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(Original Article)

Effect of Planting Dates on Vegetative Growth, Yield and Quality of Some Genotypes of Spinach (*Spinacia oleraceae* L.)

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Abstract

This experiment was carried out at the Vegetables Farm, Faculty of Agriculture, Assiut University for two successive seasons (2019/2020 and 2020/2021) to study the effect of three different planting dates (1st November 1st December and 1st January) on vegetative growth, yield and quality in four spinach genotypes (Dash F_1 hybrid, SCO-017 F_1 hybrid, Green Shine F_1 hybrid and Balady local Cultivar)

Statistical analysis of the data revealed a significant interaction between four genotypes and three planting date. The tallest plant, the highest number of leaves per plant and the highest plant fresh weight were obtained from Dash, F_1 hybrid and SCO-017 F_1 hybrid when sowing on the first planting date (1 Nov) in the first and second season, respectively.

These results may be due to the favorable weather with the first planting date and the adaptation of these F_1 hybrids to these conditions. Thus, it can be concluded that Hybrid Dash grows better in early sowing (autumn sowing, Nov. 1st) and its growth is significantly affected in late sowing (winter sowing, Jan. 1st).

Keywords: *Sowing date، planting date، Vegetative Growth، Vitamin C in Spinach، Spinacia oleraceae L*

Introduction

A leafy vegetable belonging to the *Chenopodiaceae* family is spinach (Hassler, 2018). An annual plant, spinach has distinct vegetative and reproductive growth phases. (Van der Vossen, 2004; Krarup and Moreira, 1998). There are numerous cultivars with distinctive leaf characteristics, ranging from flat to crinkly [savoy] texture and from round to hastate shape (Morelock and Correll, 2008). There are now spinach variants that can grow in many climates and photoperiods. Spinach is abundant in vitamins and minerals (Morelock and Correll, 2008; Roberts and Moreau, 2016). Spinach has a far wider range of minerals and vitamins than other popular leafy green veggies (Roberts and Moreau, 2016). It's interesting because it contains a lot of Vitamin B9 [folate], one of the Essential Medicines

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identified by the (WHO, 2017) that is used as a supplement during pregnancy and to prevent anemia (Bibbins-Domingo *et al*., 2017 and De Benoist, 2008). Spinach also has substantial levels of carotenoids (e.g., vitamin A, lutein, and zeaxanthin) (Bunea *et al.,* 2008), which are known to be good antioxidants and reactive oxygen species [ROS] scavengers (Issa *et al*., 2006). Moreover, spinach contains other molecules with high antioxidant properties, like vitamin C and vitamin E (Chun *et al*., 2005). Other phytochemicals, in the form of phenolic compounds, are notably present in the crop (Chu *et al.,* 2002; Issa *et al.,* 2006; Pandjaitan *et al.,* 2005). Phenolics include compounds such as flavonoids and polyphenols and many of them have antioxidant properties (Lin *et al.,* 2016).

Sowing date is an important factor that affects plant growth and production. It is related to environmental conditions e.g., temperature, day length, light intensity, and humidity. The suitable sowing date provides the optimum environmental conditions for spinach growing. Sowing mid-October exhibited the highest vegetative growth values and yield of spinach plants as compared to sowing November. (Waseem and Nadeem, 2001; Ramadan, 2004; Ibrahim *et al*, 2010; Sensoy *et al*., 2011). Delaying sowing date after October cause a decrease in spinach yield (Ramadan, 2004; Sensoy *et al*., 2011; Ibrahim *et al*., 2012,). Plants subjected to long days especially coupled with high temperatures above 25º C induce bolting which reduce the production of spinach crop (Hata *et al,* 2006). So, spring sowing encountered the problem of bolting which is detrimental to production of spinach. The yield of spinach depends on vegetative growth. It may be expressed in terms of number of leaves, plant heigh and weight.

The aim of the current study is investigating the effect of different planting dates on vegetative growth, yield, and quality of some spinach genotypes.

Materials and Methods

This study was carried out at the Vegetables Farm, Faculty of Agriculture, Assiut University for two successive seasons (2019 and 2020) to investigate the Influence of four genotypes and three planting dates on vegetative growth, quality, and yield of spinach (*Spinacia oleracea* L.).

Planting dates used in the experiment

1) First of November.
2) First of December.
3) First of January.

Spinach Genotypes used in the experiment

1- ‘Dash’, F_1 hybrid.

2- ‘SCO-017’, F_1 hybrid.

3- ‘Green Shine’ F_1 hybrid.

4- ‘Balady’, local cultivar.

The monthly average maximum (Max.) and minimum (Min.) temperatures during the growth seasons of spinach plants are shown in Table (1):

Table 1. The maximum and minimum temperatures during 2019/2020 and 2020/2021 seasons.

Months	2019-2020		2020-2021	
	Max	Min	Max	Min
November	28.1	14.0	24.6	13.3
December	21.3	8.0	23.0	9.9
January	18.1	6.0	20.9	6.5

Data

A random sample of 10 spinach plants taken from each-plot, at every cutting time, to determine the following parameters:

Plant height (cm)

Plant height measured from the surface of root tips to the tip of highest leaf.

Number of leaves per plant

The total number of leaves emerged in the spinach plants in each plot counted based on randomly selected ten plants and then averages calculated.

Plant fresh weight (gm)

Immediately following each harvest, whole fresh weights of plants for each plot acquired with a portable digital scale and recorded in grams.

Vitamin C content (mg/100g FW)

Ascorbic acid content (V.C) (mg / 100 ml juice): Vitamin C was determined by the method described by A.O.A.C. (1995).

Experimental Setup and data analysis

Three separate experiments were done during sowing seasons 2019/2020 and 2020/2021. Each experiment consisted of four spinach genotypes in a randomized complete block design with three replications then a combined analysis was done over the three experiments in each season. Each experimental plot was 10.5 m^2 (five ridges 60 cm wide and 3.5 m long).

The analysis of variance was performed using Proc Mixed of SAS package version 9.2 (SAS 2008) and means were compared by least significant difference (LSD) at 5% level of significance (Steel and Torrie, 1981).

Results and Discussion

Plant height

Data presented in Table 2 clearly show that plant height was significantly affected by genotypes in both seasons. SCO-017 F_1 hybrid hadwhileallest plants (45.04 and 46.01 cm) while, the shortest plants (32.39 and 34.83 cm) were obtained from Green Shine F_1 hybrid in the first and second season, respectively.

Concerning planting date data revealed that planting dates significantly affected plant height in both seasons (Table 2). However, the highest values of this trait (45.72 and 49.13 cm) were produced by the first planting date (1st Nov) the first and second season, respectively. On the other hand, the third planting date (1st Jan) significantly decreased plant height in both seasons.

Regarding the interaction between the two studied factors, data in Table (2) show that the interactions significantly affected this character in both seasons. The tallest plants (51.73 and 57.12 cm) were achieved by the first planting date (1st Nov) for Dash, F1 hybrid and SCO-017 F_1 hybrid in the first and second season, respectively. While the shortest plants (23.90 and 27.09 cm) were obtained from the third planting date (1st Jan) for Green Shine F_1 hybrid in the first and second season, respectively. These findings could be explained by the favorable environmental conditions, whereas delayed sowing dates would reduce yield production. That agree with Abed and Shebl (2016).

Table 2. Plant height of four Spinach Genotypes as influenced by planting dates in2019-2020 and 2020-2021 seasons

Genotypes	Planting date (2019 – 2020 season)				
	1st Nov	1st Dec	1st Jan	Mean	L.S.D 5%
Dash, F_1 hybrid	51.73 **a**	41.19 **cd**	28.52 **h**	**40.48 B**	**1.53**
SCO-017 F_1 hybrid	50.57 **a**	45.28 **b**	39.27 **de**	**45.04 A**	
Green Shine F_1 hybrid	38.58 **ef**	34.72 **g**	23.90 **i**	**32.39 D**	
Balady local cultivar.	42.00 **c**	36.40 **fg**	27.50 **h**	**33.03 C**	
Mean	**45.72 A**	**39.39 B**	**29.79 C**	**2.49**	
L.S.D 5%		**1.32**			
Genotypes	**Planting date (2020-2021 season)**				
	1st Nov	**1st Dec**	**1st Jan**	**Mean**	**L.S.D 5%**
Dash, F_1 hybrid	52.28 **b**	45.33 cd	37.21 f	**44.94 B**	**0.98**
SCO-017 F_1 hybrid	57.12 a	43.78 d	37.12 f	**46.01 A**	
Green Shine F_1 hybrid	40.71 e	36.71 f	27.09 g	**34.83 D**	
Balady local cultivar.	46.43 c	40.47 e	27.19 g	**38.03 C**	
Mean	**49.13 A**	**41.57 B**	**32.15 C**	**1.76**	
L.S.D 5%		**0.85**			

Number of leaves per plant

Data illustrated in Table 3 clearly obviously show that Spanish genotypes significantly affected the number of leaves per plant in both seasons. SCO-017 F1 hybrid and Green Shine F1 hybrid gave the highest values (28.5 and 30.82) for this character in the in the first and second season, respectively. While Balady local cultivar gave the lowest values (26.31 and 27.68) in first and second seasons respectively. because Balady cultivar is inability to adapt to high temperatures as shown in table 1.

Planting date significantly affected this character in the two studied seasons (Table 3). The highest number of leaves per plant (31.58 and 33.99) were recorded by sowing Spinach seeds on the first planting date (1 November) in the first and second seasons, respectively. On the other hand, the lowest values for this trait

(22.54 and 23.76). were resulted in sowing Spinach seeds on the third planting date (1 Jan) in the first and second seasons, respectively.

With respect to the interaction between the two studied factors, data in Table (3) show that the interactions significantly affected this trait in both seasons. The highest number of leaves per plant (32.73 and 37.35) was achieved by sowing at the first planting date (1st Nov) for SCO-017 F_1 hybrid and Dash F_1 hybrid in the first and second seasons, respectively. The lowest values (20.62 and 19.23) were recorded for Dash, F_1 hybrid in sown on the third planting date (1st Jan) in the first and second season, respectively. These results may be due to the appropriate weather with the first planting date and the adaptation of these, F_1 hybrid to these conditions.

Thus, it can be concluded that the hybrid Dash grows best in early sowing (autumn sowing, 1st Nov.) and its growth is greatly affected in late sowing (winter sowing, 1st Jan.). Dash, F_1 hybrid is suitable for autumn planting (November 1) and its growth is greatly affected in winter planting (January 1). Several investigations confirmed that the early sowing dates led to an increase in vegetative characters compared to the late sowing dates. (Waseem *et al*., 2000; Ramadan, 2004; Ibrahim *et al*., 2010; Sensoy *et al*, 2011 and Ibrahim *et al*, 2012).

Table 3. Number of leaves per plant of four Spinach genotypes as influenced by planting dates in2019-2020 and 2020-2021 seasons

Genotypes	Planting date (2019 – 2020 season)				
	1st Nov	1st Dec	1st Jan.	Mean	L.S.D 5%
Dash, F_1 hybrid	31.33 a	28.30 b	20.62 f	**26.75 B**	**1.28**
SCO-017 F_1 hybrid	32.73 a	28.45 b	24.31 de	**28.50 A**	
Green Shine F_1 hybrid	31.08 a	26.99 bc	22.85 e	**26.97 B**	
Balady local cultivar.	31.18 a	25.38 cd	22.37 ef	**26.31 B**	
Mean	**31.58 A**	**27.28 B**	**22.53 C**	**2.03**	
L.S.D 5%		**0.85**			
Genotypes	**Planting date (2020-2021 season)**				
	1st Nov	**1st Dec**	**1st Jan.**	**Mean**	**L.S.D 5%**
Dash, F_1 hybrid	37.35 a	31.79 cd	19.23 g	**29.46 B**	**1.07**
SCO-017 F_1 hybrid	32.58 bc	27.18 e	24.28 f	**28.01 C**	
Green Shine F_1 hybrid	34.13 b	30.72 d	27.61e	**30.82 A**	
Balady local cultivar.	31.91 cd	27.22 e	23.92 f	**27.68 C**	
Mean	**33.99 A**	**29.23 B**	**23.76 C**	**1.85**	
L.S.D 5%		**0.93**			

Plant Fresh Weight (gm)

Results in Table 4 indicated that Spinach genotypes was significantly affected plant fresh weight in both seasons. The highest values (196.21 and 193.14 gm) resulted from Dash F_1 hybrid and SCO-017 F_1 hybrid in the first and second seasons, respectively. While Balady local cultivar gave the lowest values (176.39 and 179.48 gm) in first and second seasons, respectively. This is because the Baladi

cultivar does not tolerate heigh temperatures, which led to the efflorescence of the plant and the lack of yield.

Table 4 also reveals that plant fresh weight significantly affected by planting date in both seasons. The highest values (203.35 and 203.03 gm) were produced by first planting date (1st Nov.) in the first and second seasons, respectively. These results can be attributed to the increments induced in the number of leaves per plant achieved by the planting date. These results are in agreements with those reported by (Waseem *et al*., 2000; Ramadan, 2004; Ibrahim *et al*., 2010; Sensoy *et al*, 2011 and Ibrahim *et al*, 2012).

The combination between the two studied factors (Table 4) indicated that the interactions significantly affected this character in both seasons. Dash, F_1 hybrid and SCO-017 F_1 hybrid sown on the first planting date (1st Nov.) yielded the highest values (214.75 and 212.80 gm) in the first and second season, respectively. The lowest values (164.32 and 161.30 gm) were recorded for Balady local cultivar and Dash, F_1 hybrid on the third planting date (1st Jan) in the first and second season, respectively.

These results may be due to the appropriate weather with the first planting date and the adaptation of these, F_1 hybrids to these conditions. Thus, it can be said that the hybrid Dash is suitable for early (autumn) cultivation and is not suitable for late (winter) cultivation.

These findings could be explained by the favorable environmental conditions, whereas delayed sowing dates would reduce yield production. That agree with (Abed, M. Y., and Shebl, E. F. 2016).

Several investigations confirmed that the earlier sowing dates produced larger fresh comparison with late sowing dates. (Waseem *et al*., 2000; Ramadan, 2004; Ibrahim *et al*., 2010; Sensoy *et al*, 2011 and Ibrahim *et al*, 2012,

Table 4. Plant Fresh Weight (gm) of four Spinach genotypes as influenced by planting dates in2019-2020 and 2020-2021 seasons.

Genotypes	Planting date (2019 – 2020 season)				
	1st Nov	1st Dec	1st Jan.	Mean	L.S.D 5%
Dash, F_1 hybrid	214.75 a	202.81 b	171.07 e	**196.21 A**	**3.73**
SCO-017 F_1 hybrid	213.38 a	193.25 c	180.50 d	**195.71 A**	
Green Shine F_1 hybrid	200.08 b	183.00 d	166.42 ef	**183.17 B**	
Balady local cultivar.	185.19 d	179.67 d	164.32f	**176.39 C**	
Mean	**203.35 A**	**189.68 B**	**170.58 C**	**6.44**	
L.S.D 5%		**3.23**			
Genotypes	**Planting date (2020-2021 season)**				
	1st Nov	**1st Dec**	**1st Jan.**	**Mean**	**L.S.D 5%**
Dash, F_1 hybrid	208.80 a	193.65 c	161.30 g	**187.92 B**	**2.42**
SCO-017 F_1 hybrid	212.80 a	187.80 d	178.83 e	**193.14 A**	
Green Shine F_1 hybrid	201.13 b	190.24 cd	181.28 e	**190.88 A**	
Balady local cultivar.	189.40 d	181.30 e	167.75 f	**179.48 A**	
Mean	**203.03 A**	**188.25 B**	**172.29 C**	**4.03**	
L.S.D 5%		**2.09**			

Vitamin C content (mg/100g FW)

Data presented in Table 5 clearly show that vitamin C contents was significantly affected by genotypes in both seasons. SCO-017 F_1 hybrid recorded highest value (50.63 mg/100 g Fresh weight) while, the lowest value (37.86 mg/100 g Fresh weight) were obtained from Dash F_1 hybrid.

Concerning planting date data revealed that planting dates significantly affected vitamin C content (Table 5). However, the highest values of this trait (60.35) were produced by the first planting date (1st December). On the other hand, the third planting date (1st Jan) significantly decreased vitamin C.

Table 5. Vitamin C content (mg/100g FW) of four Spinach genotypes as influenced by planting dates 2020-2021 Season

Genotypes	Planting date (2019 – 2020 season)			
	1st Nov	1st Dec	1st Jan.	Mean
Dash, F1 hybrid	34.27	52.42	26.9	37.86
SCO-017 F1 hybrid	49.47	67.22	35.2	50.63
Green Shine F1 hybrid	46.18	58.92	29.27	44.79
Balady local cultivar	50.32	62.84	36.15	49.77
Mean	45.06	60.35	31.88	

Results in Table 5 clearly show that Spinach genotypes differed significantly in Vitamin C content. SCO-017 F_1 hybrid gave the highest Vitamin C content (50.63 mg/100g FW) as compared to the lowest values for this character was obtained from Dash, F_1 hybrid. This is due to the different variety or plant, where the amount of vitamin varies Planting. Vitamin C significantly affected by the temperatures before harvest. liked same general trend were found by (Tamura, A. 2004)

data significantly affected this character (Table 5). The highest value (60.35 mg/100g FW) was obtained from second planting date (1st Nov.) as compared to the lowest value (31.88 mg/100g FW) produced by third planting date (1 Jan.). that same trend with (Tressler, 1936) found that spinach stored most of its vitamin C [ascorbic acid] content in the leaves and that the amount present depended upon the variety of plant and upon the soil in which it was grown, particularly the latter. At low temperatures the leaves lost their store of vitamin very slowly. -S. W. Johnson

The combination between the two studied factors significantly affected Vitamin C content. SCO-017 F_1 hybrid sown on second planting date (1 Dec.) gave the highest Vitamin C content (67.22 mg/100g FW). Green Shine F_1 hybrid sown on third planting date (1 Jan.) gave the lowest Vitamin C content (29.27 mg/100g FW). Because that Vitamin content decreases at elevated temperatures. These results could be attributed to the more favorable weather on 1st November than it was on 1st December and 1st January. (Table 1). When comparison to the lower temperatures on 1st December and1st January 1st November's comparatively high temperature promotes vegetative development. this is consistent with Ibrahim *et al*., (2012)

In comparison to earlier sowing dates, December brought about a considerable fall in yield and its component features. Numerous studies showed that compared to later sowing dates, earlier sowing dates yielded higher fresh and overall yields. This agrees with (Waseem *et al.,* 2000; Ramadan, 2004; Ibrahim *et al.,* 2010; Sensoy *et al.,* 2011 and Ibrahim *et al.,* 2012).

Conclusion

Under the conditions of this experiment, it is evident that the cultivation date of spinach was dependent on genotype as evidenced by the significant interaction between these two factors. The tallest plant, the highest number of leaves per plant and the highest plant fresh weight were obtained from Dash, F_1 hybrid and SCO-017 F_1 hybrid when sowing on the first planting date (1st Nov) in the first and second season, respectively. It can be concluded that Hybrid Dash grows better in early sowing (autumn sowing, 1st Nov.) and its growth is significantly affected in late sowing (winter sowing, 1st Jan.).

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تأثير مواعيد الزراعة على النمو الخضـــري والمحصـــول وجودته لبعض التراكيب الوراثية في السبانخ (*Spinacia oleraceae* L.)

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الملخص

اجريت هذه التجربة في مزرعة الخضـر بكلية الزراعة جامعة أسـيوط لموسـمين متتاليين (2020/2019 و2021/2020) لدراسة تأثير ثلاثة مواعيد زراعة مختلفة (1 نوفمبر، 1 ديسمبر، 1 يناير) على النمو الخضري والمحصول والجودة في أربعة تراكيب وراثية من السبانخ (Dash F_1 hybrid، SCO-017 F_1 hybrid، Green Shine F_1 hybrid، والصنف البلدي المحلي)

أظهر التحليل الإحصـــائي للبيانـات وجود تفاعل معنوي بين أربعـة طرز وراثيـة وثلاثـة مواعيد زراعة. تم الحصول على أطول نبات وأعلى عدد من الأوراق لكل نبات وأعلى وزن نباتي طازج في الهجينين Dash F_1 hybrid، SCO-017 F_1 hybrid عند الزراعة في الميعاد الأول (1 نوفمبر) في الموسم الأول والثاني على التوالي

قد تكون هذه النتائج بســـبب الطقس الملائم للزراعة في الميعاد الأول (1 نوفمبر) وتكييف هذه الهجن F_1 مع تلك الظروف. وبالتالي، يمكن استنتاج أن Dash F_1 hybrid ينمو بشكل أفضل في الزراعـات المبكرة (الزراعـة الخريفيـة / 1 نوفمبر) ويتـأثر نموه بشـــكل كبير في الزراعـات المتأخرة (الزراعة الشتوية / 1 يناير).