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COMPARATIVE STUDY ON GROWTH AND PRODUCTIVITY OF SOME BANANA CULTIVARS UNDER THE EGYPTIAN CONDITIONS

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ABSTRACT: This study was carried out to improve Banana crop growth and productivity by planting cultivars that may be tolerant to banana diseases with high productivity and quality. Three imported cultivars (Zeef, Grand Nine, and Canary) were planted in private orchard in El Salhya District, Sharkia Governorate, Egypt in two consecutive seasons of 2016 and 2017. The results of this work indicated that Zeef and Grand Nine were significantly higher in growth parameters such as plants length and number of functional leaves than Canary. Similar results were noticed in productivity parameters where Zeef plants and Grand Nine were significantly higher than Canary such as total yield, bunch weight, bunch length, finger length and diameter, while no clear differences were found in quality components. Also the second season 2017 (the first sucker) was higher than the first one (Mother) in the three cultivars in all parameters. Also Zeef plants and Grand Nine recorded the highest value for each of antioxidants enzymes, soluble sugars and proline, this reflects that defense system in both cultivars was stronger than Canary cultivar, so they were more tolerant to diseases than Canary plants. Therefore the general evaluation showed that Zeef and Grand Nine banana cultivars are considered promising cultivars for the Egyptian conditions with high productivity and quality and tolerant to biotic and abiotic stresses.

Key words: Banana cultivars, Zeef, Grand Nine, Canary, Quality, Productivity.

INTRODUCTION

Banana (*Musa* sp.) is one of the most consumed fruits in the world. Nowadays, Banana crop in Egypt as in many countries of the world facing a lot of challenges that led to reduce its productivity and quality. These problems may be related with the sensitivity of the local cultivars to pests and diseases or there is no adequate improved genotypes grown under the Egyptian conditions. Bananas are also an important part of the small holder farming communities and families living in rural areas.

Commercial banana cultivars within the Cavendish sub-group are triploid, seedless, sterile and parthenocarpic **(Khayat *et al*., 1997)**. Therefore, banana production has been improved in many countries by either importing promising cultivars/selections from other geographical areas or *via* the identification of superior and stable local selections **(Eckstein, 1994; Khayat *et al*., 1997; Smith *et al*., 1997)**.

Bananas can be cultivated under tropical and subtropical climates **(Karikari *et al.*, 1980; Panis and Thinh, 2001**). This climate is coupled with good soil conditions is ideal for the cultivation of high quality bananas. Good cropping practices and post-harvest management help in producing the superior banana quality required.

Moreover, banana farmers are facing several challenges including low productivity and diseases particularly fusarium wilt (**Kung'u, 1995**). Indeed, pests alone cause between 30-80% of banana losses depending on the variety **(Speijer and Fogain, 1998**). To study these

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challenges, there is a continuous need to cultivate improved cultivars and evaluate them in different Agro- ecological zones.

In addition to improve agronomic traits, improvement of external and internal fruit characteristics, resistance to pests and diseases, as well as tolerance to climatic stresses are the major targets for Musa variety development.

Grand Nine plants characterize with high yielding and resistant to different pests and diseases in a number of countries such as, Colombia **(Alvarez, 1997; Gonzalez *et al*., 2003**), Philippines (**Faylon *et al.,* 2004**), Sri Lanka **(Kudagamage, 2004)**, China **(Linbing *et al.*, 2004**), Indonesia **(Djatnika and Sutanto, 2005**) and Uganda (**Uazire *et al.,* 2008**) within a wide range of agro-ecologies.

The objectives of this study was to evaluate Banana crop growth and productivity by cultivating three different cultivars that may be adapt to Egyptian climate with higher fruit yield and quality and may have resistance to banana pests and diseases.

MATERIALS AND METHODS

This study was conducted in two successive seasons of 2016 and 2017, three Cavendish banana cultivars *(Musa acuminata* Colla, group AAA) produced by tissue culture (TC) were used for this trial, Zeef (imported from Jordan), Canary (imported from Spain) these cultivars with high characteristics for fruit quality were compared with Grand Nine (imported from Costa Reca) well grown under the Egyptian conditions. Plants were grown in a private orchard at El-Salhia El-Gededa District, Sharkia Governorate, Egypt, in a sandy soil. Trees were cultivated on March 2016 at 3.5×1.5 m distance; on June 2016 two suckers were selected beside each mother plant, and they subjected to the recommended banana orchard management. Drip irrigation was adopted 24 L/day per plant in summer and 12 l/day per plant in winter. Fertilization was applied with drip irrigation system by the recommended doses (N at 400 g/plant, K at 350-450 g/plant, and 1L phosphoric acid/fad., from April to October and (Fe at 250 g, Zn at 150 g, and Mn at 150 g were added weekly per faddan from May to August by fertigation.

Experimental Design

The experiment consisted of a total of three treatments (every cultivar was used as treatment) and each treatment consisted of eight plants, six plants of them were used as replicates and the other two plants were used as border, these treatments were distributed in the orchard in completely randomized design.

Measurements

Growth parameters

Plant length (cm) was measured using a measuring tape in two periods at the first week after planting, and after shooting. The plant length (cm) measured from the ground level to the neck of the inflorescence.

Number of suckers was counted at May in every season for the six trees of each treatment.

Number of functional leaves in May and at shooting period was counted; functional leaves had 50% of their surface area still green.

Number of days from shooting to harvesting was calculated.

Productivity parameters

At harvest (in December in both seasons) the data collected included, Bunch weight and the length and width of the longest finger of the third hand.

Finger length (cm) and width (cm) were measured using a measuring tape. This was done for the first, second seasons. Bunch weight (kg), finger length (cm) and finger width are important parameters in banana marketing.

Number of hands per bunch, number of fingers per hand and yield ton/fad was measured.

Quality Attributes

Total soluble solids (TSS) was measured using a hand Refractometer and results were expressed as Brix° **(Hazali *et al*., 2013)**.

The firmness of banana fruits was determined by the push/pull dynamometer (F D 101, Italy) was used for fruit penetration. The test was performed three times for each sample and means were taken. Results were expressed in g/cm^2.

Fruit pulp weight (g), and fruit peel weight (g) were measured by sensitive balance.

Percentage of pulp to fruit weight (%) was calculated as a percentage of total six fingers pulp weight to their total weight.

Color attributes lightness, L*; redness, a* and yellowness, b* of whole bananas fruits were conducted using Hunter Lab color analyzer (Hunter Lab Color Flex EZ, USA) according to **(Rao *et al*., 2011**). All tests were measured in triplicate samples.

Defense System Parameters

Determination of proline

The method of **Bates *et al., (*1973)** was used to determine proline accumulation in banana leaves. From the second fresh leaf material, 0.1 g was ground with 10 ml of 3% (*W/V*) aqueous sulpho salicylic acid and the homogenate filtered through Whatman 2 filter paper and one milliliter of filtrate was reacted with one milliliter acid ninhydrin reagent and one milliliter glacial acetic acid in test tube for one hour at 100^{o}C, and the reaction terminated in an ice bath. Two milliliters Toluene were added to the mixture and the upper toluene layer was measured at 520 nm using UV spectrophotometer.

Determination of total soluble sugars in leaves

Total soluble sugars content were assessed according to the method described by **Irigoyen *et al.* (1992)**.

Determination of antioxidants activities in leaves

Enzymes extraction was carried out according to the method reported by **Vitoria *et al.* (2001)**.

Catalase (CAT) was assayed spectro-photo-chemically according to **Chance and Maehly (1955)**.

Peroxidase (POD) activity was estimated by **Thomas *et al.* (1982)** method for banana leaves.

Ascorbate peroxidase (APX) was assayed spectro-photo-chemically according to **Fielding and Hall (1978)**.

Superoxide dimutase (SOD) activity was determined by recording the decrease in absorbance of superoxide-nitro blue tetrazolium complex by the enzyme **(Sairam *et al.*, 2002)**.

Glutathione reductase (GR) activity was measured after monitoring the oxidation of NADPH for the three absorbance taken at 340 nm, and the activity was expressed as A_{564} min^{-1} mg^{-1} protein **(Rao *et al.*, 1996)**.

Statistical Analysis

Data were analyzed using Statistics Analysis System (SAS) for analysis of variance (ANOVA) according to the methodology given by **Snedecor and William (1989**). Mean separation among cultivars was done using LSD at 5% level of probability

RESULTS

Growth Parameters

Growth parameters of the three evaluated cultivars are given in Figs. 1 and 2, whereas plant length at first week after planting showed that Zeef plants were significantly longer than Canary plants only in second season (2017), while no significant differences were found among all cultivars in first season (2016).

Also number of suckers was significantly higher in Zeef than Canary plants in first season (2016), as well in second season (2017) number of suckers indicted significant differences among the three cultivars as in Fig. 1B.

Functional leaves after planting showed significant differences among Zeef plants and the other cultivars in both seasons (2016) and (2017) as in Fig. 1C.

Plants length at shooting stage was significantly higher in Zeef plants than Grand Nine and Canary in (2016), while in the second season no significant differences were found among the three cultivars in plant length as in Fig. 1D.

Functional leaves at shooting period indicated no significant differences among all cultivars in both experimental seasons (2016) and (2017) as shown in Fig. 2A.

Numbers of days from shooting to maturity were significantly fewer in Zeef and Grand Nine compared to Canary plants in both seasons (2016 and 2017) as indicated in Fig. 2B.

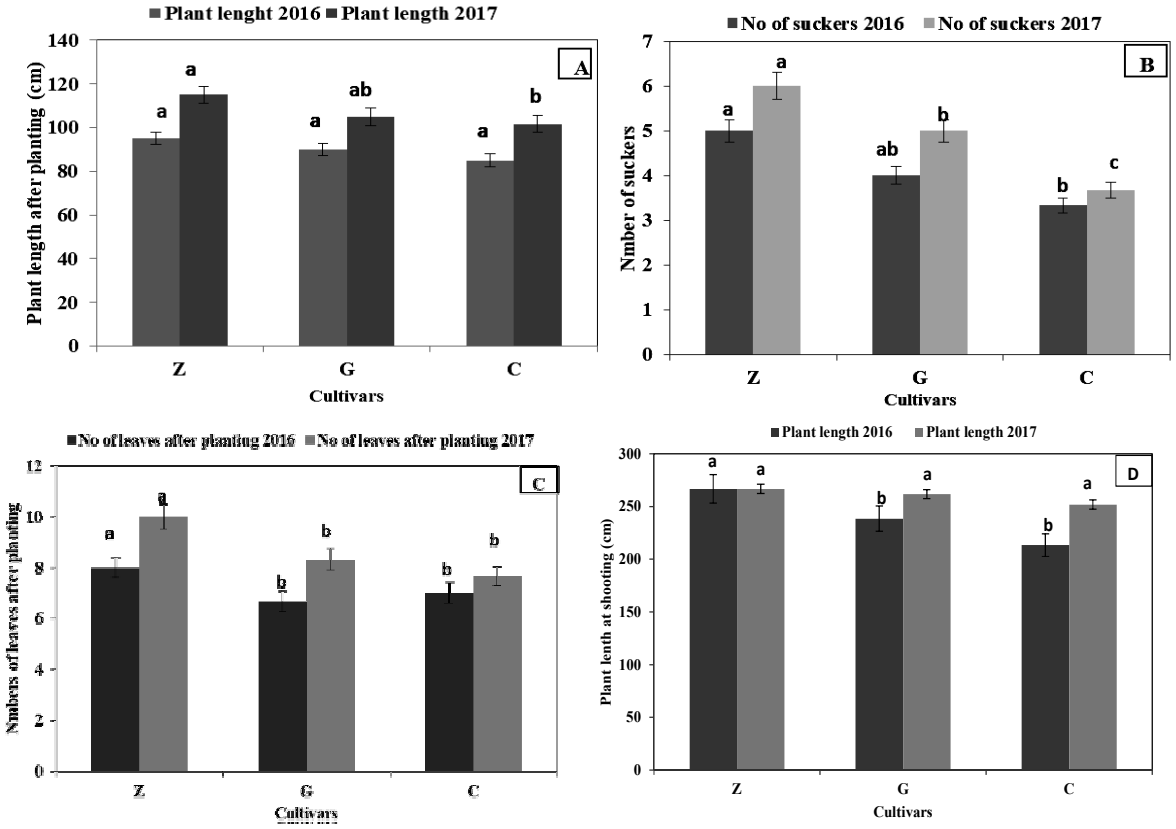

Fig. 1. (A) Average of plant length after planting (cm) for Zeef,(Z), Grand Nine(G) and Canary(C), (B) Average of number of suckers for the three cultivars,(C) Number of functional leaves after planting for the three cultivars, (D) Plant length at shooting period for the three cultivars in both seasons 2016 and 2017. Values are the average of 6 plants per cultivar, and the significant differences were calculated at LSD 0.05%

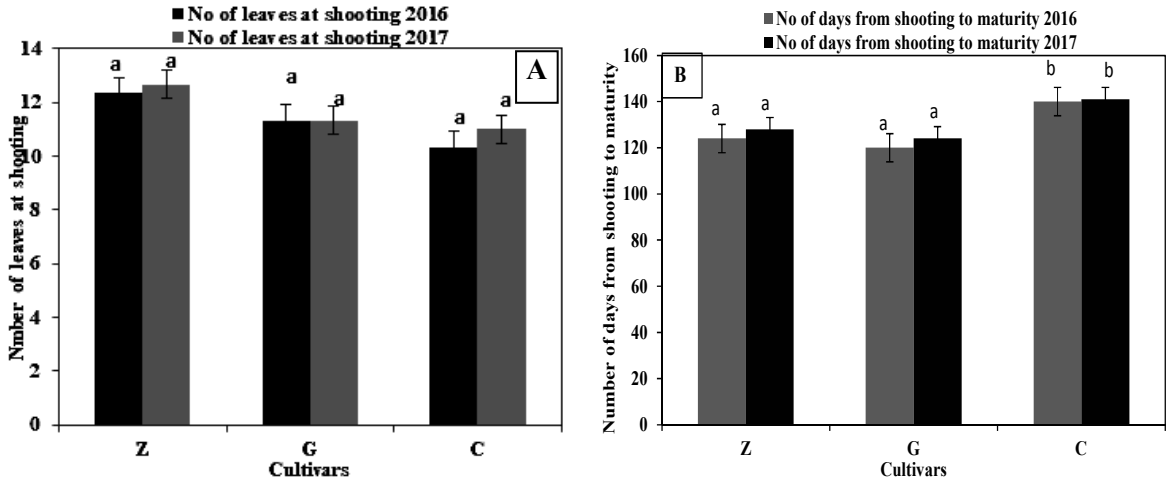

Fig. 2. (A) Number of functional leaves at shooting period for the three cultivars Zeef,(Z) Grand Nine (G) and Canary(C), (B) Number of days from shooting to maturity period in the three cultivars in both seasons 2016 and 2017. Values are the average of 6 plants per cultivar, and the significant differences were calculated at LSD 0.05%

Productivity Parameters

In general the second season (2017) was higher in yield and its components than the first season (2016) as indicated in Fig. 3. The total yield was significantly higher in Zeef than Grand Nine and canary cultivars in first season (2016), while in (2017) both Zeef and Grand Nine cultivars yield was significantly higher than Canary yield as indicated in Fig. 3A.

Also bunch weight was significantly higher in Zeef and Grand Nine cultivars than Canary in both first and second seasons as shown in Fig. 3B. Also bunch length was significantly higher in Zeef and Grand Nine cultivars than Canary cultivar in first season (2016). As well, in second season (2017) bunch length indicated significant difference among all cultivars as shown in Fig. 3C.

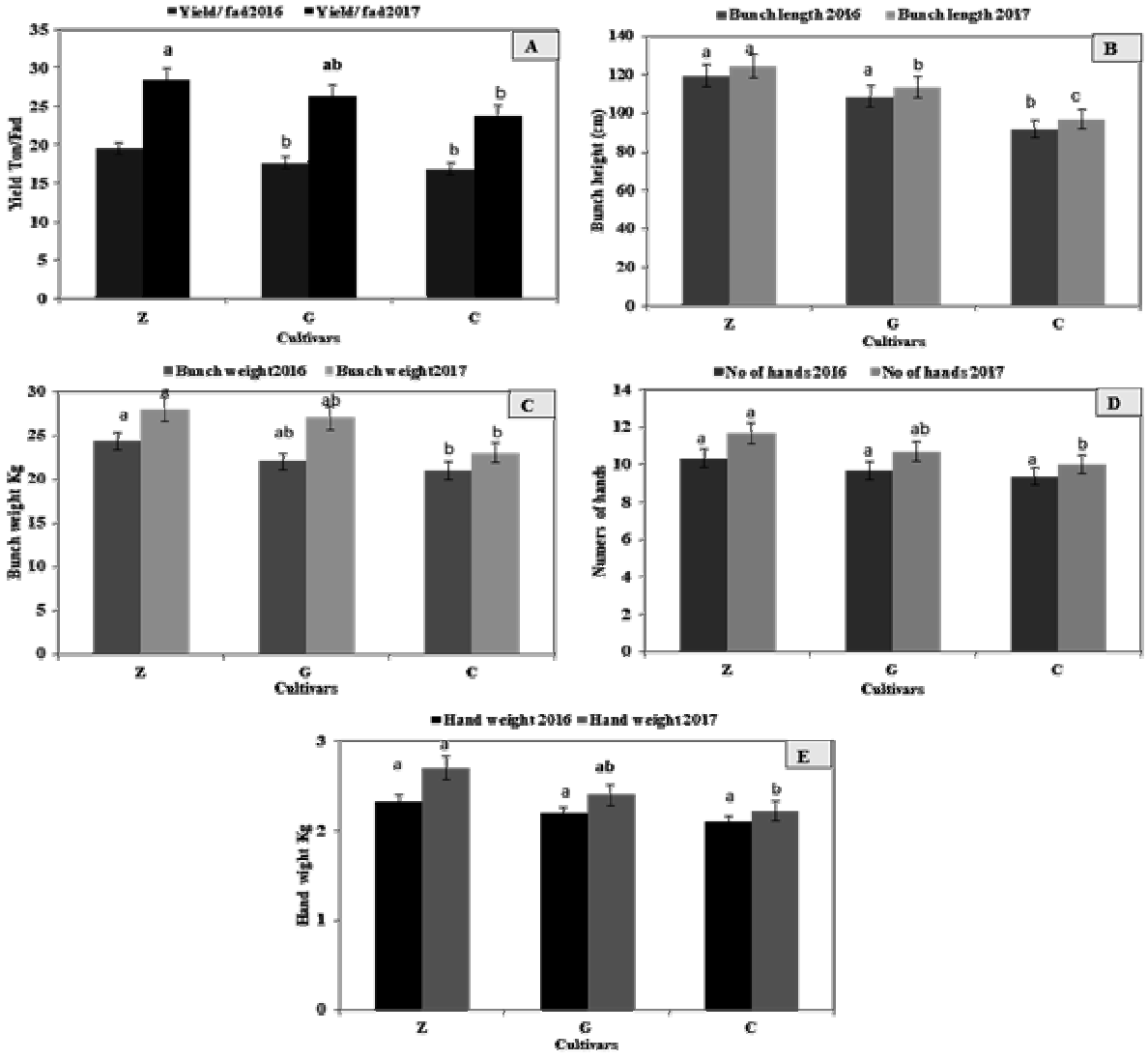

Fig. 3. (A) Average of total yield ton per faddan for Zeef,(Z) Grand Nine(G) and Canary(C), (B) Bunch length (cm) for the three cultivars,(C) Bunch weight (kg) for the three cultivars, (D) Number of hands for the three cultivars, (E) Average of hand weight (kg) for the three cultivars in both seasons 2016 and 2017. Values are the average of 6 plants per cultivar, and the significant differences were calculated at LSD 0.05%

No significant differences were found among the three cultivars in number of fingers in both experimental seasons (2016) and (2017) as shown in Fig. 4A. While finger weight indicated significant differences among the three cultivars in first season (2016), Moreover Zeef had higher significant finger weight than both Grand Nine and Canary in second season (2017) as shown in Fig. 4B. The same trend was found in finger length as it showed significant differences among all treatments in first season (2016), while in second season (2017) Zeef and Grand Nine Nine cultivars had higher finger length more than Canary variety as shown in Fig. 4C. Also finger diameter in both Zeef and Grand Nine was significantly higher than Canary cultivar in both seasons (2016 and 2017) as shown in Fig. 4D.

Quality Parameters

It was clearly noticed in Table 1 that no significant differences were found among the three cultivars in quality parameters such as total soluble solids TSS, firmness, fruit peel weight, and the percentage of pulp to fruit weight in both seasons (2016 and 2017), the only significant differences was found among Zeef and Canary in fruit pulp weight in 2016.

Color attributes in Table 2 indicate that lightness, L* was significantly higher in both Zeef and Canary than Grand Nine in both seasons (2016 and 2017), redness, a* in 2016 indicated no significant differences among the three cultivars, only Grand Nine was significantly higher than Zeef in 2017. While in 2016 yellowness, b* was significantly higher in Canary than Grand Nine, in 2017 Zeef and Canary were significantly higher than Grand Nine.

The Defense System Parameters

Significant differences were indicated among Zeef, Grand Nine and Canary in both seasons in proline, total solibul sugar, and antioxidant enzymes CAT, POX, APX, SOD and GR as indicated in Table 3. This result indicated that Zeef and Grnad Nine were more tolerant to biotic and a biotic stress, moreover it could be more tolerant to banana diseases.

DISCUSSION

In this study, it is clearly noticed the effect of the genotypes was significant on growth characteristics as Zeef plants had significant growth compared to Canary plants, while similar growth was found in Zeef and Grand Nine, the only difference that Zeef plants were slightly taller than Grand Nine plants. The same trend was found in yield and productivity components, while quality characters were unaffected by genotypes as no significant were detected among the three Cultivars in the most of quality components. Varied responses of morphological characters were recorded by other authors that most yield components are influenced by genotypes and seasons with different magnitudes. **Tenkouano and Baiyeri (2007**) reported that both genotypes and season significantly influence the performance of yield and other growth characters in banana cultivars. In a similar study the season affected growth and yield parameters, except the number of days from shooting to maturity (**Gaidashova, *et al.* 2008)**.

In addition, in this research it could be noted that banana productivity may not only depend on the plant length and the number of functional or total leaves at shooting; other factors must be taken in consideration. The same results had been conducted by **Nguthi *et al.* (1999**). For example Zeef cultivar had the highest yield yet it had similar leaves with Canary, which had the lowest yield. Therefore, genotype could be a more critical factor in determining the yield potential of a given cultivar. It was also established that, the cultivars such as Zeef and Grand Nine with longer finger also had slender ones. This is an important parameter because the market preference for dessert bananas is mainly for long and slender fingers **(Mbogoh *et al*., 2003)**.

The present study indicated that Zeef and Grand Nine cultivars were significant for antioxidant enzymes CAT, POX, APX, SOD and GR activity. This result reflects that those cultivars had stronger defense system against banana diseases more than Canary cultivar.

Banana cultivars with high concentrations of antioxidants enzymes could be tolerant to biotic or abiotic stresses which cause generation of reactive oxygen species (ROS), such as H_2O_2, super oxide (O-2), hydroxyl radicals (OH-) **(Lin and Kao, 2001; Tsai *et al*., 2004)**. Generation of ROS causes oxidative stress on plants

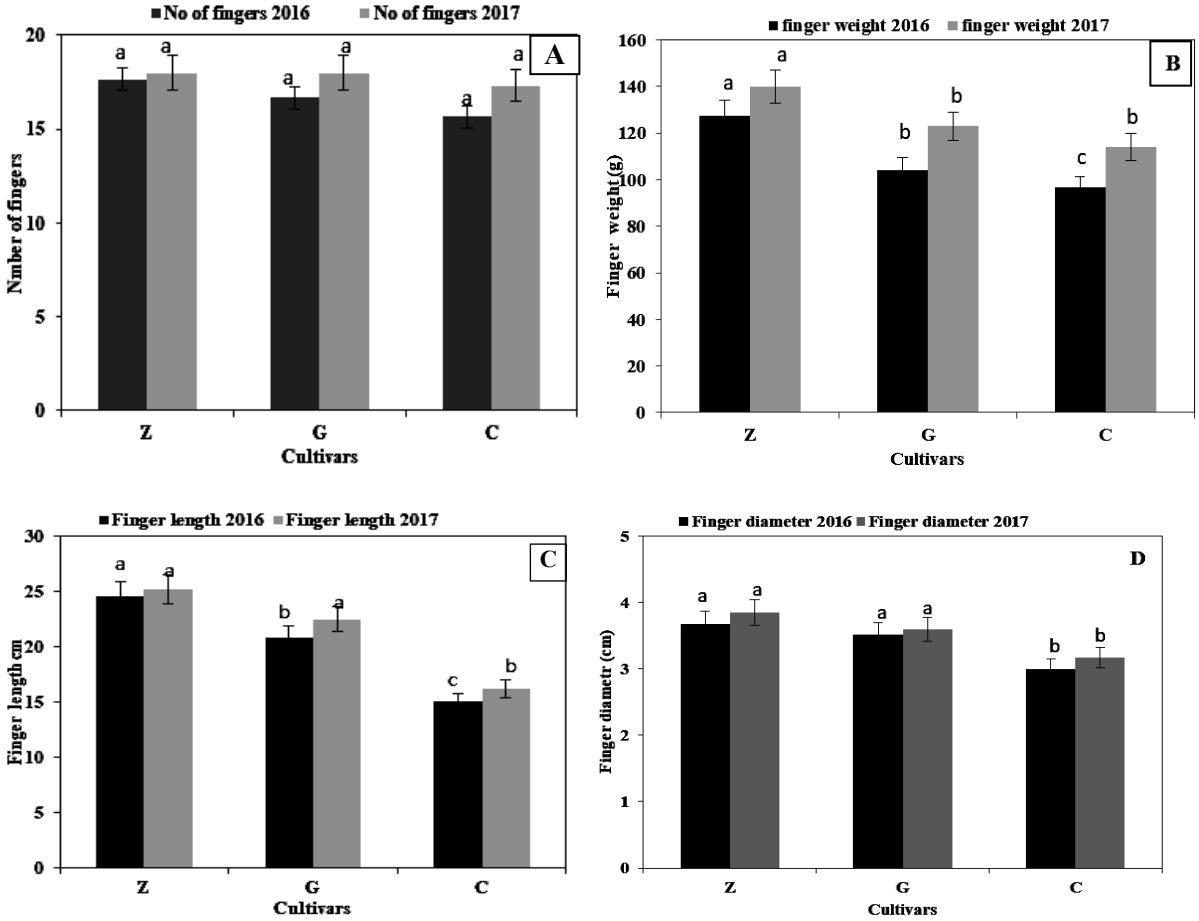

Fig. 4. (A) Number of fingers for Zeef,(Z), Grand Nine(G) and Canary(C), (B) Average of finger weight (g) for the three cultivars, (C) Finger length (cm) for the three cultivars, (D) Finger diameter (cm) for the three cultivars in both seasons 2016 and 2017. Values are the average of 6 plants per cultivar, and the significant differences were calculated at LSD 0.05%

Table 1. Total soluble solids (Brix^{o}), firmness, fruit pulp weight (g), fruit peel weight (g), and percentage of pulp to fruit weight (%) for the three cultivars in both seasons 2016 and 2017

Banana cultivars	TSS (Brix^{o}),	Firmness (g/cm^{2})	Fruit pulp weight (g)	Fruit peel weight (g)	Percentage of pulp to fruit weight (%)
			2016 Season		
Zeef	5.00 a*	788.33 a	101.00 a	51.00 a	79.37 a
Grand Nine	5.00 a	764.67 a	79.00 ab	48.67 a	75.46 a
Canary	4.83 a	748.67 a	70.00 b	48.33 a	72.16 a
			2017 Season		
Zeef	7.33 a	821.00 a	90.67 a	44.67 a	70.06 a
Grand Nine	7.33 a	747.33 a	84.00 a	42.33 a	69.03 a
Canary	7.00 a	750.33 a	77.33 a	41.00 a	67.77 a

*Values are the average of 6 plants per cultivar, and the significant differences were calculated at LSD 0.05 %.Means having the same letters in each column are insignificantly different.

Table 2. Color attributes (lightness, L*; redness, a* and yellowness, b*) for the three cultivars in both seasons 2016 and 2017

Banana cultivars	Lightness	Reedness	Yellowness
		2016 Season	
Zeef	41.04 a*	2.86 a	16.44 ab
Grand Nine	34.84 b	2.26 a	15.73 b
Canary	39.45 a	1.87 a	17.98 a
		2017 Season	
Zeef	45.67 a	2.29 b	21.08 a
Grand Nine	38.83 b	3.47 a	15.78 b
Canary	46.75 a	2.77 ab	22.36 a

* Values are the average of 6 plants per cultivar, and the significant differences were calculated at LSD 0.05%. Means having the same letters in each column are insignificantly different.

Table 3. Analyses of proline, soluble sugar, superoxide dismutase (SOD), catalase(CAT), peroxidase (POX), ascorbate peroxidase(APX), glutathione reductase (GR) for leaves of Zeef, Grand Nine and Canary cultivars in 2016 and 2017

Cultivar	Proline (µg g^{-1})		Soluble sugar (%)		SOD		CAT		POX		APX		GR	
					A564 min^{-1} g^{-1} protein									
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Z	30.3a*	31.5a	5.11a	5.19a	7.14a	7.22a	68.1a	66.7a	1.52a	1.43a	77.2a	76.5a	53.9a	52.9a
G	29.6a	30.1a	4.98a	4.13a	6.19a	6.69a	64.2a	63.5a	1.25a	1.32a	74.3a	73.8a	52.6a	52.3a
C	22.6b	21.5b	2.12b	2.42b	3.12b	3.36b	55.1b	55.7b	0.75b	0.88b	61.2b	52.6b	35.2b	36.9b

* Values are the average of 6 plants per cultivar Zeef(Z), Grand Nine(G) and Canary(C), and the significant differences were calculated at LSD 0.05 %. Means having the same letters in each column are insignificantly different.

(Cheeseman, 2007) because these ROS cuases damages in chlorophyll, protein, DNA and membrane functions. To repair and alleviate damage caused by ROS, plants have developed a complex antioxidant system **(Halliwell and Gutteridge, 2007)**. To avert the oxidative damage caused by biotic or abiotic stress, Banana plants have sophisticated many antioxidant systems; through enzymatic ones, SOD considered the first line of defense against ROS **(Alscher *et al*., 2002; Merwad *et al*., 2018)** which reducing the O_2•− radical to H_2O_2. CAT enzymes used H_2O_2 as substrate which in turn though located in the peroxysomes where the H_2O_2 concentration is very high, is absent in the cytosol and chloroplasts, and thus peroxidases eliminated H_2O_2. These include APX, which are most important enzymes in the reduction of this ROS **(Foyer, 1996; Feierabend, 2005).**

Increased accumulation of proline in Zeef and Grand Nine banana cultivars may be an adaptation to compensate for the energy for growth and survival and thereby help the plant tolerate the different stresses, similar finding was recorded by **Chandrasekhar and Sandhyarani (1996)**.

Soluble sugars also were significantly higher in Zeef and Grand Nine plants. They participate to osmotic adjustment **(Hayashi *et al.*, 1997)** and can directly or indirectly modify the genes expression involved in metabolic processes, storage functions, and defense **(Hebers and Sonnewald, 1998).**

Besides having higher yield potential, some of the promising cultivars, Zeef and Grand Nine, have been reported to have resistance to banana diseases.

In this work there were considerable differences among the three cultivars in term of time taken from shooting to bunch maturity; this result may be related with the ecological diversity of these cultivars as they emergence of different agro ecological regions.

In this study it could be noted that cultivars which took shorter time to shooting were also early in reaching to maturity. For example cultivars like Grand Nine and Zeef, were the first ones to shoot and were also the first ones to mature. Early maturity is a desirable characteristic because such cultivars are more preferred to give higher yields over time.

Bunches from second season were generally heavier than those from first one. The better performance of second season, compared with the first one, could be related with the better plant establishment at the latter season than in the first one. The same results were indicated by **Nguthi *et al.* (1999)**. In general cultivars such as Zeef and Grand Nine had bigger bunches and longer fingers than those with smaller ones. Market normally prefers cultivars with long fingers.

Conclusion

Results of this study indicated that cultivars such Zeef and Grand Nine are considered promising cultivars for the Egyptian environmental conditions as it had high production with high quality, Also Zeef plants and Grand Nine were significantly higher in antioxidants enzymes, soluble sugars and proline, so it considered tolerant to biotic and abiotic stresses.

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دراسة مقارنه علي نمو وانتاجية بعض اصناف الموز تحت الظروف المصرية

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أجريت هذه الدراسة لتحسين نمو وانتاجية محصول الموز عن طريق زراعة اصناف جديده قد تكون اكثر تحملا لامراض الموز وتتميز بالانتاجيه والجوده العالية، لذلك تم زراعة ثلاثة اصناف مستورده من الخارج وهي Zeef- Grand Nine- و Canary في احد المزارع الخاصه في منطقة الصالحيه الجديده بمحافظة الشرقية مصر، في خلال موسمين متتاليين ٢٠١٦ و٢٠١٧، ولقد أوضحت النتائج المتحصل عليها من هذا العمل ان صنفي Zeef وGrand Nine كانت اكثر معنويه في مقاييس النمو علي سبيل المثال طول النبات وكذلك عدد الأوراق الفعالة علي النبات بالمقارنه بصنف Canary، كذلك مقاييس الإنتاجية مثل المحصول الكلي، ووزن السوباطه، وطول السوباطه، وطول واستدارة الأصابع كانت أكثر معنوية في صنفي Zeef وGrand Nine بالمقارنه بCanary، بينما لم نلاحظ اي فروق معنويه في مقاييس الجوده في الثلاثة اصناف في موسمي الدراسة، كذلك أوضحت النتائج أن جميع المقاييس الخضريه والثمريه في الموسم الثاني (الخلفة الأولى) كانت أفضل من الموسم الاول (الأمهات) في الثلاثة أصناف، كذلك أوضحت النتائج أن قيم الإنزيمات المضادة للأكسدة والسكريات الذائبة والبرولين كانت أكثر معنوية في صنفي Zeef وGrand Nine بالمقارنه بCanary، وهذا يعكس مدى قوة الجهاز المناعي لهذه الاصناف وبالتالي كانت هذه الأصناف أكثر تحملا لأمراض الموز من صنف Canary، لذلك من خلال التقييم العام لهذه الأصناف أثبتت أصناف Zeef وGrand Nine بانها اصناف واعده للزراعه تحت الظروف المصريه حيث تتميز بالانتاجيه العاليه والمقاومه للاجهادات الحيويه واللاحيويه المختلفة.

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