseudostem circumference (cm) of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	80.18 I*	80.33 I	84.14 GH	87.37 BCD	85.42 EFG	83.48 c**
Anamur	83.43 H	86.43 CDE	86.18 DEF	87.30 BCD	88.70 B	86.40 b
Bozyazı	85.07 EFG	87.77 BC	86.98 CD	84.93 FG	93.73 A	87.69 a
Cultivars mean	82.89 d***	84.84 c	87.21 b	85.08 c	89.28 a	

LSD %5 locations x cultivars: 1.4836 ; LSD %5 locations: 0.6882; LSD %5 cultivars: 0.8885

\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

Table 2. Pseudostem height (m) of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	2.67 G*	2.67 G	2.72 FG	2.80 E	2.92 D	2.75 c**
Anamur	2.73 EFG	2.77 EF	2.89 D	2.88 D	3.11 C	2.87 b
Bozyazı	3.08 C	3.11 C	3.07 C	3.30 B	3.42 A	3.19 a
Cultivars mean	2.82 d***	2.85 d	2.89 c	2.99 b	3.14 a	

LSD %5 locations x cultivars: 0.0761; LSD %5 locations: 0.0322; LSD %5 cultivars: 0.0416

\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

As presented in Table 3, the average number of total leaves at shooting varied between 29 and 30 per plant (Table 3). No significant differences were found between cultivars and locations.

Table 3. Total leaf number of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	29.38	30.25	32.83	29.99	30.66	30.02
Anamur	30.01	29.65	29.44	29.64	29.93	29.73
Bozyazi	29.32	29.94	29.53	29.75	29.97	29.70
Cultivars mean	29.56	29.97	29.56	29.79	30.18	

LSD %5 locations x cultivars: N.S.; LSD %5 locations: N.S.; LSD %5 cultivars: N.S

NS: indicates non-significance.

Significant differences ( $P < 0.05$ ) for bunch stalk circumference were recorded between locations, varying from 27.75 to 29.19 cm (Table 4). This trait varied also according to cultivars from 27.59 to 29.34 (Table 4). The highest average bunch stalk circumference was found in 'Williams' and the lowest in 'Jobo'.

Table 4. Bunch stalk circumference of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	27.85 CD*	28.04 C	26.47 F	28.10 C	28.33 C	27.75 c**
Anamur	27.13 E	27.28 DE	28.19 C	29.60 B	29.29 B	28.29 b
Bozyazi	28.28 C	29.82 AB	28.13 C	29.33 B	30.40 A	29.19 a
Cultivars mean	27.75 c***	28.38 b	27.59 c	29.01 a	29.34 a	

LSD %5 locations x cultivars: 0.6464; LSD %5 locations: 0.2786; LSD %5 cultivars: 0.3597

\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

Hand number was significantly different for both cultivars and locations (Table 5). The numbers of hands per bunch were recorded as 12.05 and 12.96 among cultivars, and 11.32, and 13.29 among locations, respectively. The highest number of hands was found in 'MA13' (12.96) and the lowest in 'Jobo' (12.05). The average number of hands per bunch was highest in Anamur location (13.29) and lowest in Alanya location (11.32).

Table 5. Number of hands of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	11.27 EF*	11.38 DE	11.32 E	11.82 D	10.85 F	11.32 c**
Anamur	12.83 C	13.35 AB	13.40 AB	13.33 AB	13.55 A	13.29 a
Bozyazi	12.88 C	12.88 C	11.43 DE	13.74 A	13.08 BC	12.80 b
Cultivars mean	12.32 b***	12.53 b	12.05 c	12.96 a	12.49 b	

LSD %5 locations x cultivars: 0.4403; LSD %5 locations: 0.2029; LSD %5 cultivars: 0.2619

\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

Finger circumference was statistically different among cultivars. 'Jobo' and 'Williams' had the highest mean finger circumference (13.17 cm), followed by 'CV 902' (13.02 cm). Significant differences ( $P < 0.05$ ) for finger circumference occurred between locations too. The highest finger circumference was found at Bozyazı (13.19 m) followed by Alanya (13.29 cm).

Table 6. Finger circumference (cm) of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	13.22 ABC*	13.23 ABC	13.62 A	13.45 AB	12.95 CD	13.29 a**
Anamur	12.43 E	12.52 E	12.49 E	12.46 E	13.38 AB	12.65 b
Bozyazı	13.43 AB	13.33 ABC	13.40 AB	12.62 DE	13.19 BC	13.19 a
Cultivars mean	13.02 ab***	13.02 ab	13.17 a	12.84 b	13.17 a	

LSD %5 locations x cultivars: 0.4056; LSD %5 locations: 0.1856; LSD %5 cultivars: 0.2396

\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

The finger length was statistically different among cultivars and also locations (Table 7). The highest finger length was recorded in 'Williams' (24.23) and the lowest in 'MA13' (22.80). The average finger length varied between locations from 22.89 cm (Alanya) to 23.94 cm (Anamur).

Table 7. Finger length (cm) of different banana cultivars grown in various locations in protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	
Alanya	22.56 DEF*	23.02 CDE	23.37 CD	22.56 DEF	22.95 CDE	22.89 b***
Anamur	23.70 BC	24.33 AB	23.70 BC	23.16 CDE	24.82 A	23.94 a
Bozyazı	22.35 EF	24.38 AB	21.90 F	22.68 DEF	24.93 A	23.25 b
Cultivars mean	22.86 b***	23.91 a	22.99 b	22.80 b	24.23 a	

LSD %5 locations X cultivars: 0.8232; LSD %5 locations: 0.3821; LSD %5 cultivars: 0.4932

\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

Bunch weights are presented in Table 8. Bunch weights were also significantly different between cultivars and locations. Except for 'Jobo', bunch weight of the new cultivars was higher than the control. The highest bunch weight was recorded in 'Williams' (over 50 kg) followed by 'MA13' (over 47 kg). The highest bunch weight was recorded in Bozyazı location (over 50 kg) and the lowest in Alanya location (over 40 kg).

Table 8. Bunch weight (kg) of different banana cultivars grown in various conditions under protected cultivation.

Locations	Cultivars					Locations mean
	Control	CV 902	Jobo	MA13	Williams	

Alanya	37.83 H*	39.80 G	37.81 H	40.58 G	46.20 E	40.46 c**
Anamur	43.31 F	49.00 D	43.37 F	50.19 C	49.74 CD	47.12 b
Bozyazı	46.80 E	50.07 C	46.83 E	52.08 B	54.88 A	50.13 a
Cultivars mean	42.64 d***	46.29 c	42.66 d	47.65 b	50.27 a	
LSD %5 locations x cultivars: 0.9603; LSD %5 locations: 0.4353; LSD %5 cultivars: 0.562						

D\*Locations x cultivars means with the same capital letters is not significantly different ( $p < 0.05$ )

\*\* Locations means with the same letter are not significantly different ( $p < 0.05$ )

\*\* Cultivars means with the same letter are not significantly different ( $p < 0.05$ )

## DISCUSSION

Our experimental results showed that all traits, except for total number of leaves, were significantly affected by cultivar, location and cultivar x location interactions. Significant differences were found between cultivars in the three locations. Generally, all tested new cultivars had higher bunch weights compared to the control, 'Grand Nain'. In all locations, 'Williams' and 'MA13' presented the heaviest bunches followed by 'CV 902' and 'Jobo'. On average, bunch weights were higher in Bozyazı, followed by Anamur and Alanya.

These results suggest that the agro-environmental conditions of the site of Bozyazı were more suitable than other locations for the expression of the agronomic potential of these new cultivars. Further studies would be necessary to determine if these results can be linked to soil and/or environmental conditions. In all locations, the new cultivars tested in this study performed better than the traditional 'Grand Nain' used as control, with an increase of up 18% for bunch weight while remaining at constant number of leaves emitted.

Genotype and location interaction was statistically important for pseudostem circumference and height, bunch stalk circumference, number of hands, bunch weight and finger size. The results of this study show that plant genotype affects morphological features and yield, including the number of hands, finger length and circumference, which is in agreement with previous studies by Cauwer et al. (1995), Galán Saúco et al. (1998), Eckstein et al. (1998), Kwach et al. (2000) and Gubbuk et al. (2004). The values obtained for agronomic attributes pseudostem circumference, pseudostem height, bunch weight and finger quality varied according to cultivars, as previously reported (Cauwer et al., 1995; Galán Saúco et al., 1998; Eckstein et al., 1998; Kwach et al., 2000; Gubbuk and Pekmezci, 2004). These results indicate that multi-locational experiments are important to decide suitable cultivars for each location.

## CONCLUSIONS

Our studies on the evaluation of the agronomic performance of the banana cultivars grown in plastic greenhouse in Turkey showed that cultivars 'MA13' and 'Williams' gave the best yield parameters and fruit size, followed by 'CV 902' and 'Jobo'. At identical agronomical conditions and given the high value of banana fruits on Turkish markets, we would recommend the development of these new cultivars in Turkey in replacement of the traditional cultivar 'Grand Nain' for the benefit of Turkish growers.

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