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AVERAGE DEGREE OF HETEROSIS IN SWEET POTATO

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ABSTRACT: *Two field experiments were conducted at two locations; Menofiya and Barrage Experimental Stations, during the period 1990 up to 1997 to develop new sweet potato cultivars through studying the behaviour at different breeds resulting from crosses to obtain good vegetative growth and high yield. The obtained results could be summarized as follows, as for the number of leaves on main stem of the 25 F_1 crosses studied seven ones showed significant positive heterosis values based on their respective mid parent (MP) suggesting dominance towards the high number of leaves. The cross "55 x 66/2" gave the highest (ADH) value 66.76 %, followed by the crosses 55 x 66/3 and 55 x 66/4 with 55.68 % and 27.6 %, respectively. No dominance for this trait was observed in four crosses, i.e. 55 x 34/1, 55 x 34/4, 55 x 34/5 and 55 x 21011, since they had insignificant ADH values (-0.40, 012, -0.58 and 2.67 %, respectively) in relation to their mid parent (MP). Obtained potence ratio values in these crosses which were near to zero (-0.01, 0.00, -0.02 and 0.25, respectively, supported the no-dominance hypothesis. On the other hand, dominance toward the low number of leaves was detected in 14 F_1 hybrids. They gave significant negative heterosis values ranging from (-5.07) in the cross 55 x 210/2 to (-31.11 %) in the cross 55 x 171/4. For the leaf area the heterosis percentages based on (MP) and (HP) were ranged from (-29.22 %) to 143.02 % and from 7.46 % to 130.5 %, respectively in the first season. Of the studied 25 F_1 hybrid, 22 F_1's gave significant positive heterosis values based on their respective mid parent, suggesting dominance towards the large leaf area. The highest ADH value (143.02 %) was recorded in the cross 55 x 66/4 followed by the combinations 55 x 171/1 and 55 x 66/3 with ADH % values at 138.36 and 133.38 % respectively. Insignificant values (2.15 and 5.48) were found in two crosses, i.e. 55 x 210/1 and 55 x 210/2, respectively, which indicating no-dominance for the character. Unlikely, the remaining cross 55 x 171/5 reflected significant negative heterosis value (-29.22 %) suggesting dominance toward the small leaf area. Regarding the second season, similar results were obtained.*

Heterosis attributed to over-dominance (hybrid vigour) for the high total tuber yield was detected in 22 F_1 hybrids among 25 F_1's studied, in the first season, since they outyielded both their respective mid parent (MP) and high parent (HP). The crosses "55 x66/2", "55 x 66/6", "55 x 66/10" and "55 x 34/1" gave the highest average degree of heterosis ADH values relative to their

high parents. Also, 15 F1 crosses gave hybrid vigour values ranged from 37.20 % (in the cross 55 x 1171/3) to 282.77 % (in cross 55 x 66/2) relative to the highest parental line no. 210, while ranged from 41.42 to 294.53 % (in the same two crosses) relative to "Jewel" cultivar (the best check cv.). Data did not generally differ in the second season. Then, the utilization of F_1 hybrids in sweet potato cultivations will lead to high yield production.

Generally, all the eight crosses which were chosen and studied in the second season gave hybrids vigour for the high number of tuber roots. Moreover, they also showed heterosis over the best parental line and check cultivar.

***Key words:** Sweet potato, Lines, Heterosis, Characteristics.*

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is considered the six most important crop in the world (Morrison *et al.*, 1993). It is used for feeding human and animals. The flour of sweet potato, also, used as a substitute with wheat flour in biscuit and bread making. The total production in Egypt is still low. Therefore, more attention must be given for increasing the total yield production in this crop.

The inheritance of some sweet potato characters has been studied by many investigators. Carotene content, leaf type, stem colour and vine length appeared to be quantitatively inherited with dominance of the low carotene content, deeply cleft type of leaf, green stem and short vines (Harmon, 1960). Heritability estimates for a number of foliage and root characters were found as follow : vine purpling (0.53), leaf type (0.59) (Jones, 1969), root weight (0.41), root shape (0.62), flesh colour (0.66) and skin colour (0.81) (Jones *et al.*, 1969). The additive component of the genetic variance was more important than the non- additive component in the inheritance of all mentioned traits.

Genotypes by environment interaction of the yield components in sweet potato were studied in 27 genotypes grown at 6 different sites in Rwanda by Janssens (1984). He found that average tuber weight was environmentally controlled. He added that there was no relationship between yield stability and stability of the yield-related characters studied. All the 4 best yielder genotypes, "Rup 205", "Rusenya", "Anne-Marie" and "Carolina Lee", had average above top growth, suggesting that high top growth should be combined with good translocation of photosynthates to the tuber sink for success under low yield conditions. Progenies of backcrosses (BC) of the line 78-30-8 with each of its parents "Pushu 16" and "Yanchihong" and from crosses of the 2 parents were assessed for 8 characters into types similar to the male parent, by Zheng *et al.* (1985), BC_1 showed segregation for some aerial traits into types similar to the male parent, types similar to the female parent and intermediate types in a 1 : 1 : 1 ratio. No significant segregation

was seen in the BC_2. They also found that the red skin colour was dominant over white and the yellow flesh showed the highest heritability. They reported that both positive and negative heterosis for major characters, from -32 % to 38%, were seen in progenies of crosses among the BC_1, BC_2 and F_1. Meanwhile, variability in branch number and tuber weight was significantly lower in the BC_1 and BC_2 than in the F_1 and variability in main vine length was significantly higher.

Feng *et al.* (1988) studied some problems of combining ability in sweet potato. They reported that progenies with a high yield potential and high starch content were obtained when crosses were made with parents comparatively stable under different environmental conditions but the specific combining ability (SCA) of some crosses was variable. Twenty one local cultivars collected from different parts of India, as well as 37 F_1C_2 and 5 F_1C_3 hybrid of sweet potato were evaluated. Chen *et al.* (1989) mentioned that the broad-sense heritability of tuber yield in 20 hybrids of sweet potato was relatively low and was non-additive. However, there were high coefficients of both genotypic and phenotypic variation. They added that dry weight percentage showed predominantly dominant additive inheritance.

The inheritance of fresh and dry weight/plant was studied in field trials of 6 crosses involving 5 parents of sweet potato by Li *et al.* (1990). They reported that yields of spring were dominant and dependent upon the effects of additive genes which were also influenced by breeding coefficients and SCA.

Rajesh *et al.* (1996) found that heritability estimates were high for vine length (96.05%), number of leaves (90.3 %), number of branches (90.0 %) and tuber yield (75.9%).

The aim of this investigation is to study the average degree of heterosis in sweet potato depending on developing some lines by using the sexual reproduction.

MATERIALS AND METHODS

Two experiments were conducted, the first was carried out in (1996) at the Experimental Farm, Faculty of Agriculture, Shebin El-Kom and the second one was carried out at Barrage Experimental Station of Horticulture Research Institute, to evaluate the 25 F_1 hybrids and their parental lines, for studying the heterosis effect in sweet potato concerning some plant and tuber root characters.

In the second season (1997), the best 8 F hybrids, *i.e.* 55 x 66/2, 55 x 66/6, 55 x 66/10, 55 x 171/1, 55 x 171/2, 55 x 34/1, 55 x 21/2 and 66 x 210/1 of the 25 ones, were evaluated at Barrage Station Farm with their parental clonal lines.

A randomized complete block design with three replicates was used in all evaluation experiments. Each plot contained 18 plants spaced at 90 x 50 cm.

Three cultivars, *i.e.*, "925", "Jewel" and "Mabrouka", which widely used in Egyptian cultivation, were used as control in all evaluation experiments.

In all seasons, the planting date was 7*th* May. Usual fertilization, irrigation were practiced as used with commercial production of sweet potato. The harvest was done at full maturity (about 180 days after transplanting).

Tuber root characters :

These characters were determined in 15 plants randomly picked from each clones.

1- Average degree of heterosis (ADH %)
2- Potence ratio for number of leaves and leaf area.
3- Total yield and tuber root characteristics. (ADH %) and potence ratio for:
   a) Total yield/plant. b) Number of tuber roots/plant.
   c) Average tuber root weight.

Average tuber root weight determined by dividing the weight of tuber roots per plant on the total tuber root number.

Statistical Analysis :

All data obtained during both seasons of every experiment were subjected to statistical analysis according to Snedecor and Cochran (1972). Mean values represented the various investigated genotypes were compared by the Duncan multiple range test (Duncan, 1955). And Snedecor, (1962).

Estimates of genetic parameters were calculated as follows (Wanner *et al.*, 1980) : a) Average degree of heterosis (ADH %), was expressed as percent increase or decrease of F_1 crosses performance above the mid parents (MP) value and the high parent (HP) value as follows :

ADH % (based on MP) = F_1-MP/MP x 100
ADH % (based on HP) = F_1-HP/HP x 100)
Potence ratio (PR) = F_1-MP/½ ($P_2 - P_1$)
where :
P_1, P_2, F_1 and HP are means of P_1, P_2, F_1 and high parent, respectively. (MP) is the mid-parental value or the arithmetic mean of the two parents.

RESULTS AND DISCUSSION

The average degree of heterosis, in relation to the high parent, was only estimated for the crosses which showed dominance towards the high parent in the studied trait. Degree of dominance for each studied trait was also determined by estimating the potence ratio value. Estimates of ADH % and potence ratio of both first and second experiment seasons are presented in Tables (1-5).

1- Number of leaves on main stem :

In the first season, the obtained heterosis values of leaf number are presented in Table (1). Of the 25 F_1 crosses studied, seven ones showed

Table (1) : Average degree of heterosis (ADH %) based on mid-parents (MP) and high parent (HP), as well as, potence ratio for number of leaves in the first and second seasons in (1996 and 1997) of sweet potato genotypes.

Crosses	First season			Second season		
	ADH %		Potence	ADH %		Potence
	MP	HP	ratio	MP	HP	ratio
55 x 66/1	4.39*	-8.36**	0.32			
55 x 66/2	66.78**	48.39**	4.80	49.05**	32.87*	1.03
55 x 66/3	55.68**	36.66**	4.00		*	
55 x 66/4	27.60**	12.01**	1.98			
55 x 66/5	-		-1.41			
55 x 66/6	19.60**		-1.82	1.26		0.10
55 x 66/7	-	-7.69**	0.37			
55 x 66/8	25.27**		-1.04			
55 x 66/9	5.16*		-0.95			
55 x 66/10	-		-1.44	-8.19**		-0.67
55 x 66/11	14.43**	-5.65*	0.54			
55 x 171/1			-0.61	-13.77**		-2.41
55 x 171/2			-0.55	-4.31**		-0.76
55 x 171/3			-1.93			
55 x 171/4			-2.36			
55 x 171/5		-1.82	0.84			
55 x 34/1			-0.01	21.92**		0.96
55 x 34/2					-0.79	
55 x 34/3						
55 x 34/4			0.00			
55 x 34/5			-0.02			
55 x 34/6			-0.31			
55 x 210/1			0.25			
55 x 210/2			-0.48	1.10		0.08
66 x 210/1			-3.94	-0.93		

significant positive heterosis values, based on their respective MP, suggesting dominance towards the high number of leaves. The cross "55 x 66/2" gave the highest ADH value (66.78 %), followed by the crosses "55 x 66/3" and "55 x 66/4" with 55.68 % and 27.60 %, respectively. No-dominance for this trait was observed in four crosses, *i.e.*, "55 x 34/1", "55 x 34/4", "55 x 34/5" and "55 x 210/1", since they had insignificant ADH values (-0.40, 0.12, -0.58 and 2.67%, respectively) in relation to their MP. Obtained potence ratio values in these crosses which were near to zero (-0.01, 0.00, -0.02 and 0.25, respectively) supported the no-dominance hypothesis (Table 3). On the other hand, dominance toward the low number of leaves was detected in 14 F_1 hybrids. They gave significant negative heterosis values ranging from (-5.07 %) in the cross "55 x 210/2" to (-31.11 %) in the cross "55 x 171/4".

Estimates of ADH % values, based on the high parent, revealed that, three crosses, *i.e.*, "55 x 66/2", "55 x 66/3" and "55 x 66/4" showed significant positive heterosis values (46.39, 36.66 and 12.01 %, respectively), indicating hybrid vigour (over- dominance) for this trait. The over-dominance hypothesis in these crosses was also reported by the obtained high potence ratio values, which were more than one (4.80, 4.00 and 1.98, respectively). These superior three crosses also showed hybrid vigour relative to both the best line (55) and check cultivar "Mabrouka". They exceeded the best line by 46.39, 36.65 and 12.01 %, respectively, and exceeded the check cultivar "Mabrouka" by 67.61, 56.47 and 28.26 %, respectively. Complete dominance for the large number of leaves was also found in the cross "55 x 171/5", since gave insignificant heterosis value (-1.82 %) based on HP. The complete dominance was also confirmed in this cross by the obtained potence ratio value (0.84) which was near to one (P = 1). The remaining three crosses, *i.e.*, "55 x 66/1", "55 x 66/7" and "55 x 66/11" reflected partial dominance towards the large number of leaves. Estimated ADH % values for these crosses were significantly higher than their (MP), but they were significantly lower than their (HP). The potence ratio values which estimated as 0.32, 0.37 and 0.54, respectively also supported the partial dominance in these crosses.

Regarding the second season experiment, only the two crosses "55 x 66/2" and "55 x 34/1" significantly exceeded their respective mid-parents, suggesting dominance towards the large number of leaves. They gave significant positive heterosis values as 49.05 and 21.92%, respectively. However, relative to their high parent, only the cross "55 x 66/2" gave significant ADH% value (32.87 %), indicating over-dominance (hybrid vigour) for this trait. The potence ratio was estimated as (1.03). Meanwhile, the other cross reflected complete dominance for the large number of leaves, since it gave insignificant ADH % value (-0.79 %), relative to the high parent. For this trait, no- dominance was also observed in the three crosses "55 x 66/6", "55 x 210/2" and "66 x 210/1". The obtained ADH % values (1.26, 1.10 and -0.93,

respectively) which were insignificant based on their respective MP leaded to this suggestion. Lastly, dominance toward the low number of leaves was detected in the three crosses "55 x 66/10", "55 x 171/1" and "55 x 171/2". Since they gave significant negative heterosis values (-8.19, -13.77 and -4.31 %, respectively) relative to their respective mid-parents (Table 3).

These results were in harmony with those obtained by Rajesh *et al.* (1996).

2- Leaf area :

In the first season (Table 2), the heterosis percentages based on (MP) and (HP) were ranged from (-29.22 %) to 143.02% and from 7.46% to 130.50%, respectively. Of the studied 25 F_1 hybrids, 22 F_1's gave significant positive heterosis values based on their respective mid-parents, suggesting dominance towards the large leaf area. The highest ADH value (143.02 %) was recorded in the cross "55 x 66/4", followed by the combinations "55 x 171/1" and "55 x 66/3" with ADH % values of 138.36 and 133.38 %, respectively. Insignificant values (2.15 and 5.48) were found in two crosses, *i.e.*, "55 x 210/1" and "55 x 210/2", respectively, which indicating no-dominance for the character. Unlikely, the remaining cross "55 x 171/5" reflected significant negative heterosis value (-29.22 %), suggesting dominance toward the small leaf area.

Data also sowed that, all the crosses which exceeded their mid-parents in leaf area, except the cross "55 x 66/9" reflected hybrid vigour (over-dominance) for this trait. The hybrid vigour, based on their high parent in this crosses. In this respect, the obtained previous over-dominance suggestion for the large leaf area. The four crosses "55 x 66/3", "55 x 66/4", "55 x 66/11" and "55 x 171/1" showed heterosis amount more than 100% relative to their high parent. They recorded ADH values were 121.36, 130.50, 111.05 and 130.41%, respectively. Likewise, the previous superior four crosses, exceeded the check cultivar "Mabrouka" (the highest check cv.), and exhibited significant heterosis values as 15.41, 24.10, 5.60 and 24.01 %, respectively. Meanwhile, the superiority relative to the line 210 (the highest line) was reached to 83.07, 96.86, 67.52 and 96.73%, respectively. Complete dominance for the large leaf area was also observed in this trait, where the cross "55 x 66/9" gave insignificant heterosis value (7.46 %).

Regarding the second season, similar results were obtained, since of the studied eight crosses, the plant of mid-parents (Table 4). They showed significant positive heterosis values ranging from 10.43 % (in the cross 55 x 66/2) to 163.72 % (in the cross 55 x 171/2), suggesting dominance towards the large leaf area. Moreover, these crosses exceeded the high parent by 5.94 % to 132.10 %, indicating hybrid vigour for this trait. Estimated potence ratio for leaf area were more than one in these crosses, supporting the over-dominance suggestion. On the other hand, dominance towards the small leaf area was detected in the cross "55 x 210/2". The dominance was verified by

Table (2) : Average degree of heterosis (ADH %) based on mid-parents (MP) and high parent (HP), as well as, potence ratio for leaf area (cm^2) in the first and second seasons in (1996 and 1997) of sweet potato genotypes.

Crosses	First season			Second season		
	ADH %		Potence	ADH %		Potence
	MP	HP	ratio	MP	HP	ratio
55 x 66/1	41.44**	34.15**	7.63			
55 x 66/2	15.09**	9.16*	2.78	10.43**	5.94**	2.46
55 x 66/3	133.38**	121.36**	24.56			
55 x 66/4	143.02**	130.50**	26.33			
55 x 66/5	104.32**	93.79**	19.20			
55 x 66/6	107.23**	96.56**	19.72	78.95**	71.68**	18.64
55 x 66/7	39.04**	32.22**	7.25			
55 x 66/8	35.78**	28.79**	6.59			
55 x 66/9	13.30**	7.46				
55 x 66/10	64.42**	55.95**	11.86	60.08**	53.57**	14.19
55 x 66/11	122.52**	111.05**	22.56			
55 x 171/1	138.36**	130.41**	40.09	145.17**	115.79**	10.66
55 x 171/2	76.44**	70.46**	22.15	163.72**	132.10**	12.02
55 x 171/3	68.78**	63.15**	19.93			
55 x 171/4	19.25**	15.27**	5.58			
55 x 171/5	-29.22**					
55 x 34/1	76.24**	42.69**	3.24	122.53**	67.37**	3.72
55 x 34/2	82.12**	47.45**	3.49			
55 x 34/3	124.12**	81.45**	5.28			
55 x 34/4	45.48**	17.78**	1.93			
55 x 34/5	105.63**	66.48**	4.49			
55 x 34/6	39.76**	13.15**	1.69			
55 x 210/1	2.15					
55 x 210/2	5.48			-5.92**		
66 x 210/1	31.65**	30.43**		1.29		0.09

the obtained significant negative ADH % value (-5.92 %) based on their respective MP. The remaining cross "66 x 210/1" showed no-dominance for the trait, since it gave insignificant heterosivalue (1.29 %) relative to their MP. The obtained potence ratio value in this cross (0.09), was in accordance with the suggested no- dominance.

Total yield and tuber root characteristics :

1- Total yield/plant :

The obtained heterosis and potence ratio values in the first season are presented in Table (3). The heterosis percentages relative to mid and high parents, respectively, were ranged from -33.18 % to 1277.73 % and from 39.19 % to 938.20%. However, heterosis attributed to over-dominance (hybrid vigour) for the high total tuber yield was detected in 22 F_1 hybrids among 25 F_1's studied, since they outyielded both their respective MP and HP. Obtained ADH % based on MP and HP, which were significantly positive, leaded to over- dominance opinion. Also, obtained potence ratio values which were more than one (P > 1) supported the hypothesis. The crosses "55 x 66/2", "55 x 66/6", "55 x 66/10" and "55 x 34/1" gave the highest ADH values relative to their mid-parents (1277.73, 1163.42, 923.86 and 774.85 %, respectively) and high parent (938.20, 852.06, 671.54 and 556.63 %, respectievly). Also, high heterosis amount (hybrid vigour) values relative to the best parental line No. 210 and the best heck cv. "Jewel" were obtained in most studied crosses. Since, 15 F_1 crosses gave hybrid vigour ranged from 37.20 % (in the cross 55 x 171/3) to 282.77 % (in the cross 55 x 66/2) relative to the highest parental line (210), while ranged from 41.42 % to 294.53 % (in the same two crosses) relative to "Jewel" (the best check cv.). However, no dominance was detected in this trait, where the three crosses "55 x 66/9", "55 x 171/5" and "55 x 210/1" showed insinificant values (-12.84, -33.18 and -22.06 %, respectively) based on MP.

Regarding the second season, data not greatly differed, since all the eight studied croses signficantly outyielded their respective HP, indicating hybrid vigour for the high total yield. They showed significant positive to their high heterosis values ranged from 45.38% to 530.76% relative to their high parent. The over-dominance was also established by the obtained potence ratio values which are found more than one (P > 1) in all the studied crosses. The cross "55 x 66/6" gave the highest useful hybrid vigour value (530.76 %), follwoed by the cross "55 x 66/10" with ADH value as 498.87 %. Moreover, all the studied crosses, without any exception, significantly outyielded the best parental line (210) and the best check cultivar "Jewel". The hybrid vigour based on the line 210 ranged from 45.38 % (in the cross 66 x 210/1) to 219.05 % (in the cross 55 x 66/6), while it ranged from 71.46 % to 476.28 % relative to the check cv. "Jewel" in the mentioned two crosses.

Table (3) : Average degree of heterosis (ADH %) based on mid-parents (MP) and high parent (HP), as well as, potence ratio for total yield of tuber roots/plant (kg) in the first and second seasons in (1996 and 1997) of sweet potato genotypes.

Crosses	First season			Second season		
	ADH %		Potence ratio	ADH %		Potence ratio
	MP	HP		MP	HP	
55 x 66/1	350.30**	239.33**	10.71			
55 x 66/2	1277.73*	938.20**	39.07	533.80**	409.21**	21.86
55 x 66/3	129.55**	72.73**	3.95			
55 x 66/4	622.86**	444.72**	19.05			
55 x 66/5	575.94**	409.36**	17.61			
55 x 66/6	1163.42*	852.06**	35.57	684.65**	350.76	28.06
55 x 66/7	490.16**	344.72**	14.99			
55 x 66/8	404.17**	279.93**	12.36			
55 x 66/9	-12.84					
55 x 66/10	923.86**	671.54**	28.25	644.97**	498.87**	26.43
55 x 66/11	179.32**	110.49**	5.48			
55 x 171/1	516.31**	454.22**	46.31	337.10**	318.37**	75.28
55 x 171/2	455.12**	372.17**	38.13	315.89**	298.27**	70.59
55 x 171/3	230.65**	197.31**	20.69			
55 x 171/4	281.43**	242.91**	25.24			
55 x 171/5	-33.18					
55 x 34/1	774.85**	556.63**	23.22	547.39**	311.42**	9.54
55 x 34/2	499.20**	348.99**	14.93			
55 x 34/3	282.81**	186.97**	8.46			
55 x 34/4	163.57**	97.53**	4.89			
55 x 34/5	188.56**	116.18**	5.64			
55 x 34/6	271.41**	178.43**	8.12			
55 x 210/1	-22.06					
55 x 210/2	225.29**	122.52**	4.89	167.65**	101.52**	5.10
66 x 210/1	134.58**	39.11**	1.97	122.38**	45.38**	2.31

Genearlly, according to data obtained in the two experimental seasons, it could be concluded that, the F_1 crosses in sweet potato had hybrid vigour regarding total tuber root yield. Then, the utilization of F_1 hybrids in sweet potao cultivations will be lead to increase the yield production.

The results were insistently observed with those of Li *et al.* (1990) and Rajesh *et al.* (1996) who found that yelds of spring were dominant and dependent uon the effects of additive genes.

2- Number of roots/plant :

For first season experiment, of the studied 25 F_1's, significant positive heterosis values in relation to MP value were found in 21 hybrid combinations, where suggesting dominance towards the high root number. Obtained ADH values ranged from 24.38 % (in the cross 55 x 171/4) to 243.37% (in the cross 55 x 34/1). While, insignificant heterosis values, *i.e.*, 17.37 and 8.94 were found in the two crosses "55 x 34/5" and "55 x 34/6", indicating no-dominance for the trait. On the other hand, the dominance toward the low tuber root number was observed in the two crosses "55 x 66/9" and "55 x 210/1", where they gave significant negative heterosis values (-20.10 and -22.43 %). In this respect, the obtained potence ratio values were (-0.60 and -1.20, respectively) indicating partial and complete dominance for the low tuber root number in the crosses "55 x 66/9" and "55 x 210/1", respectively (Table 4).

Regarding heterosis amount relative to the high parent, 17 crosses significantly outyielded their respective high parents in total number of tuber roots. They showed hybrid vigour for the high number of roots, with heterosis values ranging from 17.53 % to 138.13 %. Also, the obtained high potence ratio values in these crosses which were more than one were in accordance with the over-dominance hypothesis. The cross "55 x 171/3" gave the highest ADH value (138.13 %), followed by the crosses "66 x 210/1", "55 x 66/3" and "55 x 34/1" with heterosis values 133.61, 124.37 and 114.82%, respectively.

Moreover, all the 7 heterotic crosses significantly surpassed the best parental line (55) and the best check cultivar (925) in this trait. The heterosis values ranged from 17.51 and 54.83 % (in the cross 55 x 66/7) to 138.04 and 213.65 % (in the cross 55 x 171/3), respectively.

Complete dominance for the high number of tuber roots was found in the four crosses "55 x 66/8", "55 x 171/4", "55 x 171/5" and "55 x 34/2", since they showed insignificant heterosis values (2.76, -8.35, 9.67 and -1.38 %, respectively). The estimated potence ratio in these four crosses (1.11, 0.68, 1.37 and 0.96) supported the complete dominance suggestion.

Concerning the second season experiment, all the eight studies crosses, without any exception, showed hybrid vigour for the high number of tuber roots, since they outyielded both their MP and HP. They gave significant

Table (4) : Average degree of heterosis (ADH %) based on mid-parents (MP) and high parent (HP), as well as, potence ratio for number of tuber roots per plant in the first and second seasons in (1996 and 1997) of sweet potato genotypes.

Crosses	First season			Second season		
	ADH %		Potence	ADH %		Potence
	MP	HP	ratio	MP	HP	ratio
55 x 66/1	128.49**	71.29**	3.85			
55 x 66/2	176.75**	107.47**	5.29	157.89**	131.50**	13.86
55 x 66/3	199.29**	124.37**	5.97			
55 x 66/4	147.67**	85.68**	4.42			
55 x 66/5	137.45**	78.02**	4.12			
55 x 66/6	84.58**	38.38**	2.53	79.44**	61.08**	6.97
55 x 66/7	56.77**	17.53*	1.70			
55 x 66/8	37.08**	2.76	1.11			
55 x 66/9	-20.10*		-0.60			
55 x 66/10	157.23**	92.84**	4.71	150.78**	125.13**	13.23
55 x 66/11	125.05**	68.72**	3.75			
55 x 171/1	89.26**	39.45**	2.50	78.36**	61.90	7.71
55 x 171/2	66.24**	22.49**	1.85	83.26**	66.35**	8.19
55 x 171/3	223.19**	138.13**	6.25			
55 x 171/4	24.38*	-8.85	0.68			
55 x 171/5	48.85**	114.82**	1.37			
55 x 34/1	243.37**	-1.38	4.07	220.12**	96.37**	3.49
55 x 34/2	57.63**	30.72**	0.96			
55 x 34/3	108.94**	19.97*	1.82			
55 x 34/4	91.77**		1.53			
55 x 34/5	17.37		0.29			
55 x 34/6	8.94		0.15			
55 x 210/1	-22.43**		-1.20			
55 x 210/2	129.51**	93.47**	6.95	101.31**	82.28**	
66 x 210/1	170.38**	133.61**	10.82	156.21**	153.75**	9.71

positive heterosis values relative to their MP ranging from 78.36% to 220.12%, while it ranged from 61.08% to 153.75% based on their high parent. The crosses "66 x 210/1", "55 x 66/2" and "55 x 66/10" reflected the highest ADH% values (153.75, 131.50 and 125.13%, respectively). Obtained potence ratio values in these crosses which were more than one supported the over-dominance hypothesis.

Comparing the crosses with the parental lines and check cultivars showed that, all the eight crosses exhibited significant heterosis over the best line (55) and the best check cv. "925". They showed heterosis values relative to the best line ranged from 60.89% (in the cross 55 x 66/6) to 131.13% (in the cross 55 x 66/2), while relative to the best check cv. heterosis values ranged from 74.46% to 150.84% in the same two crosses.

Generally, it can see taht, the eight crosses which chosen and studied in the second season gave hybrid vigour for the high number of tuber roots in both seasons. Moreover, they showed heterosis over the best parental line and check cv. in both seasons. The established of over-dominance in both seasons in the same crosses leaded to the opinion of beneficial hybrid vigour for number of tuber roots, which considered one of the components of total yield in sweet potato. This figure encourage the utilization of F_1 crosses of sweet potato in commercial production. The appearance of hybrid vigour for the eight crosses in the two experimental seasons concerning the number of tubers and total yield of tubers indicate that the number of roots has large effect on total yield in these crosses.

3- Average tuber root weight :

For the experiment of the first season, estimates of ADH % in relation to MP value (Table 5) showed that, 17 hybrid combinations gave significant positive heterosis values, suggesting dominance towards the high average tuber root weight. Obtained heterosis values in these crosses ranged from 25.34% (in the cross 55 x 210/2) to 561.31% (in the cross 55 x 66/6). No-dominance for this trait was detected in other seven crosses, where they gave insignificant heterosis values ranged from -26.14 % in the cross "55 x 66/3" to 16.32 % in the cross "55 x 66/11". Unlikely, the remaining cross "55 x 171/5" gave significant negative heterosis value (-62.50 %), indicating dominance towards the small parent for average tuber root weight.

Estimates of ADH % relative to HP showed that, of the 17 crosses which exceeded their mid-parents in average tuber root weight, 15 reflected hybrid vigour for this trait. This hybrid vigour was verified by the obtained significant positive heterosis values and by the estimated potence ratio. The potence ratio were more than one in these crosses. The highest ADH % (540.15 %) was given by the cross "55 x 66/6", followed by the cross "55 x 66/2" with heterosis value of 365.77%. These superior two crosses also exceeded the best parental line and the best check cv. They surpassed the

line 210 by 73.87 and 26.73 %, respectively, while surpassed the check cv. "Jewel" by 88.60 and 37.46 %, respectively. The remaining two crosses "55 x 34/3" and "55 x 210/2" reflected complete and partial dominance, respectively, for the large average root weight, obtained ADH % was insignificant in the first cross, while it was significantly negative in the second cross. The complete and partial dominance was also identified in these two crosses by the obtained potence ratio values (1.46 abd 0.43, respectively). The first value was near to one and the second value was near to 0.5.

For second season experiment, of the studied eight crosses, seven ones significantly exceeded their mid- parents in average tuber root weight, suggesting dominance towards the large roots. They gave significant positive heterosis vales ranging from 27.29 % (in the cross 55 x 210/2) to 341.62 % (in the cross 55 x 66/6). The remaining cross "66 x 210/1" reflected no-dominance for this trait, since it showed insignificant heterosis value (-12.99 %).

From the seven heterotic crosses, six ones significantly surpassed their respective high parent, indicating hybrid vigour (over-dominance) for the large average tuber root weight. They showed significant positive heterosis values ranging from 75.35 % in the cross "55 x 34/1" to 290.99 % in the cross "55 x 66/6". The over-dominance was also confirmed in these crosses by the obtained potence ratio values which ranged from 8.51 to 26.38 (P > 1). The remaining cross "55 x 210/2" gave insignificant ADH % value (-10.17%), reflecting complete dominance for the large roots.

Comparing the F_1 crosses with the highest parental time line and check cultivar showed that, the two crosses "55 x 66/6" and "55 x 171/1" exhibited heterosis over the line 210 and check cultivar "Jewel". They surpassed the line 210 by 60.89 % and 16.12 %, respectively and the "Jewel" cv. by 53.56 and 10.83 %, respectively, (Table 5).

Generally, it is noticed that, hybrid vigour was rarely apparent for average tuber root weight when the crossing was carried between large-tubered and small- tubered parents. Since, the resulted crosses showed either no-dominance or dominance (in partial or complete) towards the large roots. However, it is interesting to mention that, this behaviour in the inheritance of average tuber root weight nor prevent the appearance of hybrid vigour in total tuber root yield. Since, the resulted dominance for the large total root number, on the other hand, could be lead to the hybrid vigour in total root yield. In other way, under this study, all the crosses which showed hybrid vigour for both number of roots and root weight gave hybrid vigour for total root yield. The hybrid vigour in this case is expected, since the heterosis for total yield mainly resulted from the combined heterosis for average rot weight and number of roots per plant. Meanwhile, when the inheritance

Table (5) : Average degree of heterosis (ADH %) based on mid-parents (MP) and high parent (HP), as well as, potence ratio for average of tuber root weight (kg) in the first and second seasons in (1996 and 1997) of sweet potato genotypes.

Crosses	First season			Second season		
	ADH %		Potence	ADH %		Potence
	MP	HP	ratio	MP	HP	Ratio
55 x 66/1	89.59**	83.53**	27.105			
55 x 66/2	381.16**	365.77**	115.313	147.99**	119.56**	11.43
55 x 66/3	-26.14					
55 x 66/4	180.90**	171.92**	54.730			
55 x 66/5	174.37**	165.59**	52.753			
55 x 66/6	561.31**	540.15**	169.813	341.62**	290.99**	26.38
55 x 66/7	261.70**	250.12**	79.172			
55 x 66/8	253.88**	242.55**	76.805			
55 x 66/9	4.55**					
55 x 66/10	282.38**	270.15**	85.429			
55 x 66/11	19.31			199.96**	165.57**	15.44
55 x 171/1	172.79**	88.38**	3.856			
55 x 171/2	167.40**	84.66**	3.736	141.35**	110.69**	9.72
55 x 171/3	-14.84		-0.331	123.87**	95.43**	8.51
55 x 171/4	158.08**	78.22**	3.528			
55 x 171/5	-62.50**					
55 x 34/1	102.93**	52.71**	3.130	90.71**	75.35**	10.35
55 x 34/2	202.37**	127.54**	6.153			
55 x 34/3	48.09**	11.44	1.462			
55 x 34/4	9.35		0.284			
55 x 34/5	95.71**	47.28	2.910			
55 x 34/6	177.52**	108.84**	5.398			
55 x 210/1	-11.00		-0.181			
55 x 210/2	25.34**	-21.38*	0.426	27.29**	-10.17	0.65
66 x 210/1	-6.77		-0.118	-12.99		-0.25

behaviour was differed between the two characters, it is interesting to mention any traits play the main role in the hybrid vigour. The previous question could be answerable in the hybrids derived from crossing the lines 55 and 66 with the line 210. The crosses "55 x 210/2" and "66 x 210/1" reflected hybrid vigour (over-dominance) for total root yield, during the two experimental seasons, though they had no-dominance or dominance (in partial or complete) towards the large roots, while they showed over-dominance for total root number (Tables 4 & 5). Then, we can state that, hybrid vigour in sweet potato was rarely apparent for average root weight when the crossing was carried out between large-tubered and small tubered lines. It could be concluded that the high total root yielding sweet potato may be due to the high number of roots per plant rather than in tuber root sizes.

REFERENCES

Chen, F.X., J.W. Xie and X.Z. Zhang. 1989. Hereditary tendency of tuber yield, dry chip percentage and bacterial wilt resistance in sweet poatto. J. Fujian Agric. College, 18 (1) : 133-138. (C.F. Plant Breed. Abstr., 60 : 1648).

Duncan, D.B. 1955. Multiple range and multiple F tests. Biometrics, 11 : 1-42.

Feng, Q.H., W.J. Li, S.Y. Lu and C.G. Wu. 1988. Some problems of combining ability in sweet potato. Acta Agronomica Sinica, 14 : 124-130.

Harmon, S.A. 1960. Genetic studies and compatibilities in the sweet potato (*Ipomoea batatas*). Diss. Abstr., 21 : 411-412. (C.F. Plant Breed. Abstr., 31 : 3568).

Janssens, M.J.J. 1984. Genotype by environment interactions of the yield components in sweet potato. In : Proc. Sux Symp., Intenational Soc. Trop. Root Crops, Lima, Peru, 21-26. Internat Potato Center, pp. 543-551. (C.F. Plant Breed. Abstr., 55 : 6228).

Jones, A. 1969. Quantitative inheritance of ten vine traits in sweet potatoes. J. Amer. Soc. Hort. Sci., 94 : 408-411.

Jones, A., C.E. Steinbauer and D.T. Pope. 1969. Quantitative inheritance of ten root traits in sweet potatoes. J. Amer. Soc. Hort. Sci., 94 : 271-275.

Li, W.J., S.Y. Lou, Q.H. Feng and C.G. Wu. 1990. Genetic analysis on fresh and dry weight of sweet potato per plant. Heredites (Beijing), 12 (4) : 9-11. (C.F. Plant Breed. Abstr., 62 : 10249).

Morrison, T.A., R. Pressey and S.J. Kaks. 1993. Changes in Alpha and Beta amylase during storage of sweet potato lines with varying starch hydrolysis potential. J. Amer. Soc. Hort. Sci., 118 : 236-242.

Rajesh, K., B.P. Jain, D.K. Ganguli, R. Kumar, G.T. Kurup, M.S. Palaniswami, V.P. Potty, G. Padmaja, S. Kabeerathumma and S.V. Pillai. 1996. Variability character association and path analysis in sweet potato. Tropical Tuber Crops : Problems, Prospects and Future Strategies, pp. 140-145.

Snedecor, W.G. 1962. Statistical Methods. 5*th* Ed., The Iowa State Univ. Press. Ames, Iowa, U.S.A., 535 p.

Snedecor, W.G. and W.G. Cochran. 1972. Statistical Methods. 6*th* Ed., Iowa State Univ. Press, Ames, Iowa, U.S.A., 593 p.

Zheng, J.Z., G.W. Zheng, J.L. Huang and W.T. Liu. 1985. Preliminary study of genetic variation in the main characters of backcross progenies of sweet potato. Fujian Nongye Keji (Fujian Agric. Sci. and Technology), No. 2 : 30-33. (C.F. Plant Breed. Abstr., 56 : 3932).

درجة قوة الهجين في البطاطا

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الملخص العربي

تم إجراء تجربتين حقليتين بمزرعتى كلية الزراعة جامعة المنوفية ومزرعة البحوث الزراعية بالقناطر الخيرية التابعة لمعهد بحوث البساتين خلال عامى ١٩٩٦ و ١٩٩٧ لتقييم سلالات جديدة من البطاطا من خلال دراسة سلوك السلالات المختلفة الناتجة من التهجينات للحصول على نمو خضرى قوى ذو محصول مرتفع ... ويمكن تلخيص النتائج المتحصل عليها فيما يلى :

بالنسبة لعدد الأوراق على الساق الرئيسى فإنه من بين الـ ٢٥ هجين التى درست أظهرت سبع هجن منها قوة الهجين على أساس متوسط الأبوين مشيرة إلى السيادة نحو إرتفاع عدد الأوراق على الساق الرئيسى حيث التلقيح 55 x 66/2 أعطى قيم عالية لـ ADH (٦٦,٦٧ %) يليها التلقيح 55 x 66/3 ,55 x 66/4 قيم ٥٥,٦٨ % و ٢٧,٦ % على التوالى. إنعدام السيادة فى هذه الصفة ظهر فى أربع هجن هى 55 x 34/1 ,55 x 34/4 ,55 x 34/5 ,55 x 210/16 حيث تراوحت قيم ADH بين -٠,٥٨و ٠,٢٢ و -٠,٤٠ و ٢,٦٧ % على التوالى على أساس متوسط الأبوين، وكانت قيم Potence ratio فى هذه التلقيحات (٠,٢٥، -٠,٠٢، ٠,٠٠، -٠,٠١) على التوالى والتى تؤكد عدم وجود سيادة. ومن جهة أخرى فإن السيادة تجاه العدد القليل من الأوراق تأكدت فى ١٤ هجين. حيث أعطت قيم معنوية سـالبة لدرجة قوة الهجين تراوحت بين (-٥,٠٧ %) فى التلقيح 55 x 210/2 و (-٣١,١١ %) فى التلقيح 55 x 71/4 عند حسابها على أساس الـ MP.

وبالنسبة لمساحة الورقة فإن النسبة المئوية لقوة الهجين على أساس متوسط الأبوين (MP) والأب العالى (HP) تراوحت مابين (-٢٩,٢٢ %) لـ ١٤,٣٢ % و ٧,٤٦ % لـ ١٣٠,٥ % على التوالى وذلك فى الموسم الأول. ومن بين الـ ٢٥ هجين فإن ٢٢ هجين أظهرت قوة هجين عالية

بالنسبة لمتوسط الآبـــاء مشيرة إلى السيادة نحو مساحة الورقة الكبيرة. وكانت أعلى قيمة لـ ADH (١٤٣,٠٢ %) وجدت فى النمو 66/4 x 55 تلاها الهجينين 171/1 x 55 و 66/3 x 55 بقيم ADH ١٣٨,٣٦ % و ١٣٣,٣٨ % على التوالى. كما وجدت قيم غير معنوية (٥,٤٨ و ٢,١٥) فى التلقيحين 210/1 x 55 و 210/2 x 55 على التوالى، مشيرة إلى عدم وجود سيادة لهذه الصفة. بينما فى الهجين الباقى (171/5 x 55) فإنه أعطى قوة هجين سالبة ومعنوية (-٢٩,٢٢ %) مشيرة إلى سيادة تجاه مساحة الورقة الصغير، كما ظهرت نتائج مماثلة فى الموسم الثانى. ووجدت قوة الهجين والتى تعزى إلى السيادة الفائقة للزيادة المرتفعة فى محصول درنات البطاطا والتى اكتشفت فى ٢٢ هجين من بين الـ ٢٥ والتى درست فى الموسم الأول حيث أنهم تفوقوا فى المحصول على الأب المرتفع High parent (HP). الهجين 34/1 x 55 and 66/10 x 55, 66/6 x 55, 66/2 x 55 أعطت أعلى درجة قوة هجين ADH بالمقارنة بالاباء الداخلة فى تركيبهم. وأيضا فإن 15 F_1 crosses أعطت قيم عالية من قوة الهجين ADH تراوحت من ٣٧,٢ % فى الهجين 1171/31 x 55 لـ ٢٨٢,٧٧ % فى التلقيح 66/2 x 55 بالنسبة إلى أعلى الاباء فى السلالة رقم ٢١٠ بينما تراوحت هذه النسبة بين ٤١,٤٢ % إلى ٢٩٤,٥٣ % فى كلا التلقيحين بالنسبة للصنف Jewel (أفضل صنف للمقارنة). ولم تختلف النتائج بصفة عامه فى الموسم الثانى عن الأول، وعليه فإن إستخدام هجن الجيل الأول F_1 hybrids فى زراعة البطاطا سوف تؤدى إلى الزيادة فى إنتاجية المحصول.

وبصفة عامة فإن الهجن الثمانية والتى أختيرت للدراسة فى الموسم الثانى أعطت قوة هجين بالنسبة لعدد الدرنات الجذرية بالإضافة إلى أنها أظهرت قوة هجين مرتفعة عن أفضل الاباء والصنف القياسى.