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Stability of Vegetative Growth Characteristics and Marketable Fruit Yield of Seven Field-Grown Summer Squash Genotypes under Arid Zone Conditions

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ABSTRACT. A 2-year field study (1995-1996) was conducted in King Abdulaziz University Experimental Station, northeast of Jeddah at Wadi Hada Al-Sham, which represents arid zone climate, to examine the stability and variation of seven commonly grown summer squash cultivars ('Cilca F_1', Spirit, Lebbanum V. nerrow, 'Gada F. Rs', Gbery Zucchini, 'Hybrid Scarlita', and 'Alexandrani').

Seasonal variation in plant growth was great between the least (1996) and the more favorable (1995) growing season. Summer squash cultivars also differed markedly in their growth across different seasons. Spirit cultivar showed an excellent performance and had the tallest plants during both seasons of planting, as well as the largest number of leaves/plant followed by Alexandrani cultivars.

The cultivars showed a wide range of variation for number of flowers/plant, number of fruits/plant and fruit yield, as well as fruit length, diameter and fruit size and shape.

Cilica F_1 produced above average yield in both years and exhibiting superior adaptability compared to other cultivars included in this study, followed by Spirit cultivar. This investigation re-emphasizes the need for several growing seasons for testing cultivars stability and performance.

Introduction

Summer squash are the edible young (several days past anthesis) fruit of *Cucurbita pepo,* a highly diverse species. An easy to grow, short season crop, summer squash is adapted to temperate and subtropical climate and grown in many regions. Squash production is economically important worldwide; 7.5 million metric tons of squash were produced in 1992 (Food and Agriculture Organization of the United Nations, 1993).

Yield stability is a critical consideration in cultivar development. Crop cultivars with average, yet consistent, yields generally are more valuable than those with outstanding potential, but whose yields fluctuate in time and space. Selections for high performance in an optimum environment generally have below average stability, whereas selections under less desirable conditions can result in the development of lines with above average stability (Poysa *et al.* 1986; Beaver *et al.* 1985; Finlay and Wilkinson 1963; and George 1975). Several methods have been developed to determine the yield stability of genotypes across sites and seasons (Choo *et al.* 1984; Eberhart and Russel 1966; and Finlay and Wilkinson 1963; Stevens and Rudich, 1978; and Stoffella *et al.,* 1984). Yield and vegetative growth characteristics are well-known screening techniques, for different genotypes grown under certain environments in different seasons of plantings. Differences among genotypes in growth and behavior, *i.e.* plant height, number of leaves/plant and leaf area were observed by many investigators (Paris, 1996; Baggett, 1972; Francois, 1984; Franco *et al.* 1997; and Byari, 1991). Differences were also found among genotypes for number of flowers/plant, number of fruit set/plant and yield (Francois, 1984; Franco *et al.* 1997; Dufault, 1986; McCraw and Greig, 1986; Nesmith, 1993a; Nesmith, 1993b; Byari, 1991; and Weston and Zandstra, 1989).

Great variation among summer squash genotypes for fruit shape was observed. Six extent horticultural groups of summer squash have been recognized on the basis of fruit shape (Paris 1986). Of these six, the vegetable marrow, cocozelle, and zucchini groups can be assigned to subspecies pepo and the scallop, crookneck, and straightneck groups to subspecies ovifera.

Their distinct fruit shapes allow the summer squash groups to be identified easily in even some of the earliest illustrated botanical works (Paris, 1989). Differences among genotypes for fruit diameter, fruit length and fruit size were found (Nesmith, 1993c; Weston and Zandstra, 1989; Franco *et al.,* 1997; and Byari, 1991).

This study was conducted to identify the most stable genotypes among the popular and highly productive cultivars which would be used as parents in future breeding programs to incorporate stability genes in improving the yield and quality of summer squash.

Material and Methods

A 2-year field study (1995 and 1996) was conducted in King Abdulaziz University Experiment Station, northeast of Jeddah at Wadi Hada Al-Sham, which represents arid zone climate, to examine the stability performance of seven commonly summer squash cultivars ('Cilica F_1, Spirit, Lebbanun V. nerrow, Gada F1 RS, Gbery Zucchini', Hybrid Scarlita and Alexandrani, Fig. 1). Two lines were also planted, but due to weakness and death of most of their plants, no data were collected and discarded from the trials. The soil was sandy loam with a pH of 7.2-7.6. Seeds were sown by hand, three seeds per site, at 60cm spacings in the row on 26th February 1995 and 24th February 1996, and covered with a cup of a mixture of peatmoss, and vermiculite to prevent crust formation. Seedlings were thinned after germination to one plant per site. The experimental

plots were established in a randomized complete block design with four replications. Each block consisted of 10 plants of each cultivar. Guard rows were planted on both ends of the experimental area. Fertilization was done according to the soil test recommendations of 170kg N/ha, 200kg P_2O_5/ha and 200kg K_2O/ha. Drip irrigation system was used in watering the plants. A 10-day interval spray schedule was followed throughout the growing period for disease and insect control. Three hygrothermograves were used in measuring temperatures and relative humidity. Day temperature at planting was 20-25ºC and night temperature was 17-20ºC and relative humidity 60-80%. Day temperature during the period of planting was 27-34ºC, night temperature 19-23ºC and relative humidity 40-55%.

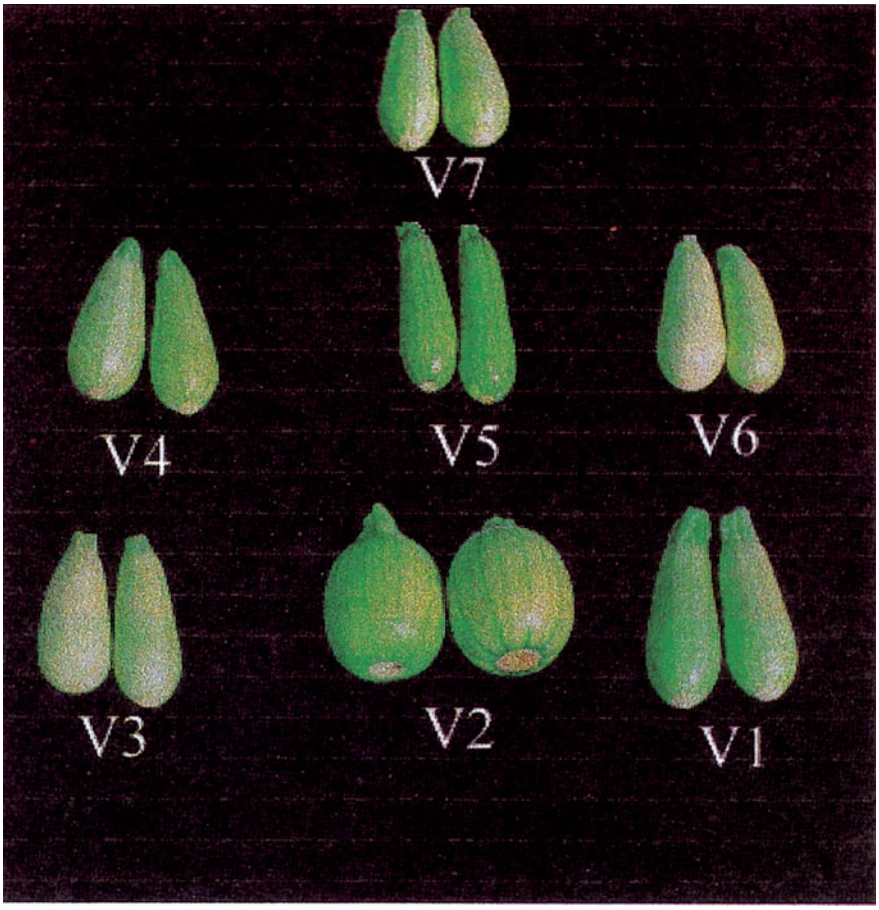

FIG. 1. Different shapes and sizes of summer squash cultivars.

V1 = Cilica F_1
V2 = Spirit
V3 = Lebbanun v. nerrow
V4 = Gada F_1 RS
V5 = Gbery Zucchini
V6 = Hybrid Scarlita
V7 = Alexandrani

Plant characteristics were measured or counted such as plant height, number of leaves/plant, number of flowers/plant, number of fruit set/plant, fruit set %, and yield as well as fruit diameter length, and fruit sizes.

Results and Discussion

Seasonal variation in plant growth between the least (1996) and the most favorable (1995) growing season was observed (Table 1). Cultivars also differed markedly in their growth across different seasons. This was evident from data presented in Table 1 for plant height and number of leaves/plant.

Spirit squash cultivar showed an excellent performance in vegetative growth during both seasons, and had the tallest plants and highest number of leaves/plant, followed by Alexandrani cultivar in plant height. Whereas hybrid Scarlita was the second in number of leaves/plant. Cilica F_1 squash cultivar showed poor performance in plant height whereas Gbery Zucchini had the lowest number of leaves/plant.

TABLE 1. Means for plant height and number of leaves/plant of seven summer squash cultivars grown for two seasons under arid zone conditions.

Variety	Season 1		Season 2	
	Plant height (cm)	No. of leaves/plant	Plant height (cm)	No. of leaves/plant
Cilica F_1	30.60	37.35	28.80	35.15
Spirit	103.50	52.30	97.10	48.80
Lebbanun v. nerrow	39.35	43.95	37.30	42.15
Gada F_1 RS	37.20	44.80	35.10	40.50
Gbery Zucchini	34.00	35.85	30.75	32.40
Hybrid Scarlita	36.50	45.55	34.05	43.25
Alexandrani	43.25	41.90	42.05	38.85
L.S.D. .05	3.98	2.88	7.97	3.72
.01	5.45	3.94	10.23	5.10

The results presented in Table 1 for the vegetative growth, indicated that Alexandrani and Lebbanun v. nerrow cultivars appeared to be the most stable cultivars for plant height and number of leaves/plant during the favourable and the least favourable seasons among the seven squash cultivars. These results were in general agreement with previous results (Baggett, 1972; Fancois, 1984; Franco *et al.* 1997; and Byari, 1991).

Seasonal differences in mean number of flowers/plant, number of fruit set/plant, percentage of fruit set, and fruit yields between the two seasons were obvious (Table 2). Summer squash cultivars differed markedly in their productivity across the two years of planting. Means for number of flowers/plant, number of fruit set/plant, percentage of setting fruit, and fruit mean yields were higher in 1995 than 1996 for all cultivars. This was possibly due to the more favourable environmental condition during the time of

planting in 1995, especially the day and night temperature. Spirit summer squash cultivar produced the highest number of flowers/plant in both years of planting, followed by the Alexandrani and Lebbanun v. nerrow in first year of planting. Gada F_1 Rs. cultivar was the lowest in production of flowers/plant. However, Gada F_1 Rs. cultivar was the most stable cultivar in flower production compared with other seven cultivars during the two seasons of planting, but was not the highest in flower production. Cilica F_1 cultivar produced the highest number of fruits/plant in both seasons. Spirit cultivar was the second in fruit production in the first year followed by Hybrid Scarlita cultivar. Whereas hybrid Scarlita was the second in fruit production in second year, Lebbanun v. nerrow showed poor performance and produced the lowest number of fruits/plant in both years. These results are in agreement with other investigators (Byari, 1991; Beaver *et al.,* 1985; Choo *et al.,* 1984; Eberhart and Russel, 1966; Poysa *et al.,* 1986; and Stofella *et al.,* 1984).

TABLE 2. Means for number of flowers/plant, number of fruit set/plant, percentage of fruit set, and fruit yield of seven summer squash cultivars grown for two seasons under arid zone conditions.

Variety	Year 1 1995			Year 2 1996			Fruit yield (kg/plant)	
	No. of flowers per plant	No. of fruit set/plant	% of fruit set	No. of flowers per plant	No. of fruit set/plant	% of fruit set	Season 1 1995	Season 2 1996
Cilica F_1	20.15	15.75	78.48	18.90	13.95	75.10	1.824	1.337
Spirit	22.95	15.30	66.76	21.20	12.75	60.91	1.856	1.266
Lebbanun v. nerrow	21.50	14.55	67.89	19.80	12.50	64.73	1.133	0.929
Gada F_1 RS	18.95	14.90	78.62	17.40	13.20	77.20	1.227	1.002
Gbery Zucchini	19.85	15.00	75.24	17.75	12.55	71.87	1.096	0.854
Hybrid Scarlita	20.05	15.25	76.10	17.60	13.65	77.55	1.615	1.262
Alexandrani	21.65	15.20	70.19	19.70	13.10	67.15	1.271	1.055
L.S.D. .05	1.70	0.59	6.43	2.06	0.83	7.89	0.110	0.095
.01	2.33	0.80	8.81	2.83	1.13	10.81	0.151	0.130

The data presented in Table 2 also indicate that the summer squash cultivars differed in their ability of setting fruits during the periods of planting. For example, Gada F_1 Rs had the highest percentage of fruit set in first year whereas Hybrid Scarlita proved its superiority in the second year of planting. Spirit cultivar showed poor performance and had the lowest percentage of setting fruit although it has the highest number of flowers in both years, followed by Lebbanun v. nerrow cultivar. However, in spite of the low fertility rate in Spirit squash cultivar, it has the highest yield in the first season of planting, whereas Cilica F_1 cultivar exhibited an excellent performance during both seasons and gave the highest yield in the second season and was the second in yield production during the first season. The high yield produced by Spirit cultivar was due to the larger fruit sizes than Cilica F_1 cultivar and the other cultivars. Gbery Zucchini cultivar had the lowest yield and also Lebbanun v. nerrow cultivar had poor yield compared with the other cultivars. Poor yield produced by Gbery Zucchini and Lebbanun v. nerrow cultivars was due to the smaller size of fruits. Data presented in Table 2 indicate that there

were no stable results for any cultivar under investigation for number of fruits/plant and yield during the times of planting. However, F_1 Cilica produced above-average yields in both years exhibiting superior adaptability compared to the other cultivars included in this study. These results were similar to the results obtained by Poysa *et al.,* 1986; Stevens and Rudich, 1978; and Stoffela *et al.,* 1984.

Seasonal variation was very small and insignificant among summer squash cultivars for fruit length, fruit diameter, and fruit sizes in both years of planting (Table 3). However, data presented in Table 3 indicate that there were small differences for fruit length, fruit diameter and fruit size during the seasons of planting. But there were significant differences among different cultivars for fruit length, fruit diameter, and fruit size and shape within each growing season. These results were similar to the results found by Beaver *et al.,* 1985; Choo *et al.,* 1984; Eberhart and Russel, 1966; and Poysa *et al.,* 1986.

TABLE 3. Means for fruit length, diameter and fruit size for seven summer squash cultivars grown for two seasons under arid zone conditions.

Variety	Season 1 1995			Season 2 1996		
	Fruit length (cm)	Fruit diameter (cm)	Fruit size (cm^3)	Fruit length (cm)	Fruit diameter (cm)	Fruit size (cm^3)
Cilica F_1	11.91	4.50	103.90	11.00	4.12	113.75
Spirit	7.86	6.18	124.25	6.88	5.60	118.00
Lebbanun v. nerrow	9.27	4.04	63.50	7.90	3.93	68.25
Gada F_1 RS	9.28	4.03	80.00	9.13	3.67	94.25
Gbery Zucchini	9.83	3.88	68.25	9.72	3.38	76.00
Hybrid Scarlita	10.21	4.32	83.75	9.41	3.74	85.75
Alexandrani	9.91	4.35	89.75	9.53	3.86	89.50
L.S.D. .05	0.91	0.56	26.73	1.87	0.97	56.98
.01	1.25	0.77	36.62	2.56	1.32	78.07

Most of the summer squash cultivars were almost stable for fruit shape, length, diameter, and size. Seasonal changes had minor effects on fruits shape and sizes.

Data presented in Tables 4, 5 and 6 present the combined data for 1995 and 1996 to represent cultivar general behavior and production through two years of planting. Significant differences among squash cultivars for plant height and number of leaves/plant was detected (Table 4). Spirit cultivar had the tallest plants and the highest number of leaves/plant, followed by Alexandrani for plant height and Hybrid Scarlita for number of leaves/plant, whereas Gbery Zucchini cultivar had the least plant in height and the least number of leaves/plant. Significant differences were also found among the different summer squash cultivars for number of flowers/plant, number of fruits/plant, percentage of setting, and mean fruit yields (Table 5). Spirit cultivar produced the highest number of flowers/plant followed by Lebbanun v. nerrow, and Alexandrani cultivars, whereas Gbery Zucchini had the lowest number of flower/plant. Cilica F_1 cultivar produced the highest number of fruits/plant followed by Hybrid Scarlita and Alexandrani

cultivars, whereas Lebbanun v. nerrow showed poor ability in setting fruit compared with other cultivars.

Cilica F_1 showed the best performance and had the highest yield followed by Spirit and Hybrid Scarlita cultivars. Gbery Zucchini showed poor performance and had poor yield compared with other cultivars under study. However, Gbery Zucchini produced excellent marketable fruits.

TABLE 4. Combined means for plant height and number of leaves/plant of seven summer squash cultivars grown under arid zone conditions for two planting seasons.

Classification	Plant height (cm)	Number of leaves
Variety[2]	**[1]	**
1. Cilica F_1	29.70 e	36.25 d
2. Spirit	100.30 a	50.55 a
3. Lebbanun v. nerrow	38.32 bc	43.05 bc
4. Gada F_1 RS	36.15 cd	42.65 bc
5. Gbery Zucchini	32.37 de	34.12 d
6. Hybrid Scarlita	35.27 cd	49.40 b
7. Alexandrani	42.65 b	40.37
s.e.[3]	1.863	1.060
L.S.D. (.05)	5.54	3.15

[1]Indicating the statistical significance of the classification as a source of variation **: $p < .01$
[2]Means not followed by the same letter differ significantly, $p < .05$
[3]Standard error.

TABLE 5. Combined means for number of flowers/plant, number of fruit set/plant, percentage of fruit set, and fruit yield for seven summer squash cultivars grown under arid zone conditions for two planting seasons.

Cultivars		Number of flowers/plant	Number of fruits/set	% of fruit-set	Yield (kg)
		**[1]	**	**	**[1]
1.	Cilica F_1	19.52 bcd	14.85 a	76.78 ab	1.580 a
2.	Spirit	22.07 a	14.02 bcd	63.83 c	1.561 a
3.	Lebbanun v. nerrow	20.65 abc	13.52 d	66.30	1.03 d
4.	Gada F_1 Rs.	18.17 d	14.05 bcd	77.91 a	1.11 c
5.	Gbery Zuccini	18.80 cd	13.77 cd	73.55 ab	0.98 d
6.	Hybrid Scarlita	18.82 bcd	14.45 ab	77.53 a	1.43 b
7.	Alexandrani	20.67 ab	14.15 bc	68.67 bc	1.163 c
s.e.[3]		0.626	0.201	2.77	0.278
LSD (0.5)		1.861	0598	6.744	0.082

[1]Indicating the statistical significance of the classification as a source of variation * : $p < .05$; ** : $p < .01$
[2]Means not followed by the same letter differ significantly, $p < .05$
[3]Standard error.

TABLE 6. Combined means for fruit diameter, length, and sizes of seven summer squash cultivars grown under arid zone conditions for two planting seasons.

Cultivars	Fruit diameter (cm) **[1]	Fruit length (cm) **	Fruit sizes (cm^3) 0
1. Cilica F_1	4.31 b	11.45 a	108.32 ab
2. Spirit	5.89 a	7.37 c	121.12 a
3. Lebbanun v. nerrow	3.98 b	8.58 bc	65.87 c
4. Gada F_1 RS	3.89 b	9.20 b	87.12 abc
5. Gbery Zucchini	3.63 b	9.77 b	72.12 bc
6. Hybrid Scarlita	4.03 b	9.81 b	84.75 abc
7. Alexandrani	4.01 b	9.72 b	89.62 abc
s.e.[3]	0.241	0.416	13.09
L.S.D. (.05)	0.717	1.238	38.897

[1]Indicating the statistical significance of the classification as a source of variation * : $p < .05$; ** : $p < .01$
[2]Means not following by the same letter differ significantly, $p < .05$
[3]Standard error.

Significant differences for diameter, length and fruit sizes (Table 6). Spirit cultivar had the largest fruit diameter followed by Cilica F_1 and Alexandrani cultivars, whereas Gbery Zucchini had the smallest fruit diameter. Cilica F_1 cultivar also had the tallest fruits followed by hybrid Scarlita and Gbery Zucchini cultivars. Lebbanun v. nerrow had the smallest fruit length. Spirit cultivar also produced the biggest fruit in size, whereas Lebbanun v. nerrow had the smallest fruit in size.

Generally Cilica F_1 cultivar showed best performance in flower production, fruits, and yield and had an acceptable vegetative growth and produced very good marketable yield. Spirit cultivar had an excellent vegetable growth and very good yield but it had poor marketable fruits due to large fruit size and unacceptable fruit shape. Gbery Zucchini cultivar had small vegetative growth and poor yield, but an excellent marketable fruits. The other cultivars produced an acceptable yield with good fruit quality and vegetative growth.

The present study indicate significant year to year variability among seven summer squash cultivars regarding marketable fruit yield, number of flowers/plant, vegetative growth, and fruit size and shape.

This investigation re-emphasizes the need for several growing seasons for testing of advanced breeding lines and potential cultivars for selection of high yielding stable genotypes.

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مـدى ثبات الصفات الخضريـة والمحصول التسويقي للثمار لسبعـة أصنـاف من الكوسة المنـزرعة تحت ظروف الأراضي القاحلة

صالح حسين بياري

قسم زراعة المناطق الجافـة ، كلية الأرصاد والبيئة وزراعة المناطق الجافـة

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المستخلص . في دراسة حقلية لمدة سنتين (١٩٩٥-١٩٩٦م) في محطة التجارب لجامعة الملك عبد العزيز الواقعة في شمال شرق جدة في وادي هدى الشام الذي يمثل مناخ المناطق القاحلة زرعت ٧ أصناف من الكوسة الصيفية لدراسة تأقلمها وتباينها وهذه الأصناف هي : (Cilica Fl, Spirit, Lebbanun v. nerrow, Hybrid Scarlita, Gberry Zucchini, Gada Fl Rs, Alexandrani) . كان للتباين الموسمي تأثير واضح في نمو النباتات حيث كانت النباتات خلال الموسم ١٩٩٥م أفضل منها في عام ١٩٩٦م .

تباينت أصناف الكوسة أيضًا في نموها من سنة إلى أخرى . وأظهر الصنف Spirit نموًا خضريًا قويًا وكان أكثر الأصناف طولاً وعددًا للأوراق خلال الموسمين الزراعيين يليه في القوة صنف Alexandrani . كما وجد تباين كبير بين أصناف الكوسة في كمية إنتاج الأزهار والثمار والمحصول إضافة إلى طول الثمار وقطرها وحجمها وشكلها . وأعطى الصنف Cilica Fl إنتاجًا فوق المتوسط خلال السنتين وأظهر تأقلمًا جيدًا مقارنة بالأصناف الأخرى التي درست بالتجربة يليه الصنف Spirit . ولقد أكدت الدراسة الحاجة إلى الزراعة في عدة مواسم لاختبار مدى تأقلم الصنف وإعطاء إنتاج ونمو ثابت خلال المواسم الزراعية المختلفة .