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STUDIES ON PRODUCTION OF HYBRIDS PEPPER (*Capsicum annuum* L.):
1-EVALUATION AND CHARACTERIZATION OF SOME SWEET PEPPER (*Capsicum annuum* L.) GENOTYPES FOR SOME ECONOMIC TRAITS

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ABSTRACT

Two field experiments were carried out during the summer seasons of 2003 and 2004 under open field in the Horticulture Experimental Station at El –Baramoon , Dakhalia governorate, Egypt, to evaluated and characterized some genotypes of sweet pepper (*Capsicum annuum* L.) and also these genotypes were compared with the check cultivar for plant growth , yield and yield components, fruit characteristics ,as well as, quality traits. Considerable differences were recorded for all the studied genotypes for all traits in both seasons. The obtained results showed that the highest values recorded in the genotypes; i.e., "Marconi Rosso x California Wonder" , "California Wonder x Marconi Rosso" and "Fushimi Long Green x Marconi Rosso". for early and total yield ; Fushimi Long Green cv. , "Fushimi Long Green x Marconi Rosso" and " Marconi Rosso x Fushimi Long Green " for numbers of fruits / plant ; California Wonder cv. , "Vikima x California Wonder" and "California Wonder x Marconi Rosso " for average fruit weight ; "Fushimi Long Green x Marconi Rosso" and "Marconi Rosso x Fushimi Long Green" for total soluble solids (T.S.S.) and "Fushimi Long Green x Vikima " and " Marconi Rosso x Fushimi Long Green " for vitamin C .These genotypes can be used by breeders in their breeding programs according to their objectives . Furthermore, the variation in these traits might be useful for breeders in pepper selection .

INTRODUCTION

Pepper (*Capsicum annuum* L.) , is considered one of the most favorable and common vegetable crops grown in Egypt , as well as , in many other countries . It is a favorite throughout the year and is used in various ways; i.e., fresh , cooked , canned , picked and dry ground . It is cultivated in open field and in greenhouses . Therefore , it is available in the market all year around . For increasing the national agricultural production , there are two ways , the first way is to add new areas to the cultivated land (horizontal extension), the second way is to increase the productivity per unit area (vertical extension) . Since the cultivated land is rather limited , high yielding varieties or hybrids are essential for vertical extension for increasing yield. Pepper shows a wide range of variation for growth characteristics (Villalon 1983 ; Khalil *et. al*., 1988 and Manju and Sreelathakumary 2004) , for yield

and yield components traits (Olufolaji and Makinde ,1994 ; Mohamed *et. al.,* 1995; Narasimha *et .al*., 2001 and Ali *et. al.,* 2004) , for fruit characteristics (Abou El Hassan *et. al*., 1986 ; Farag , 2000 ; Sabrina et. al., 2003 and Valsikova and Belko, 2004) , as well as quality traits (Khalil and Omran ,1982 ; Millett and Jones, 1982, and Khalil *et .al*., 1988) . In this investigation , four different parental cultivars and all possible F_1 hybrids among them including reciprocal hybrids as well as the check cultivar (F_1 Gedion) were evaluated for the some important economical traits in pepper to determined the best genotypes for commercial production to replace the old ones .

MATERIALS AND METHODS

The genetic material used in the present investigation include four cultivars , all these cultivars belonging to the species of *Capsicum annuum* L. . These cultivars were Marconi Rosso , California Wonder , Fushimi Long Green, and Vikima. Plants from each cultivar were selfed for three generations throughout 1999 and 2000 seasons and in the summer season of 2001, all single crosses including the reciprocals were made among the four parental cultivars according to a complete diallel cross mating system and these crosses yielded 6 F_1 hybrids (F_1) and 6 F_1 reciprocals (F_{1r}). Therefore , the genetic materials included : 4 parents and 12 F_1 hybrids (6 F_1 hybrids and 6 F_1 reciprocals). All the genotypes were evaluated in two field trials in Horticulture Experimental Station at El –Baramoon , Dakhlia governorate in 2003 and 2004 summer seasons .

The experimental design was a randomized complete blocks design with three replications. Each replicate consisted of 17 plots which included : 4 parents , 6 F_1 , 6 F_{1r} hybrids and the check cultivar (F_1 Gedion). Land preparation , fertilizer applications and other field practices were carried out in accordance with the regular procedures used in Horticulture Experimental Station at El –Baramoon for pepper cultivation . The plot consisted of one ridge 3 m. long and 50 cm. wide . In each replicate , 10 plants for each parents , crosses and the check cultivar were planted in a single row at a spacing of 50 cm . between rows and 30 cm. between plants within the row . Seeds were sown in mid February and forty five day old seedling were transplanted in the first week of April with one seedling per pit on the northern side.

Differences among genotypes for all traits were tested for significance according to F-test and the differences between any two means were tested for significance using the least significance difference values (LSD) at both 5% and 1% level of significance . Observation were recorded on growth characteristics; i.e., plant height (from the crown to the top of the plants in the end of the season) and days to 50 % flowering , yield and yield components; i.e., early yield (as the average weight of fruits per plant in the first three harvests) , total yield (as the average total weight of picked fruits per plant throughout the entire harvesting season), number of fruits / plant and average fruit weight (g.) , fruit characteristics(using 10 randomly picked fruits per plot) ;i.e., fruit length (cm.) , fruit diameter (cm.), fruit shape

and fruit flesh thickness(mm.) and quality traits i.e., total soluble solids % (Rick , 1974) and vitamin C (A.O.A.C.,1990).

RESULTS AND DISCUSSION

Data in Tables (1 and 2) show that there were highly significant differences among all the studied pepper genotypes in the two experimental seasons for all the studied traits .

Growth characteristics :

Data of growth characteristics listed in Table (1)show significant differences among the studied pepper genotypes in the two experimental seasons for plant height and flowering date . Data of plant height showed that , the values of plant height ranged from 49.9 and 51.1 cm . for Vikima cv. to 80.3 and 83.3 cm . for the cross "Marconi Rosso x Fushimi Long Green" in the first and second season , respectively . The highest height were produced by the crosses "Marconi Rosso x Fushimi long green" , "Fushimi long green x Vikima" and Marconi Rosso cv. , with an average of 80.3, 79.2 and 77.9 cm. respectively. Meanwhile , the minimum average plant height were given by the genotypes; i. e, Vikima cv., "California Wonder x Vikima" and California Wonder cv. (49.9 , 56.1 and 56.3 cm. , respectively.) . Generally , of the 12 crosses under study ,all crosses except "California Wonder x Vikima", "Vikima x California Wonder" , "Fushimi Long Green x California Wonder" and "California Wonder x Fushimi Long Green" significantly exceeded the check cultivar (F_1 Gedion) , while in the second season , all crosses except "Fushimi Long Green x Marconi Rosso" , "Marconi Rosso x Fushimi Long Green" and " Marconi Rosso x California Wonder " did not significantly exceed the check cultivar (F_1 Gedion) .

Regarding flowering date , data for this trait showed that, the number of days to 50 % flowering of the plants ranged from 46.4 to 56.8 day in the first season , and from 46.8 to 57.4 day in the second season . In the two experimental seasons , there were significant decrease in the number of days required to 50 % flowering of the plants in most crosses . In the first season , all the crosses except "Fushimi Long Green x Vikima " " Vikima x Fushimi Long Green " and "California Wonder x Vikima "take a period less than the earliest parent. Also , 7 crosses flowered earlier than the slandered check (F_1 Gedion) by about 10.52 % . These crosses were "Marconi Rosso x California Wonder", "California Wonder x Marconi Rosso" , "Marconi Rosso x Fushimi Long Green" , "Fushimi Long Green x Marconi Rosso" , "Vikima x Marconi Rosso ", "California Wonder x Fushimi Long Green" and "Fushimi Long Green x California Wonder" . These observations is in agreement with those obtained by Villalon (1983) , Khalil et. al. (1988) and Manju and Sreelathakumary(2004) ,who found significant differences among the parents and the crosses for growth characters .

Yield and yield components :

Data concerning yield and its components listed in Table (1) show highly significant differences among all studied genotypes concerning yield and yield components in the two experimental seasons .

The results showed that , the obtained values in the first and second season , respectively ranged from 315.5 to 657.5 g. /plant and from 332.4 to 645.8 g./ plant for early yield and from 1.213 to 2.630 kg. / plant and from 1.154 to 2.510 kg . / plant for total yield . The crosses ; i.e., "Marconi Rosso x California Wonder", "California Wonder x Marconi Rosso" and "Fushimi Long Green x Marconi Rosso" gave the highest early yield (657.5, 630.0 and 619.5 g. / plant , respectively) and total yield (2.630 , 2.521 and 2.478 kg./ plant , respectively) .While ,the three crosses i.e., "Fushimi Long Green x Vikima " , "Vikima x Fushimi Long Green" and "California Wonder x Fushimi Long Green" gave the lowest early yield (319.5, 321.3 and 340.5 g. /plant , respectively) and also , gave the lowest total yield values (1. 278 , 1.285 and 1.362 kg. / plant ,respectively) . From the 12 crosses , 6 crosses ; i.e., "Marconi Rosso x California Wonder", "California Wonder x Marconi Rosso" , "Marconi Rosso x Fushimi Long Green ", "Fushimi Long Green x Marconi Rosso", "Vikima x Marconi Rosso" and "Vikima x California Wonder" significantly exceeded the high parent in early and total yield , and 5 and 4 crosses for early yield and total yield , respectively , significantly exceeded the check cultivar (F_1 Gedion). In view of the present results , it could be concluded that the better parent (Marconi Rosso cv .) would be planted by pepper growers . In the same time , The superior F_1 hybrid which was obtained by crossing Marconi Rosso x California Wonder should be utilized for feature improvements and developing new improved varieties through breeding programs .

Concerning number of fruits per plant trait , in the two experimental seasons the cultivar Fushimi Long Green gave the highest number of fruits / plant among all the studied genotypes followed by the crosses i. e., "Fushimi Long Green x Marconi Rosso" , "Marconi Rosso x Fushimi Long Green" and "Fushimi Long Green x California Wonder" (76.9, 56.1 ,51.1 and 50.5 fruit / plant in the first season and 78.4, 52.8, 43.8 and 50.7 fruit / plant in the second season ,respectively) . All crosses except "Marconi Rosso x Vikima", "California Wonder x Vikima" and "Vikima x California Wonder" significantly exceeded the check cultivar by about 81.47 % , and there are five crosses significantly exceeded the high parent for this trait .

Data concerning average fruit weight showed that, in the two experimental seasons , the cultivar California Wonder gave the highest average fruit weight among all the studied genotypes followed by the crosses "Vikima x California Wonder", "California Wonder x Marconi Rosso" and "Vikima x Marconi Rosso" (80.7 , 77.1 , 76.9 and 73.4 g. in the first season and 81.2, 78.7, 79.9 and 78.1 g.in the second season, respectively). Data also showed that all crosses produced smaller fruit weight than the better parent and the control cultivar in the two experimental seasons . Olufolaji and Makinde (1994) , Mohamed et. al. (1995) , Narasimha *et .al*. (2001) and Ali *et. al*., (2004), also , all these found highly significant differences among pepper genotypes for yield and its components traits .

Fruit characteristics:

Significant differences were observed among the studied genotypes for fruit characteristics; i.e., fruit length, fruit diameter , fruit shape index and fruit flesh thickness in the two experimental seasons as shown in Table (2)

The highest values for fruit characteristics recorded in the genotypes i.e., "Marconi Rosso x Fushimi Long Green", Marconi Rosso and Fushimi Long Green cvs. in the first season and Marconi Rosso cv. , "Marconi Rosso x Fushimi Long Green" and "Fushimi Long Green x Marconi Rosso" in the second season for fruit length(14.8 , 14.1 and 13.6 cm. in the first season, and 14.8 , 14.7 and 13.8 cm. in the second season, respectively) , "California Wonder x Vikima" , "Vikima x California Wonder" and "California Wonder x Marconi Rosso" in the two experimental seasons for fruit diameter (5.9 , 5.7 and 5.4 cm. in the first season and 5.5, 5.6 and 5.8 cm. in the second season, respectively) and for fruit flesh thickness (3.80 ,3.50 and 3.60 mm. in the first season, and 3.60 , 3.70 and 3.80 mm. in the second season, respectively) and Fushimi Long Green cv. , "Fushimi Long Green x Marconi Rosso" and "Marconi Rosso x Fushimi Long Green" for fruit shape index in the two experimental seasons (7.2 , 4.8 and 4.6 in the first season and 6.1 , 4.8 and 4.2 in the second season, respectively). Meanwhile , the lowest values observed in these genotypes i.e., Vikima cv. and Fushimi Long Green x California Wonder x Vikima for fruit length in both seasons , Fushimi Long Green and Marconi Rosso cvs. for fruit diameter and fruit flesh thickness in both seasons and California Wonder x Vikima and Vikima x California Wonder in both seasons for fruit shape. Similar results were reported by Abou El Hassan *et. al.,* (1986) , Sabrina et. al., (2003) and Valsikova and Belko (2004),who showed that there were significant differences among the pepper genotypes in fruit characteristics.

Quality traits :

Significant differences among the investigated pepper genotypes in total soluble solids content (T.S.S.) and vitamin C in fruits of the parents and the crosses in the two experimental seasons were observed and the results presented in Table (2) . The obtained values for total soluble solids content (T.S.S.) ranged from 4.4 % for the cultivar California Wonder to 6.6 % for the cross " Fushimi Long Green x Marconi Rosso " in the first season and from 5.6 % in the cross "Vikima x Marconi Rosso" to 6.5% for the cross "Fushimi Long Green x Marconi Rosso" in the second season . The highest percentage values; i.e, 6.6 , 6.5 and 6.2 % were obtained from the crosses "Fushimi Long Green x Marconi Rosso" , "Marconi Rosso x Fushimi Long Green" and "California Wonder x Marconi Rosso" , respectively . On the other hand , the minimum fruit T.S.S content were obtained from the crosses "Vikima x Marconi Rosso" , "Marconi Rosso x Vikima" and "California Wonder x Fushimi Long Green " (5.3 , 5.5 and 5.6 % , respectively) . As a whole , all crosses except "Vikima x Marconi Rosso" produced fruits richer than the check in T.S.S content by about 30.0 % , also, five crosses; i.e., "Marconi Rosso x California Wonder" , "California Wonder x Marconi Rosso" , "Marconi Rosso x Vikima" , "California Wonder x Vikima" and "Vikima x California Wonder" significantly exceeded the better parent in T.S.S. content .

For vitamin C content , the obtained data ranged from 108.3 mg. /100 g. fresh weight of fruits in the cultivar California Wonder to 160.8 mg. / 100 g. fresh weight of fruits in the cross " Fushimi Long Green x Vikima " in the first season , and ranged from 119.9 mg./100g. in the cross "Vikima x California Wonder " to 165.7 mg./100g. in the cross "Fushimi Long Green x California Wonder" in the second season, the highest content for vitamin C were obtained from the crosses "Fushimi Long Green x Vikima" , "Marconi Rosso x Fushimi Long Green" and "California Wonder x Fushimi Long Green " (160.8 , 158.9 and 155.4 mg. /100g. fresh weight of fruits , respectively). While , the lowest mean values; i.e, 123.9 , 130.7 and 131.8 mg. / 100 g. fresh weight of fruits were given by the crosses "Vikima x California Wonder" , " Marconi Rosso x Vikima" and "California Wonder x Vikima" , respectively.

The comparison with the check cv. (F_1 Gedion), all crosses significantly exceeded this cultivar in vitamin C content by 50.8% . Data also showed that five crosses ("Fushimi Long Green x Vikima" , "Marconi Rosso x Fushimi Long Green" , "California Wonder x Vikima" , "California Wonder x Fushimi Long Green" and "Vikima x California Wonder") significantly exceeded their rich parent in vitamin C. Khalil and Omran (1982); Millett and Jones (1982) and Khalil et .al., (1988) , found highly significant differences for these traits(T.S.S. and vitamin C) among the genotypes pepper when evaluated some pepper genotypes for these traits.

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تقييم وتصنيف بعض الطرز الو راثية لبعض الصفات الاقتصادية في الفلفل

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اجريت تجربتان حقليتان فى صيف موسمى ٢٠٠٣ , ٢٠٠٤ م تحت ظروف الحقل المفتوح في محطة البساتين بالبرامون بمحافظة الدقهلية, بهدف تقييم وتصنيف بعض التراكيب الو راثية من الفلفل الحلو و كذلك مقارنة تلك التراكيب الو راثية مع صنف تحكيمى وذلك لصفات النمو و المحصول ومكوناتة و صفات الثمرة بالإضافة إلى صفات الجودة . سجلت اختلافات معنوية كبيرة بين كل التراكيب الو راثية المدروسة لكل الصفات و أظهرت النتائج أن الهجن ماركوني روزا X كاليفورنيا وندر و كاليفورنيا وندر X ماركوني روزا و فيوشيمي لونج جرين X ماركوني روزا سجلت أعلى القيم بالنسبة لصفات المحصول المبكر والكلى , والصنف فيوشيمي لونج جرين والهجن فيوشيمي لونج جرين X ماركوني روزا و ماركوني روزا X فيوشيمي لونج جرين كانت الأعلى فى صفة عدد الثمار على النبات و الصنف كاليفورنيا وندر و الهجن فكيما X كاليفورنيا وندر و كاليفورنيا وندر X ماركوني روزا كانت الأعلى فى صفة متوسط وزن الثمرة و فيوشيمي لونج جرين X ماركوني روزا وماركوني روزا X فيوشيمي لونج جرين اعطت افضل واعلى القيم بالنسبة لصفة المواد الصلبة الذائبة الكلية و فيوشيمي لونج جرين X فكيما و ماركوني روزا X فيوشيمي لونج جرين كانت الأعلى بالنسبة لصفة محتوى الثمرة من فيتامين ج . تلك المواد الو راثية يمكن للمربين استخدامها في برامج التربية وفقا للأهداف المطلوبة حيث إن تلك الاختلافات الموجودة في هذه الصفات لها أهمية لدى المربين خلال عملية الانتخاب لمحصول الفلفل .

Table 1: Means of the studied pepper genotypes for growth characteristics, and yield and its components grown in 2003 and 2004 seasons

Characters / Pepper genotypes	Plant height cm.		Flowering date		Early yield g./plant		Total yield Kg. /plant		Number of fruits /plant		Average fruit weight g.	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Parents												
Marconi Rosso	77.9	80.1	54.4	55.2	470.8	468.8	1.972	1.845	25.5	24.5	75.8	73.8
California Wonder	56.3	54.8	55.8	56.2	368.4	428.5	1.543	1.528	19.2	18.5	80.7	81.2
Fushimi Long Green	74.1	74.9	52.8	53.1	334.1	334.6	1.213	1.212	76.9	78.4	15.9	16.3
Vikima	49.9	51.1	56.8	57.4	315.5	332.4	1.234	1.154	18.9	14.8	64.5	67.0
F_1 hybrids												
Marconi Rosso x C.W.	75.4	81.1	48.8	49.1	657.5	625.5	2.630	2.510	36.5	32.8	71.8	75.5
r	72.2	71.3	49.2	48.4	630.0	645.8	2.521	2.460	33.7	30.4	76.9	79.9
Marconi Rosso x Fushimi L.G.	80.3	83.3	47.9	48.2	591.3	507.8	2.365	2.248	51.1	43.8	52.5	50.7
r	74.8	79.3	46.4	46.8	619.5	414.8	2.478	2.343	56.1	52.8	46.8	41.9
Marconi Rosso x Vikima	74.9	68.8	51.9	50.2	455.8	535.7	1.832	1.975	26.8	28.2	70.1	72.3
r	71.2	64.7	50.8	52.4	541.3	487.1	2.165	1.915	29.8	24.8	73.4	78.1
C.W. x Fushimi L.G.	68.8	68.2	46.8	46.9	340.5	428.5	1.362	1.565	43.8	42.9	33.7	38.5
r	65.5	71.1	48.1	47.8	385.5	465.8	1.542	1.608	50.5	50.7	31.5	32.2
C.W. x Vikima	56.1	52.8	53.7	53.2	381.7	520.5	1.527	1.684	23.2	21.9	68.5	78.4
r	57.1	61.4	51.8	52.2	450.8	465.5	1.803	1.735	24.1	22.4	77.1	78.7
Fushimi L.G. x Vikima	79.2	71.1	51.1	49.8	319.5	442.6	1.278	1.393	48.3	50.3	28.8	29.8
r	71.2	64.8	52.4	48.1	321.3	475.1	1.285	1.410	38.9	47.8	34.1	31.8

F_1 (Gedion)	62.2	68.8	53.5	52.8	489.5	552.5	2.218	2.492	23.8	25.2	89.7	98.1
L.S.D 0.05	6.8	7.1	2.4	2.3	41.6	47.25	0.096	0.093	3.8	3.92	4.1	4.3
L.S.D 0.01	8.3	7.9	3.5	3.8	55.1	54.91	0.132	0.141	4.6	5.01	5.6	5.9

C.W. : California Wonder. **S_1 and S_2 : The first and second season , respectively .**

Table 2: Means of the studied pepper genotypes for fruit characteristics and quality traits grown in 2003 and 2004 seasons

Characters / Pepper genotypes	Fruit length cm.		Fruit diameter cm.		Fruit shape index		Fruit flesh thickness mm.		Total soluble solids %		Vitamin C mg. /100 g. fresh weight	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Parents												
Marconi Rosso	14.1	14.8	3.9	3.5	3.6	4.2	2.43	2.44	4.7	5.2	136.7	142.1
California Wonder	10.5	10.6	5.3	5.5	2.2	2.0	3.40	3.38	4.4	4.5	108.3	121.4
Fushimi Long Green	13.6	12.9	1.9	2.1	7.2	6.1	1.10	1.05	5.9	6.1	148.2	153.1
Vikima	9.9	9.6	4.5	4.2	2.0	2.2	3.10	3.20	4.5	4.7	117.3	126.5
F_1 hybrids												
Marconi Rosso x C.W.	13.4	13.2	5.1	5.3	2.6	2.5	3.30	3.20	6.1	5.9	133.5	146.8
r	12.5	12.4	5.4	5.8	2.3	2.1	3.60	3.80	6.2	6.0	136.7	150.8
Marconi Rosso xFushimi L.G.	14.8	14.7	3.2	3.5	4.6	4.2	2.60	2.40	6.5	6.4	158.9	150.8
r	13.2	13.8	2.8	2.9	4.8	4.8	1.70	1.80	6.6	6.5	154.2	148.3
Marconi Rosso x Vikima	13.2	13.1	4.7	4.4	2.8	3.0	3.20	3.10	5.5	5.8	130.7	142.8
r	10.6	10.8	4.7	4.9	2.3	2.2	3.50	3.40	5.3	5.6	136.5	136.8
C.W. x Fushimi L.G.	13.1	12.1	3.8	3.9	3.4	3.1	3.10	3.10	5.6	5.9	155.4	159.9
r	12.3	12.1	3.3	3.4	3.7	3.6	2.10	1.90	5.8	6.1	151.7	165.7
C.W. x Vikima	9.9	9.9	5.9	5.5	1.7	1.8	3.80	3.60	5.8	5.9	131.8	125.7
r	10.3	10.4	5.7	5.6	1.8	1.9	3.50	3.70	5.9	5.7	123.9	119.9
Fushimi L.G. x Vikima	13.2	13.2	3.1	3.2	4.3	4.1	1.90	1.80	5.9	6.0	160.8	149.5
r	10.8	11.9	3.7	3.9	2.9	3.1	2.60	2.80	5.9	5.9	148.8	155.5

F_1 (Gedion)	11.8	10.9	6.1	5.6	1.9	1.9	3.90	4.10	4.6	5.3	95.2	103.6
L.S.D 0.05	1.8	2.1	0.8	0.89	0.8	0.901	0.19	0.20	0.8	0.81	6.5	6.8
L.S.D 0.01	2.4	2.5	1.1	1.08	1.0	0.992	0.28	0.31	0.9	0.87	8.7	9.1

C.W. : California Wonder. **S_1 and S_2 : The first and second season , respectively .**