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Genetic behavior of some economic characteristics of cucumber (*Cucumis sativus* L.) under high temperature conditions

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Abstract

This study was conducted at the Horticulture Research Institute, Agriculture Research Center in Egypt during the period from 2017 to 2019 to develop cucumber (*Cucumis sativus* L.) inbred lines and hybrids tolerant to high temperature to reduce losses in quality and yield and evaluate them under greenhouse conditions. Twenty two inbred lines and twenty hybrids were evaluated in the two successive summer plantings of 2017/18 and 2018/19 under greenhouse conditions along with the hybrid Lamar as a control. Total yield reflected great variation among the inbred lines and ranged from 5.50 to 0.53 kg m^{-1}. P_{10} gave the greatest total yield and it was at par with P_{19}. Narrow range (3.20 to 2.50 cm) was observed among hybrids for fruit diameter. The highest value was recorded in $P_2 \times P_5$. Fruit weight reflected great variation among the hybrids and the hybrid, $P_2 \times P_5$ gave the heaviest fruit weight. Data showed significant differences among hybrids for total yield and hybrid $P_1 \times P_3$ gave the highest value of total yield and was at par with hybrid Lamar (control). The cross $P_1 \times P_4$ achieved high specific combining ability (SCA) effects for all traits in this study which means comparing the general combining ability effects (GCA) of the parents to their corresponding crosses' SCA indicate that the GCA effects of the parents were reflected in the SCA effects of the crosses for the most studied traits. The reciprocal effects in F_1 diallel crosses were significant for most of the traits studied and the cross $P_5 \times P_1$ achieved high SCA effects for all traits.

Key words: Cucumber, *Cucumis sativus*, genetic behavior, combining ability, correlation, high temperature

Introduction

Cucumber, one of the most important members of cucurbits in Egypt, is very popular among Egyptians as it is used in various forms, such as salad, pickle and fresh cut vegetable. It has high potential for increased productivity and income generation as well. Abiotic stress is one of the most common causes of crop deficit and loss, and hence an important area of research. Moreover, global climate change during past decades indicate the importance of researh on different abiotic stresses for mitigation of its effect. In 2017, the total area cultivated with cucumber was about 117009.52 ha with total productivity of 1064785.71 tons and an average yield of 21.66 ton/ha (Ministry of Agriculture and Land Reclamation Statistics, Egypt, 2017. Dar *et al.* (2015) found that heat stress (rise in temperature) induced significant variations in morphological, physiological and chemical parameters of plants. High temperature reduced the plant height, number of leaf per plant, and related morphological and physiological processes in cucumber.

Selective mating designs such as diallel, which may allow inter-mating of the selects in different cycles and exploit both additive and non-additive gene effects, could be useful for the genetic improvement of fruit yield and nutritional traits (Singh and Pawar, 2005). In F_1 hybrid breeding, analysis of combining ability has been used in practical plant improvement programs to determine the relative importance of general combining ability (GCA), specific combining ability (SCA) of the parents in the performance of F_1 hybrids, and superior parents for crossing in hybridization programs (Yoshioka *et al.*, 2010). General combining ability is the manifestation of the additive gene action for the selection of parents and SCA represents the non-additive gene action (Singh *et al.*, 2011). Shakya *et al.* (2006) collected wide range of cucumber germplasms sown in high temperature and long day photoperiod condition. The germplasms varied widely in duration of producing the first male and female flowers after sowing, number of branches per plant, number of female flowers and fruits per plant, yield per plant and marketable yield and ten entries were found the most promising from all cucumber germplasms. Soliman *et al.* (2018) stated that high rate of parent heterosis and potence ratio values were observed for the traits supporting the over dominance hypothesis as well as other degrees of dominance were observed in many crosses concerning few traits. The significant mean squares of reciprocal crosses for fruit length, fruit diameter, and yield per plant suggested that maternal inheritance also played an important role in the inheritance of these traits (Golabadi *et al.*, 2015).

Thus, there is potential to generate superior cultivars by selection in segregating generations and by hybrid production. Keeping in view the drastic effects of heat-stress, improvement of local cucumber hybrids with good fruit quality under high temperature conditions in late summer is very important. Therefore, the current study was planned with the objectives to produce new cucumber hybrids tolerant to high temperature with good fruit quality and having higher yielding potential.

Materials and methods

Source of cucumber germplasm: Field trials were conducted under high temperatures of late summer seasons in the vegetable research farm of Horticultural Research Institute, Agricultural Research Center (ARC), Kaha, Egypt during 2017, 2018 and 2019. Twenty two inbred lines of cucumber were evaluated under high temperatures during 2017 and 2018 late summer seasons using the drip irrigation system. Recombinant inbred lines evaluated were 1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A, 11A, 12A, 13A, 14A, 15A, 16A, 17A, 18A, 19A, 20A, 21A and 22A. They were produced by the first author of the present study from previous cucumber breeding program by selfing and selection during 6 generations.

Experiment: All genotypes (22 parents and 20 F_1 hybrids) and commercial F_1 hybrid, Lamar as control were grown using the drip irrigation system in the greenhouse facilities under high temperature conditions at the vegetable research farm of Horticultural Research Institute, Kalubia Governorate during late summer of 2017 season. The nursery of each accession was transplanted in the greenhouse in three replicates following randomized complete block design layout (RCBD). Land preparation and field practices were applied according to recommendations of the Egyptian Ministry of Agriculture. Seeding and transplanting dates were in April 2017 and 2018. Averages of temperatures during the growing evaluation season of the study at Kalubia governorate were 25/15.2, 29/21.2, 33.5/24.1, and 34.9/23.5 °C day/night in April, May, June, and July, respectively (Central Laboratory for Agricultural Climatic, Ministry of Agriculture and Land Reclamation, Egypt).

Main stem length was measured in centimeters from the cotyledon node to the top end after 2 months from transplanting. Number of leaves were counted from the cotyledon node to the top end after 2 months from transplanting on the main stem. Average fruit length was determined in centimeters using average of 10 fruits/ plot by ruler. Average fruit diameter was determined in centimeters using average of ten fruits by Vernier caliper. Spines and bitternes were determined at the marketable stage of the fruit by panel test.

Statistical analysis: Averages representing mean plot values were subjected to the analysis of variance (ANOVA) procedure of RCBD design (Gomez and Gomez, 1984) to test the differences between parental genotypes for studied traits in the two crosses.

Biometrical analyses: The relative importance of variances due to GCA and SCA were compared via the predictability factor (PF) $[2\sigma^2_{GCA}/(2\sigma^2_{GCA}+2\sigma^2_{SCA})]$. The ratio closer to unity, the greater the predictability based on the general combining ability alone (Baker, 1978). Combining abilities (general and specific) were estimated following Method 1, Model 1 of Griffing (1956).

Results and discussion

The data presented in Table 1 indicated significant differences in plant length, leaf number, number of days to first female flower opening between the inbred lines. The data, generally, show

Table 1. Mean performance of 22 inbred lines for plant length, number of leaves and number of days to first female flower opening (mean of 2017 and 2018)

Genotype	Plant length	Leaf number	Number of days to first female flower opening	Bitterness	Spines
P_1	201.17ef	24.63ef	42.00efgh	-	+
P_2	177.83hi	23.82efg	41.33fgh	-	+
P_3	192.87fg	21.08g	41.33fgh	-	+
P_4	185.53gh	23.73efg	41.66efgh	-	+
P_5	205.60e	25.70de	41.33fgh	-	+
P_6	203.23e	25.60def	41.33fgh	-	+
P_7	250.17a	24.36efg	41.00fgh	-	+
P_8	168.87j	24.70ef	40.33gh	-	+
P_9	251.03a	24.63ef	40.66fgh	-	+
P_{10}	181.53h	34.84ab	38.33h	-	-
P_{11}	151.13k	26.19de	45.00defg	-	+
P_{12}	102.83m	28.68cd	46.33defg	-	+
P_{13}	130.17l	25.19ef	46.33defg	-	+
P_{14}	131.17l	24.36efg	45.66defg	-	+
P_{15}	164.50j	33.63ab	58.66ab	-	+
P_{16}	102.53m	25.74de	61.66a	-	+
P_{17}	215.80cd	34.06ab	46.66def	-	+
P_{18}	208.47de	33.50ab	47.66de	-	+
P_{19}	207.40e	31.69bc	41.00fgh	-	-
P_{20}	172.17ij	22.37fg	38.33h	-	-
P_{21}	227.83b	33.38ab	49.00cd	+	+
P_{22}	220.87bc	35.50a	54.33bc	+	+

that, plant length ranged from 251.03 to 102.53 cm, the lowest plant length was recorded in P_{16}, while the highest plant length was recorded in P_9. Leaf number recorded significant differences among inbred lines where the greatest leaf number was recorded in P_{22}, while the least leaf number was recorded in P_3. Data in Table 1 revealed that, the different inbred lines of cucumber showed significant differences in number of days to first female flower opening. P_{10} and P_{20} took the lowest number of days till first female flower opening, on the contrary inbred P_{16} required the highest number of days till first female flower opening.

Highly significant difference among fruit length of the evaluated lines was observed (Table 2). Fruit length ranged from 35.03 to 8.66 cm. The highest fruit length was produced by P_3 while, the lowest fruit length was recorded in P_{16} and P_{20}. Fruit diameter ranged from 4.23 to 1.86 cm. The lowest value was recorded in P_{20}, while the highest value was recorded in P_8 and P_9. Fruit weight reflected great variations among the evaluated lines where P_9 gave the heaviest fruit weight whereas P_{20} gave the low fruit weight. Total yield also reflected great variation among the selected lines and ranged from 5.50 to 0.53 kg m^{-1} and P_{10} gave the greatest total yield without significant difference from P_{19}. On the other hand P_{15} gave the lowest total yield.

Data presented in Table 3 revealed significant differences in plant length among the hybrids. Plant length ranged from 225.80 to 185.23 cm and the lowest plant length was recorded in hybrids $P_3 \times P_4$ and $P_4 \times P_1$, while the highest plant length was recorded in $P_2 \times P_5$ at par with the control. It is clear that values of leaf number recorded significant differences among all hybrids and ranged from 38.26 to 28.40 and higher leaf number was recorded in $P_4 \times P_5$, while the least leaf number was recorded in $P_5 \times P_1$ with no significant difference with $P_5 \times P_2$. Number of days till first female

Table 2. Mean performance of 22 inbred lines for fruit length, fruit diameter, fruit weight and total yield (mean of 2017 and 2018)

Genotype	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Total yield (kg/m²)
P_1	16.23h	3.10efg	88.83cdef	1.23def
P_2	18.33f	2.90fgh	89.57cdef	1.63cd
P_3	35.03a	3.40cd	275.80b	0.96def
P_4	31.23b	3.60bc	312.27ab	1.63cd
P_5	22.26e	2.970efgh	88.90cdef	1.30cdef
P_6	30.20c	2.50i	128.40c	1.43cdef
P_7	25.73d	2.14jk	57.13efghi	1.10def
P_8	12.76k	4.10a	87.37def	1.00def
P_9	31.26b	4.23a	341.50a	1.50cdef
P_{10}	18.23f	2.80h	80.63defg	5.33a
P_{11}	12.33k	3.70b	78.97defg	1.50cdef
P_{12}	13.56j	3.20de	82.17defg	1.56cde
P_{13}	10.33m	3.00efgh	49.60fghi	0.90def
P_{14}	9.56n	3.16def	34.63hi	1.33cdef
P_{15}	11.53l	3.23de	55.67fghi	0.53f
P_{16}	8.66 o	2.33ij	44.67ghi	0.60ef
P_{17}	13.80ij	3.80b	79.60defg	1.40cdef
P_{18}	13.60j	3.16def	99.57cd	1.86cd
P_{19}	16.66gh	2.86gh	82.93defg	5.50a
P_{20}	8.76o	1.86k	30.50i	4.26b
P_{21}	14.30i	3.10efg	72.60defgh	2.26c
P_{22}	17.20g	2.30ij	96.17cde	2.26c

flower opening is very important to the breeders for increasing the early yield of hybrids. Data (Table 3) show the significant difference between all hybrids and commercial hybrid Lamar. It was found that hybrid P_4×P_3 was superior among all hybrids and gave the first female flower at few number of days compared with the control. On the other hand, hybrid P_5×P_3 took the highest number of days till appearing the first female flower. These results are in agreement with earlier researchers on cucumber (Abd-Rabou and Zaid, 2013; El Sayed, 2015; Soliman, *et al.*, 2018).

Data given in Table 4 revealed that, wide range in fruit length was observed among hybrids. The recorded fruit length ranged from 18.96 to 12.60 cm. The highest fruit length were produced by P_2×P_1 and P_2×P_3 while, the lowest fruit length was recorded in P_5×P_4. Narrow range was observed among hybrids for fruit diameter which ranged from 3.20 to 2.50 cm the lowest value was recorded in P_3×P_4 at par with hybrids P_1×P_2, P_1×P_4, P_1×P_5 and P_3×P_5, while the highest value was recorded in P_2×P_5. Fruit weight reflected great variation among the hybrids and hybrid P_2×P_5 had the high fruit weight. Table 4 show the significant differences among hybrids for total yield. Lamar (control) gave the highest value of total yield weight and there was not significant difference between control and hybrid P_1×P_3 on the contrary hybrid P_2×P_5 gave the lowest value of total yield weight. These results are in agreement with Abd-Rabou and Zaid (2013); El Sayed (2015) and Soliman *et al.* (2018) on cucumber.

Table 3. Mean performance of 20 hybrids for plant length, number of leaves and number of days to first female flower opening (mean of 2018 and 2019)

Genotype	Plant length	Leaf number	Number of days to first female flower opening	Bitterness	Spines
P_1×P_2	215.17c	31.43fgh	39.00e	+	+
P_1×P_3	198.20f	31.23gh	38.66e	-	-
P_1×P_4	220.60b	34.66c	45.00abc	-	-
P_1×P_5	197.60f	34.43cd	38.66e	-	-
P_2×P_1	221.07b	33.06e	40.00e	+	+
P_2×P_3	205.10e	34.66c	41.00cde	+	+
P_2×P_4	210.23d	33.50cde	38.66e	+	+
P_2×P_5	225.80a	31.56fg	48.00ab	+	+
P_3×P_1	191.33g	33.20de	39.33e	-	-
P_3×P_2	205.63e	32.56ef	38.33e	+	+
P_3×P_4	185.23h	36.70b	41.00cde	-	-
P_3×P_5	220.50b	33.43cde	42.33cde	-	-
P_4×P_1	185.90h	30.30ghi	40.00e	-	-
P_4×P_2	210.23d	30.30ghi	40.33de	+	+
P_4×P_3	203.47e	31.33fgh	38.33e	-	-
P_4×P_5	209.20d	38.26a	41.33cde	-	-
P_5×P_1	189.63g	28.40j	45.00abc	-	-
P_5×P_2	205.77e	29.23ij	47.66ab	+	+
P_5×P_3	203.47e	31.43fgh	49.00a	-	-
P_5×P_4	210.23d	30.23hi	44.33bcd	-	-
Lamar	225.53a	35.30bc	39.00e	-	-

Table 4. Mean performance of 20 hybrids for Fruit length, Fruit diameter, fruit weight and total yield (mean of 2018 and 2019)

Genotype	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Total yield (kg/m²)
P_1×P_2	15.43f	2.76efg	113.33f	5.13b
P_1×P_3	16.20de	2.80def	116.50e	6.50ab
P_1×P_4	16.90cd	2.66fg	107.67g	3.40defg
P_1×P_5	14.66gh	2.73efg	108.00g	5.03bc
P_2×P_1	18.93a	3.10abc	169.33b	3.23efg
P_2×P_3	18.96a	3.13ab	168.67b	3.23efg
P_2×P_4	18.70ab	3.00abcde	129.67c	2.96fgh
P_2×P_5	18.16b	3.20a	179.67a	1.93h
P_3×P_1	16.50cd	2.80def	111.17f	4.63bcd
P_3×P_2	15.50ef	2.80def	112.83f	3.16efgh
P_3×P_4	14.23hi	2.50g	93.93i	3.83cdef
P_3×P_5	15.40f	2.73efg	107.50g	3.50defg
P_4×P_1	15.50ef	3.10abc	120.17d	4.33bcde
P_4×P_2	13.73i	2.86bcdef	105.67gh	3.36defg
P_4×P_3	14.53gh	2.83cdef	103.57h	3.93bcdef
P_4×P_5	14.10hi	2.83cdef	105.87gh	2.90fgh
P_5×P_1	17.10c	2.80def	107.00g	2.23gh
P_5×P_2	15.16fg	2.83cdef	103.33h	2.53gh
P_5×P_3	18.10b	2.80def	117.33de	2.50gh
P_5×P_4	12.60j	3.06abcd	92.83i	3.10efgh
Cont (Lamar)	15.40f	2.43h	105.00gh	6.70a

The highest value for coefficient of variation was recorded by total yield and on the other hand, the lowest value was recorded for fruit length. High estimates of BSH for all studied traits indicated minor role of the environment on these characters and major role of genetics. The relative importance of variances due to GCA and SCA were compared via the predictability factor (PF).Total yield gave the highest ratio of predictability factor (PF) indicated the relative superiority of dominant gene effects over additive gene effects for the genetic control while leaf number gave relatively small deviation of PF from unity observed in this trait indicates the prime importance of additive gene action for the genetic control. These results agree with those reported earlier (Dogra and Kanwar, 2011; Golabadi, 2015) for cucumber.

General and specific combining abilities of studied traits: Estimation of GCA effects of lines represented that P_5 exhibited good general combining ability for all the traits (Table 6) and it was also found to be good new combiner containing positive alleles for improving all studied traits. Among the lines, P_1 were good general combiner for plant length, leaf number, number of

Table 5. Analysis of variance for agronomic traits in cucumber

Components of variance	Plant length	Leaf number	Number of days to first female flower opening	Fruit length	Fruit diameter	Fruit weight	Total yield
CV (%)	1.45	4.32	4.45	1.09	2.98	11.95	17.37
σ^2 e	7.16	1.41	4.017	0.037	0.008	164.00	0.11
σ^2 g	1726.59	20.89	37.56	64.12	0.36	7354.73	1.85
σ^2 p	1733.75	22.3	41.577	64.157	0.368	7518.73	1.96
H^2BS	0.95	0.93	0.90	0.99	0.97	0.97	0.94
GCV (%)	150.81	2.48	13.61	44.98	19.56	80.03	70.74
PCV (%)	151.12	2.56	14.32	44.99	19.77	80.91	72.81
GCV / PCV	0.99	0.96	0.95	0.99	0.98	0.98	0.97
PF	0.71	0.32	0.89	0.80	0.60	0.52	0.94

days to first female flower opening, fruit length, fruit weight and total yield. P_2 was good general combiner for all traits except leaf number. The potentiality of crossing between specific parents was detected by estimating specific combining ability effects (SCA) of each F_1 cross for all traits (Table 7). The cross $P_1 \times P_4$ showed high SCA effects for all traits in this study which means comparing the general combining ability effects (GCA) of the parents to their corresponding crosses (SCA) indicate that the GCA effects of the parents were reflected in the SCA effects of the crosses for the most studied traits. The reciprocal effects in F_1 diallel crosses estimated by Griffing's analysis were significant for most of the traits studied. Where, the cross $P_5 \times P_1$ achieved high SCA effects for all traits. These results indicate that extra-nuclear genes also have a significant contribution to the control of all the traits investigated. Therefore, the transfer of desirable traits could probably be easier with the production of cytoplasmic male sterility (CMS) lines. On the other hand, the use of reciprocal crosses could be used for different purposes in hybrid seed production. These results agree with those reported by Golabadi (2015) for cucumber.

Trait correlation: Based on the correlation coefficient analysis, fruit length and fruit weight revealed the highest positive

Table 6. General combining ability (GCA) effects of inbred lines for some cucumber characters

Genotypes	Plant length	Leaf number	Number of days to first female flower opening	Fruit length	Fruit diameter	Fruit weight	Total yield
P_1	-5.6**	0.31*	-1.68*	0.95*	0.02^{NS}	1.97*	0.87*
P_2	8.09**	0.18^{NS}	-0.62*	0.50*	0.18*	13.3**	-0.63*
P_3	-1.76*	0.32*	-0.92*	0.45*	0.00^{NS}	0.26^{NS}	0.59*
P_4	-6.59**	-1.30**	-1.35**	-2.04**	-0.20*	-17.40^{NS}	-0.01^{NS}
P_5	5.86**	0.49*	4.58**	0.15*	-0.11*	1.91*	-0.82*
S.E. (ĝi-ĝj)	0.37	0.10	0.32	0.05	0.02	0.49	0.11

NS, *, **: insignificant, significant at 0.05 and 0.01 % probability levels, respectively

Table 7. Specific combining ability (SCA) effects of the F_1's for some cucumber characters

Crosses	Plant length	Leaf number	Number of days to first female flower opening	Fruit length	Fruit diameter	Fruit weight	Total yield
$P_1 \times P_2$	14.48**	-0.46^{NS}	-0.11^{NS}	-0.08^{NS}	-0.08^{NS}	16.59**	0.30*
$P_1 \times P_3$	-2.41*	-0.77^{NS}	-0.31^{NS}	-0.87^{NS}	-0.04^{NS}	2.13*	0.46*
$P_1 \times P_4$	10.91**	1.18*	3.62**	1.471*	0.19*	19.91**	-0.64*
$P_1 \times P_5$	-11.20**	-1.68*	-2.98*	-1.03*	-0.02^{NS}	-5.86*	-0.07^{NS}
$P_2 \times P_1$	-5.50*	0.84*	-0.71	0.46^{NS}	-0.02^{NS}	17.72**	-0.40*
$P_2 \times P_3$	4.20*	2.33*	-0.45^{NS}	1.93*	0.09^{NS}	12.33**	0.16*
$P_2 \times P_4$	-2.70*	-1.63*	1.95*	0.20^{NS}	0.08^{NS}	16.82**	0.04^{NS}
$P_2 \times P_5$	-1.83*	1.11*	0.02^{NS}	0.14^{NS}	0.01^{NS}	6.45*	-0.34*
$P_3 \times P_1$	3.35*	-1.60*	0.08^{NS}	0.32^{NS}	0.01^{NS}	0.77^{NS}	-0.41*
$P_3 \times P_2$	5.91*	2.77*	-2.31*	-0.58^{NS}	0.34**	5.40*	0.18*
$P_3 \times P_4$	-6.33*	-0.88^{NS}	-0.50^{NS}	-1.75*	-0.17*	-28.00**	0.95**
$P_3 \times P_5$	3.43*	-0.92^{NS}	-0.33^{NS}	-0.15^{NS}	-0.01^{NS}	2.67*	0.93**
$P_4 \times P_1$	17.35**	2.18*	2.50*	0.70^{NS}	-0.22**	-6.25*	-0.47*
$P_4 \times P_2$	3.98*	3.02*	-3.16**	-1.22*	-0.03^{NS}	0.50^{NS}	1.41**
$P_4 \times P_3$	-0.27^{NS}	-1.05*	1.33*	1.73*	0.17*	27.92**	0.03^{NS}
$P_4 \times P_5$	0.00^{NS}	3.20*	-0.83*	2.48**	0.07^{NS}	12.00**	-0.20*
$P_5 \times P_1$	10.02**	2.10*	0.16*	1.50*	0.18*	38.17**	-0.30*
$P_5 \times P_2$	-9.12**	1.08*	1.33*	-0.15^{NS}	-0.17*	-4.82*	-0.05^{NS}
$P_5 \times P_3$	8.517**	0.07^{NS}	-3.33**	-1.35*	-0.03^{NS}	-4.92*	0.50**
$P_5 \times P_4$	-0.52^{NS}	4.07*	-1.50*	0.75^{NS}	-0.12*	6.51*	-0.10^{NS}
S.E.(Sij-Sik)	0.75	0.20	0.64	0.11	0.04	0.98	0.22
SE(Sij-Skl)	0.65	0.17	0.55	0.09	0.04	0.84	0.19

NS, *, **: insignificant and significant at 0.05 and 0.01 % probability levels, respectively.

correlation (0.82) (Table 8). It is logical, as fruit weight naturally increases with the fruit length. On the other hand fruit diameter and leaf number revealed the lowest negative correlation (-0.02).

Table 8. Correlation coefficient between different traits of cucumber inbred lines

Traits	Leaf number	NDF	Fruit length	Fruit diameter	Fruit weight	Total yield
Plant length	0.17	-0.34	0.55	0.04	0.36	0.18
Leaf number	1.00	0.36	-0.33	-0.02	-0.30	0.34
NDF		1.00	-0.44	-0.13	-0.29	-0.39
Fruit length			1.00	0.17	0.82	-0.09
Fruit diameter				1.00	0.51	-0.31
Fruit weigh					1.00	-0.12
Total yield						1.00

NDF= Number of days to flowering

On the basis of results, it was concluded that the nature of gene action controlling most of the studied traits seems to be more cumulative (non additive) than additive although the additive genetic variance was important. In this experiment hybrid $P_1 \times P_3$ gave the highest total yield as a high temperature tolerant cumber genotype.

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