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Hybrid Performance of Qualitative and Quantitative Traits in Summer Squash Affected By Uv- Irradiation

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Abstract

Summer squash, *Cucurbita pepo* L. is the edible immature fruits belonging to the important family cucurbitaceae. Therefore, the main objective of this study is to evaluate six hybrid performances of summer squash over the mid parent for vegetative growth and yield components. The hybrids were extracted from the seeds of two varieties subjected to ultraviolet radiation. Irradiated and non irradiated plants were hybridized via a half diallel crosses technique.The better hybrid performance in leaf area per plant was achieved by the hybrid extracted from hybridization between $P_1 \times M_1$~P_1 followed by $P_2 \times M_1$~P_1. Meanwhile, superiority hybrid performance in the number of days needed to first female flower appeared was shown by the hybrid extracted from $P_2 \times M_1$~P_1 with a value 0.87 followed by the selfing hybrid $P_2 \times M_1$~P_2 with a value 0.95. Therefore, the best hybrid performance in the early maturity was achieved by the hybrid extracted from hybridization between $P_2 \times M_1$~P_1 followed by $P_1 \times M_1$~P_2 and $P_2 \times M_1$~P_2. The hybrid $P_1 \times M_1$~P_2 revealed better performance in the gene expression of chlorophyll a in leaves followed by $P_1 \times P_2$. In addition, the hybrid $P_2 \times M_1$~P_2 was superior performance in the gene expression of chlorophyll b and total chlorophyll in leaves and fruits. The hybrid $P_1 \times M_1$~P_2 expressed superiority performance in the quality of fruits as fruit diameter, fruit volume and fruit shape index. All hybrids obtained from these study exhibited positive performance in yield components.

Key words: UV irradiation, hybrid performance, fruits quality, fruits productivity, summer squash, chlorophyll pigments, vegetative growth, homogeneity values.

Introduction

Summer squash (*Cucurbita pepo* L.) is a cross pollinated plant having a diploid chromosome number (2n=2x=40) which planted for its fruits.Summer squash is the edible immature fruits of*Cucurbita pepo* L., which belonging to the important family cucurbitaceae. Fruit shape vary from round to disc shaped to very long. Hybrid vigor phenomenon is one of the most important genetic phenomena that leading to increase crop productivity in several crops. The imported hybrids are characterized by higher production and quality of their fruits. The seeds of imported hybrids are very expensive and may be not adopted to the Egyptian condition due to higher or lower temperatures and soil salinity **(Al-gumar 1999)**. It become necessary for plant breeders to develop local hybrids from the available varieties to extract singular hybrids or imported with a good degree of diversity to obtain superior hybrids. This phenomenon was specialized in the size of hybrid, fertility, growth rate and productivity in relation to its parents **(Sabouh *et al*. 2010)**. This phenomenon was associated with first generation hybrid **(Kaur and Dhall 2017)**.

Heterosis breeding using a good combiner parents is one of the best techniques to improve the economical cultivars. Heterosis phenomenon resulting from hybridization between genetically dissimilar parents particularly in cross pollinated crops **(Madhu 2010)**. The nature of gene action related to the expression genes of quantitative traits was important for effective development of varieties **(Ene *et al*. 2016)**. Hybrid vigor is one of the most efficient tools to exploit genetic diversity. This phenomenon was great importance in plant breeding as a major source for increasing and improving productivity of economical crops as summer squash **(Paris and Cohen 2002)**. Production of highest yield hybrids that better than the better parent depends to the over dominance gene action **(El-Sahooki 2004)**.

Heterosis played a vital role in increasing yield quality and quantity of crops. It refers to the phenomenon that F_1 hybrid extracted from crossing between two genetically dissimilar genotypes which showed increased or decreased vigor in relation to the better parent or mid parent value **(Poehlman 1979)**. In cucurbits heterosis was first observed by **Hays and Jones (1961)**. Heterosis is known as the hybrid vigor expressed by F_1 hybrids **(Hallauer *et al*. 2010)**. Heterosis can be defined in three different means including mid parent, standard variety and better parent heterosis. Standard variety is designated as standard heterosis while the better parent heterosis was better known as heterobeltiosis **(Alam *et al*. 2004)**.

The exploitation of hybrid vigor is much easier in cross pollinated crops as summer squash being monoecious and poses more seed per cross provides heterosis on commercial scale **(Naik *et al*. 2019)**. Ultraviolet radiation (UV) induced mutations to speed up generation and development new species by its action on DNA. Non-ionizing radiation includes ultraviolet which characterized by small wavelengths and energies and insufficient to produce ionization phenomena. Responses to UV caused by its direct effects of UV radiation on essential components and cellular membranes by the action of free radicals, reducing mRNA transcription, protein synthesis and enzymatic activity **(Lazar *et al*. 2011)**. In this way, UV-radiation was used in this study to increase genetically dissimilar between both varieties of summer squash used in this study as a tool to obtain superior hybrids, characterized by the vigor of the plants and could be the basis for intensification of crop production **(Mariz-ponte *et al*. 2018)**. Genetic improvement of crop depends on the genetic diversity present in the population. Mutation on the gene level called point mutation caused alterations in gene structure caused appearance or disappearance of new traits **(Ambavane *et al*. 2015)**. There is a prime need for development hybrids in summer squash superior in their productivity and suited to specific agro ecological conditions.

Irradiation is a method that induced mutation in plant cells. During irradiation the high energy radiation pass through the matter and caused ionizing disturbances that affect the internal structure of the cells **(Caldwell and Flint 1994)**. Plants exposed to elevated UV-radiation exhibit various physiological and morphological changes **(Caldwell *et al*. 1998)**. UV-radiation induced considerable variation among species and varieties within the same species **(Mcleod and Newsham 1997, Correia *et al*. 1999)**. Seeds from both varieties of summer squash used in this study were soaked in water before UV-irradiation to increase the influencing effects physical mutagen as UV **(Conger *et al*. 1968)**. Water content in the seeds involve in the facilitate mobility and action of free radicals, as well as oxygen with physical mutagens **(Ehrenberg 1961)**.The main objective of this research was to estimate the degree of hybrid performance in the extracted hybrids from the parents affected by UV-irradiation.

Materials and Methods

Genetic materials

Two varieties of summer squash genotypes named Alexandarani (P_1) and Dyana (P_2) were used in this study. Both varieties were obtained from Horticulture Research Institute, Agriculture Research Center, Egypt. They are used as parents for crossing programme in all possible combinations adopting half diallel cross mating design **(Doijode and Sullamath 1983)**.

Ultraviolet irradiation

Seeds of both genotypes were first soaked in water for 24 hours and then irradiated for four minutes using the laminar cabinet UV rays as an artificial sourceof UV. The laminar cabinet used in this study was present in Microbial Genetics Laboratory, Faculty of Agriculture, Mansoura University.

The spectrum of UV-radiation was classified into three categories; lower energy named UV-A (320 – 400 nm), high energy named UV-B (280 – 320 nm) and higher energy named UV-C (254 – 280 nm). The UV-A is less effective than UV-B and UV-C for induced mutations **(Barta *et al*. 2004)**. The spectrum of UV lamp used in this study was 300 nm, therefore it was classified as UV-B. Seeds of summer squash were exposed to UV-radiation for four minutes which equal 752.8 joules/m^2 according to **Kondrateva *et al*. (2020)**. The joules defined as the amount of energy extracted when a force of one newton is applied over a displacement of one meter which equivalent one watt of power radiated for one second.

Experimental design

Irradiated and nonirradiated seeds of both genotypes were sown in outdoor experimental plots in Randomized Complete Block design with three replications. Each experimental plot consisted of 10 rows with three meter length and 0.5 meter width. Two seeds were planted in each hill with a distance 50 cm between the plants. The plants were thinned to one plant per hill after two weeks of germination. The plants were irrigated when needed. All replications were received similar treatments as irrigation, pest and disease control and other agricultural practices. Fruits were collected at two-days intervals. The average number of leaves per plant was counted at the end of season. M_1 plants were which planted to obtain M_2 plants and their hybrid fruits.

Table 1. Cross-pollination between two genotypes of summer squash including irradiated and nonirradiated plants.

Hybridization between Male plant (♂) × Female plant (♀)	Designation ♂ × ♀
Unirradiated Alexandarani× Unirradiated Dyana	$P_1 \times P_2$
Unirradiated Alexandarani× Irradiated Alexandarani	$P_1\times M_1$~P_1
Unirradiated Alexandarani× Irradiated Dyana	$P_1\times M_1$~P_2
Unirradiated Dyana × IrradiatedAlexandarani	$P_2\times M_1$~P_1
Unirradiated Dyana × Irradiated Dyana	$P_2\times M_1$~P_2
Irradiated Alexandarani× Irradiated Dyana	M_1~$P_1\times M_1$~P_2

The fruits of M_1 plants were harvested at maturity. Evolved traits were recorded in M_2 generation. Observation on days to first male and female flowering appeared was recorded on plot basis. Observations were recorded on sex randomly selected plants from each plot of each treatment.

Leaf area

It was expressed as cm^2 when the plants reached to 50 days old using fresh weight method. Ten disks were taken from the fresh leaves using corkpiercing one cm diameter and then weighted. All the plant leaves were weighted to be apply in the following formula.

$$\text{Leaf area } (cm^2) = \frac{\text{Fresh weight of total leaves per plant} \times 10 \times \text{area of disk}}{\text{Fresh weight of 10 disk}}$$

Plastid pigments of chlorophyll in leaves and fruits

Plastid pigments were extracted by methanol from fresh leaves and fruits and then determined spectrophotometrically. The extraction of pigments content $(\mu g / mg \text{ fresh weight})$ was done according to **Lichtenthaler and Wellburn (1983)** method. The absorption spectrum of different pigments was determined at wavelength corresponding to 663 nm and 646 nm using Eppendorf BioSpectrometer Kinetic (Germany).

$$\text{Chlorophyll a } (\mu g / mg \text{ FW}) = \frac{12.25\ (A663) - 2.79\ (A646) \times \text{volume (ml)}}{\text{Weight of leaf tissue (mg)}}$$

$$\text{Chlorophyll b } (\mu g / mg \text{ FW}) = \frac{21.5\ (A646) - 5.1\ (A663) \times \text{volume (ml)}}{\text{Weight of leaf tissue (mg)}}$$

Fruit volume

The volume of fruits was calculated by water displacement method using graduated cylinder according to **Gholami *et al*. (2012)**.In addition, the following traits were estimated as; plant height which measured when the plants begin to blooming, first female flowering, first male flowering, first picking date, fruit length, fruit diameter, fruit shape index, number of fruits per plant, fruits weight per plant, fruit weight, number of fruits per plot for the first seven pickings and the weight offruits per plot during the first seven pickings.

Homogeneity assays

The degree of homogeneity between different genotypes obtained in this study was estimated using the following equation according to **Gomez and Gomez (1984)**.

$$\text{Coefficient of variation} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

Hybrid performance

The degree of hybrid performance was calculated in relation to the mid parent according to **Marxmathi *et al*. (2018)**.

Statistical analysis

Results are the mean values of three biological replicates. ANOVA was used to analyze the general effects of UV irradiation. The data collected were subjected to the analyses of variance to test the significance of differences between genotypic means using F- test and least significant difference (LSD) according to **Steel and Torrie (1960)**.

Results and Discussion

Hybrid performance

Hybrids breeding in summer squash is one of the importance for plant breeders due to flexibility and saving the parents properties, in addition to higher productivity. Furthermore, hybrid fruits showed homogeneity and vigor in their vegetative growth. Hybridization between high genetic diversity genotypes is important for breeding new hybrids. Hybrid vigor phenomenon is one of the important genetic phenomena that contributing to increase crop productivity in summer squash which belonging to cucurbitaceae family. Not only the imported hybrids characterized as higher productivity and good quality of fruits, but also their seeds are expensive to the farmers and it may be not adapted to environmental conditions of other countries due to the effect of temperatures, drought and salinity if high or low. Therefore, it is necessary for plant breeders to construct local Egyptian hybrids via crossing between local pure lines to extract new hybrid genotypes defined as a good performance in quantitative and qualitative traits. The hybrid vigor release superior hybrids in relation to both parents average or the better parent. This phenomenon was appeared in the first generation of crosses.

Hybrid performance of vegetative growth

The results in **Table 2** show that there are no significant differences between the genotypes in vegetative growth indicators. The selfing hybrid between $P_2 \times M_1{\sim}P_2$ was superior if compared with all genotypes in the performance for the number of leaves / plant and plant height followed by the cross hybrids between $M_1{\sim}P_1 \times M_1{\sim}P_2$ and $P_2 \times M_1{\sim}P_1$ for the number of leaves / plant. The hybrid performance in number of leaves / plant was varied from 0.87 in the cross between wild type varieties ($P_1 \times P_2$) to 1.23 in selfing cross hybrid ($P_2 \times M_1{\sim}P_2$).

Table 2. M_2 hybrid performance in vegetative growth and flowering of summer squash affected by UV- irradiation**.**

Genotypes ♂ × ♀		Number of leaves /plant	Leaf area / plant	Plant height	Number of days to first female flowering	Number of days to first male flowering
$P_1 \times P_2$		0.87	1.04	1.06	0.96	0.99
$P_1 \times M_1$~P_1		0.99	2.68	1.07	1.02	0.99
$P_1 \times M_1$~P_2		0.93	1.49	1.13	0.95	0.96
$P_2 \times M_1$~P_1		1.08	2.15	1.27	0.87	0.94
$P_2 \times M_1$~P_2		1.23	0.82	1.41	0.95	0.96
M_1~$P_1 \times M_1$~P_2		1.11	1.02	1.13	0.98	0.99
F-test		Is	Is	Is	Is	Is
LSD	0.05	0.32	1.22	0.30	0.101	0.04
	0.01	0.44	1.68	0.41	0.14	0.06

Notes
M_1 = First irradiated generation.
M_2 = Second irradiated generation.
M_1~P_1 = First irradiated generation derived from P_1.
M_1~P_2 = First irradiated generation derived from P_2.
Is = Insignificant differences.

In addition, the best hybrid performance in the leaf area was achieved by selfing hybrid between $P_1 \times M_1$~P_1 with a value 2.68 followed by $P_2 \times M_1$~P_1 with a value 2.15 and $P_1 \times M_1$~P_2 with a value 1.49. Furthermore, the hybrid performance for leaf area was ranged between 0.82 by the selfing hybrid $P_2 \times M_1$~P_2 to 2.68 by $P_1 \times M_1$~P_1. The best performance in plant height was obtained by the selfing hybrid $P_2 \times M_1$~P_2 with a value 1.41 followed by cross hybrid $P_2 \times M_1$~P_1 with a value 1.27, ($P_1 \times M_1$~P_2) and (M_1~$P_1 \times M_1$~P_2) with the same value 1.13. Hybrid performance in plant height was ranged between 1.06 ($P_1 \times P_2$) to 1.41 ($P_2 \times M_1$~P_2). The best hybrid performance in the number of days needed to first female flower appeared was $P_2 \times M_1$~P_1 with a value 0.87 followed by the two hybrids $P_2 \times M_1$~P_2 and $P_1 \times M_1$~P_2 with the same value 0.95.

The hybrid performance for earliness of first female flowering was ranged between 0.87 ($P_2 \times M_1$~P_1) to 1.02 ($P_1 \times M_1$~P_1). Meanwhile, the best hybrid performance in the number of days needed to first male flower appeared was $P_2 \times M_1$~P_1 with a value 0.94 followed by $P_1 \times M_1$~P_2 (0.96) and $P_2 \times M_1$~P_2(0.96). The hybrid performance of first male flower appeared was ranged between 0.94 ($P_2 \times M_1$~P_1) to 0.99 ($P_1 \times P_2$, $P_1 \times M_1$~P_1 and M_1~$P_1 \times M_1$~P_2). These results indicated that the best hybrid performance gave early maturity was $P_2 \times M_1$~P_1 followed by $P_1 \times M_1$~P_2 and $P_2 \times M_1$~P_2. Hybrids expressed variations in vegetative growth and early maturity indicators reflected the differences in the behavior of gene expression by different cross genotypes. The results indicated that the extracted hybrids affected by UV- irradiation were superior in growth vigor if compared with wild type varieties.

These results agreed with **Kushwaha *et al*. (2011)**, who found that the extracted hybrids gave the highest rate of cucumber yield and early yield. The same authors obtained thirteen hybrids were the best in fruit forming factor compared with all standard hybrids. The positive values of hybrid vigor compared with the highest parents are controlled by dominance genes that leading to increase the indicators of vegetative growth parameters. The negative values in hybrid performance of vegetative traits are controlled by partial dominance genes **(Singh *et al*. 2016)**. The results indicated that there was a geneticdifferences between the parents and extracted hybrids affected by UV- irradiation in most of growth traits. Furthermore, the best hybrid performance is characterized by a highervalues of positive heterosis in vegetative traits and lower values of earliness.

Sex expression genes in summer squash is affected by the environment, genetic and hormonal factors. The female sex expression genes was promoted by medium temperature and short photoperiod etc. which turn the influence of sex expression genes **(Agbaje *et al*. 2012)**. Expression of heterosis was much easier in cross pollinated crops as summer squash being monoecious and poses more seeds per cross **(Naik *et al* 2019)**. Hence, the first male and female flowers appeared reflected the earliness parameter, meanwhile flowering at lower node is indication of earliness. In cucurbits male flower appeared at lower node, usually sex to seven days before the female flower open. Therefore, the results obtained in this study are in harmony with **Naik *et al*. (2019)**, who found that cucumber hybrids exhibited significant negative heterosis concerning the number of days needed to first male and female flowers appeared was related to the direction of earliness. Similar standard heterosis was recorded in cucumber by **Singh and Ram (2009)**. This also is in the line of **Singh *et al*. (2015)** in cucumber, who found significant negative heterosis for the number of days needed to first female flower appeared.

Furthermore, **Pandey *et al*. (2005)** stated that the reason for significant negative heterosis of both checks for earliness may be due to the presence of dominant loci in different directions that leading to cancellation the effects of recessive genes. The same authors decided that the crosses do not produce heterosis reflected that the parent involved in these crosses do not differ in the gene frequency of the trait under investigation. The appearance of first male and female flowers appeared is a prime objective in the development of early hybrids. The development of early fruiting genotypes focus on the negative heterosis related to the number of days needed to flowering **(Arya and Singh 2014)**. Thus, improvement of single traits could be achieved by crosses between two target parents followed by selection methods. This requires a sequence of hybridizations followed by selection. Therefore, a diallel mating design was applied to stimultaneously contribute genes to a gene pool of F_1 which subsequent subjected to mass selection **(Jensen 1970)**. Therefore, heterosis would be useful to plant breeders to extract new genotypic hybrids superior in their quality of fruits and productivity.

Hybrid performance in the expression of chlorophyll pigment genes

The results presented in **Table 3** showed insignificantdifferencesbetweengenotypesforthehybri dperformanceofchlorophyllformation in leaves and fruits, except chlorophyll b in fruits showed significant differences among the genotypes. The hybrid $P_1\times M_1\sim P_2$ produced the highest (1.40) performance for chlorophyll a in leaves followed by $P_1\times P_2$ (1.19). The hybrid performance of chlorophyll a in leaves was varied from 0.84 ($P_2\times M\sim P_1$) to 1.40 ($P_1\times M_1\sim P_2$). The hybrid $P_2\times M_1\sim P_2$ produced the highest values of gene expression in chlorophyll b (1.34) formed in leaves followed by $M_1\sim P_1\times M_1\sim P_2$ with a value 0.57. Furthermore, chlorophyll b performance in leaves was ranged between 0.25 ($P_1\times M_1\sim P_1$) to 1.34 ($P_2\times M_1\sim P_2$).

Table 3. M_2 hybrid performance in chlorophyll formation of summer squash affected by UV- irradiation.

Genotypes ♂ × ♀		Leaves			Fruits		
		Chla	Chlb	Total	Chla	Chlb	Total
$P_1\times P_2$		1.19	0.45	0.76	0.59	0.64	0.63
$P_1\times M_1\sim P_1$		0.95	0.25	0.54	1.41	0.61	0.85
$P_1\times M_1\sim P_2$		1.40	0.54	0.89	2.13	0.45	0.90
$P_2\times M_1\sim P_1$		0.84	0.48	0.67	1.00	0.27	0.53
$P_2\times M_1\sim P_2$		1.13	1.34	1.22	3.11	0.57	1.34
$M_1\sim P_1\times M_1\sim P_2$		1.06	0.57	0.83	0.68	0.63	0.65
F- test		Is	Is	Is	Is	**	Is
LSD	0.05	0.52	0.70	0.44	1.73	0.36	0.59
	0.01	0.71	0.96	0.61	2.37	0.50	0.81

Notes
Chl = Chlorophyll.
M_1 = First irradiated generation.
M_2 = Second irradiated generation.
$M_1\sim P_1$ = First irradiated generation derived from P_1.
$M_1\sim P_2$ = First irradiated generation derived from P_2.
Is = Insignificant differences.
** = Significance at 0.01 level of probability.

The results confirmed that the hybrid performance for total chlorophyll in leaves was varied from 0.54 ($P_1\times M_1\sim P_1$) to 1.22 ($P_2\times M_1\sim P_2$). These results indicated that the selfing hybrid ($P_2\times M_1\sim P_2$) produced the highest performance in the gene expression of chlorophyll b and total chlorophyll formed in leaves.

The best hybrid performance in gene expression of chlorophyll b and total chlorophyll in leaves appeared the same trend for chlorophyll a and total chlorophyll in fruits. Chlorophyll a performance in fruits was varied from 0.59 ($P_1\times P_2$) to 3.11 ($P_2\times M_1\sim P_2$). The two hybrids $P_2\times M_1\sim P_2$ and $P_1\times M_1\sim P_2$ showed superior performance in the gene expression of chlorophyll a in fruits with a values 3.11 and 2.13, respectively. The hybrid performance of gene expression in chlorophyll b formed in fruits was ranged between 0.64 ($P_1\times P_2$) to 0.27 ($P_2\times M_1\sim P_2$). Superior hybrid performance in the gene expression of chlorophyll b formed in fruits was shown by the hybrids extracted from both unirradiated varieties ($P_1\times P_2$). Also the find results revealed that the gene expression of total chlorophyll in fruits was varied from 0.53 ($P_2\times M_1\sim P_1$) to 1.34

(P_2× M_1~P_2). Fruits of summer squash contain a variety of pigments as chlorophylls and carotenoids **(Gross 1991)**. The major pigments in immature fruit are chlorophylls, whose concentrations affect the coloring of green fruits. The results obtained in this study are in harmony with **Hu *et al*. (2002)**, who reported that green color in bitter gourd fruits was dominant over the white color and controlled by one gene. The results obtained by **Huang and Hsieh (2016)** also showed green color in bitter gourd was dominant but did not support the one gene theory.

The results obtained in this study agreed with **Huang and Hsieh (2016)**, who stated that chlorophyll a and total chlorophyll concentrations were nonsignificant in all parameters studied in bitter gourd and the additive genes were more important in the contribution of chlorophyll concentrations. **Srivastava and Nath (1972)** characterized two F_2 populations from two hybrid combinations between green and white fruit parents in bitter gourd which found that immature fruit color was controlled by one nucleus gene with no cytoplasmic factor involved. However, **Hu *et al*. (2002)** also speculated that the light green colors were probably affected by incomplete dominance or modifier genes. However, the fruits of summer squash were appeared in different colors. **Nath and Hall (1963)** showed that the green color of summer squash fruits at immature stage was monogenetically dominant over the yellow color and the green striped fruit exhibited simple dominance over the plain green. In contrast, **Globerson (1969)** found that the green fruits vs. white was controlled by two genes (*C* and *R*), of which the *C* gene has an epistatic control.

In the present study extracted hybrids as P_2× M_1~P_2. Followed by P_1 ×M_1~P_2 revealed the best performance in the expression of chlorophyll genes in leaves (1.22 and 0.89) and fruits (1.34 and 0.90), respectively. This indicated that heterozygosity in cross pollinated crops as summer squash was optimum in the gene expression of chlorophyll production. Furthermore, green fruit color was affected by a genetic process involved in chlorophyll production. As shown in this study it can be identifying the best heterotic combinations inducing the better performance of green color in fruits and its exploitation for commercial purpose. Desirable level of heterosis over the mid parent was obtained in several hybrids for the chlorophyll in leaves and fruits. The results indicated that UV- irradiation induced genetic diversity to be used as a tool for obtaining heterozygous genotypes expressed superiority in the performance of hybrids if compared with their parents. The expression of mid parent heterosis showed a greater magnitude in the hybrids of inbred lines of *Cucurbita moschate* as shown before by **Restrepo *et al*. (2018)**. During the period of fruit development which begins from flowering at the ends of fruit ripening, fruits are pale-green color with very small oval plastids. Their color is hardly greenish as result of diffraction of light on the plastids, not of presence of chlorophyll. At the time of fruits ripening their volume increases without any changes in the number of plastids per cell and their size. Small amount of chlorophyll is evident in young fruits without chloroplasts observed by the electron microscope **(Ljubesic 1973)**.

Hybrid performance in fruits quality

The results in **Table 4** shows that there were insignificant differences among genotypes in the quality of fruits. The best hybrid performance for the number of days needed to first collection of fruits was shown by P_2 × M_1~P_1 (0.93)

Table 4. M_2 hybrid performance in fruits quality produced by summer squash affected by UV- irradiation**.**

Genotypes ♂×♀		Number of days to first fruits collection	Fruit length	Fruit diameter	Fruit volume	Shape index of fruit
P_1× P_2		0.98	1.01	0.96	0.98	1.02
P_1× M_1~P_1		1.06	0.97	0.99	1.02	0.96
P_1× M_1~P_2		0.95	0.98	0.93	0.93	1.05
P_2× M_1~P_1		0.93	0.95	0.95	1.02	0.98
P_2× M_1~P_2		1.00	1.01	0.96	1.11	1.03
M_1~P_1× M_1~P_2		0.98	0.96	1.03	1.13	0.90
F- test		Is	Is	Is	Is	Is
LSD	0.05	0.09	0.07	0.10	0.24	0.12
	0.01	0.12	0.10	0.13	0.33	0.16

Notes
M_1 = First irradiated generation.
M_2 = Second irradiated generation.
M_1~P_1 = First irradiated generation derived from P_1.
M_1~P_2 = First irradiated generation derived from P_2.
Is = Insignificant differences.

followed by reciprocal cross $P_1\times M_1\sim P_2$ (0.95). The hybrid performance in numberof daysneededtofirst collectionof fruits was varied from 0.93 ($P_2 \times M_1\sim P_1$) to 1.06 ($P_1\times M_1\sim P_2$). The highest performance in fruit length was obtained by $P_1\times P_2$ and $P_2\times M_1\sim P_2$ with the same value 1.01. Hybrid performance in fruit length was varied from 0.95 ($P_2\times M_1\sim P_1$) to 1.01 ($P_1\times P_2$, $P_2\times M_1\sim P_2$). Hybrid performance in fruit diameter was ranged between 0.93 ($P_1\times M_1\sim P_2$) to 1.03 ($M_1\sim P_1\times M_1\sim P_2$). Superior hybrid performance in fruit diameter was obtained by $P_1\times M_1\sim P_2$ with a value 0.93. Hybrid performance in fruit volume was varied from 0.93 ($P_1\times M_1\sim P_2$) to 1.13 ($M_1\sim P_1\times M_1\sim P_2$). The better hybrid performance in fruit volume was obtained by ($P_1\times M_1\sim P_2$) with a value 0.93. The shape index of fruit was ranged between 0.90 ($M_1\sim P_1\times M_1\sim P_2$) to 1.05 ($P_1\times M_1\sim P_2$). The results obtained in this study agreed with **Elias *et al*. (2020)**, who demonstrated that the hybrids of *Cucurbita pepo* were not shown significant superiority in the number of fruit branches. The variation between the means of parents and their specific hybrid led to hybrid vigor or hybrid performance. The highest negative heterosis was preferred in the number of days needed to first fruits collection, fruit diameter and fruit size.

In addition, **Elias *et al*. (2020)** stated that the inheritance of hybrid traits in which the hybrid vigor was negative is affected by the influence of negative non additive action as reported before by **Hanchinamani (2006)**. Meanwhile, **Balestre *et al*. (2008)** decided that the inheritance of traits in specific hybrids showed positive and significant heterosis were affected by the influence of dominant gene action. The quality of fruits is the most important traits in summer squash leading plant breeders seek to produce superior hybrids in terms of fruit form which determines its quality as fruit length and diameter. This indicates the physiological and nutritional status of plant that reflected the impact of genetic and environmental conditions leading to their adoption and then distributed to the farmers. The genotypes of summer squash varied in fruit length, fruit diameter and fruit shape index which they are indicating good yield quality. The superiority of some hybrids in fruit quality as shown in this study could be due to the influence of gene action and probably maternal effect of female parent. The hybrid $P_1\times M_1\sim P_2$ had the highest performance in fruit shape index with a value 1.05. The results obtained herein agreed with **Pandey *et al*. (2005)**, who stated that the crosses do not show heterosis reflected that the parents involved in the cross do not differ in the gene frequency in relation to the locus of traits under investigation. The appearance of first female flower at lower node was a prime aim in development of earliness hybrids. The early fruiting genotypes was expressed by negative heterosis in desirable of node number at which first female flower formed **(Arya and Singh 2014)**. Furthermore, **Naik *et al*. (2019)** reported that negative heterosis for days to 50 percent and 100 percent flowering indicated the earliness in cucumber. Heterosis in negative direction is desirable for days to first packing, as well. Heterosis in positive direction is desirable for days to last harvest which results in yield increase.

Hybrid performance in yield components

The data presents in **Table 5** showed hybrid performance in fruits productivity.The differences between hybrids obtained showed insignificant differences for all yield components. Heterosis points to the importance of non-additive gene action. The analysis do not delete inbreeding from the genotype effects **(Allard 1960)**.

Table 5. Yield performance of M_2 hybrids affected by UV- irradiation**.**

Genotypes ♂×♀		Number of fruits per plant	Fruits weight /plant	Mean fruit weight
$P_1\times P_2$		1.16	1.28	1.07
$P_1\times M_1\sim P_1$		1.28	1.42	1.03
$P_1\times M_1\sim P_2$		1.39	1.58	1.12
$P_2\times M_1\sim P_1$		1.68	1.73	1.04
$P_2\times M_1\sim P_2$		1.36	1.58	1.16
$M_1\sim P_1\times M_1\sim P_2$		1.36	1.43	1.03
F- test		Is	Is	Is
LSD	0.05	0.70	0.90	0.16
	0.01	0.96	1.24	0.22

Table 5. Continued.

Genotypes ♂ × ♀		Number of fruits per first seven collections	Fruits weight per first seven collections	Number of total fruit /10 plants	Total fruits weight / 10 plants
$P_1 \times P_2$		2.09	2.91	1.16	1.28
$P_1 \times M_1 \sim P_1$		2.18	2.59	1.28	1.42
$P_1 \times M_1 \sim P_2$		3.44	3.49	1.39	1.58
$P_2 \times M_1 \sim P_1$		5.92	6.44	1.68	1.73
$P_2 \times M_1 \sim P_2$		1.14	1.76	1.36	1.57
$M_1 \sim P_1 \times M_1 \sim P_2$		1.50	1.67	1.36	1.43
F- test		Is	Is	Is	Is
LSD	0.05	4.001	4.21	0.70	0.90
	0.01	5.48	5.77	0.97	1.24

Notes
M_1 = First irradiated generation.
M_2 = Second irradiated generation.
$M_1 \sim P_1$ = First irradiated generation derived from P_1.
$M_1 \sim P_2$ = First irradiated generation derived from P_2.
Is = Insignificant differences.

The results agreed with **Rubino and Wehner (1986)**, who found in *Cucumis sativus* that there was no significant inbreeding after six generations of self pollinating in open pollinated population. Superior hybrid performance in the number of fruits per plant was achieved by $P_2 \times M_1 \sim P_1$ with a value 1.68 followed by $P_1 \times M_1 \sim P_2$ with a value 1.39. Hybrid performance in the number of fruits per plant was varied from 1.16 ($P_1 \times P_2$) to 1.68 ($P_2 \times M_1 \sim P_1$). Therefore, the best hybrid performance in fruits weight/plant was achieved by the hybrid extracted from hybridization between $P_2 \times M_1 \sim P_1$ with a value 1.73 followed by $P_1 \times M_1 \sim P_2$ and $P_2 \times M_1 \sim P_2$ with the same value 1.58. Hybrid performance for mean fruit weight was varied from 1.03 ($P_1 \times M_1 \sim P_1$ and $M_1 \sim P_1 \times M_1 \sim P_2$) to 1.16 ($P_2 \times M_1 \sim P_2$). Better hybrid performance in the mean of fruit weight was achieved by $P_2 \times M_1 \sim P_2$ (1.16) followed by $P_1 \times M_1 \sim P_2$ (1.12). This indicated that traits with high quantitative genes expression are best improved using recurrent selection to make significant long-term improvements.

The best hybrid performance in fruits productivity/first seven collections was achieved by $P_2 \times M_1 \sim P_1$ with a value 5.92 followed by $P_1 \times M_1 \sim P_2$ with a value 3.44. The number of fruits formed per first seven collections showed hybrid performance ranged between 1.14 by the self pollinated hybrid ($P_2 \times M_1 \sim P_2$) to 5.92 by cross hybrid ($P_2 \times M_1 \sim P_1$). Furthermore, fruits weight per first seven collections appeared the same trend of hybrid performance obtained in the number of fruits produced in the first seven collections. The best hybrid performance in the number of total fruits formed per 10 plants was achieved by $P_2 \times M_1 \sim P_1$ with a value 1.68 followed by $P_1 \times M_1 \sim P_2$ with a value 1.39. Hybrid performance in the total number of fruits formed per 10 plants was varied from 1.16 ($P_1 \times P_2$) to 1.68 ($P_2 \times M_1 \sim P_1$). Total fruits weight per 10 plants appeared the same trend of hybrid performance obtained in the number of total fruits per 10 plants. The results revealed that the best performance of hybrid productivity was shown by the hybrids extracted from $P_2 \times M_1 \sim P_1$ followed by $P_1 \times M_1 \sim P_2$. Both hybrid genotypes were superiored in the number of fruits formed per plant, fruits weight per plant, mean fruit weight, number of fruits produced per first seven collections, fruits weight per first seven collections, number of total fruits per 10 plants and total fruits weight per 10 plants. These traits are the main components of fruits productivity in summer squash. The results obtained herein reflected that superior performance exhibited productivity in summer squash was achieved by hybrids resulted from hybridization between two varieties one of them subjected to UV- irradiation, as non ionizing radiation. Thus, both genotypes recorded above are considered as the most indicated genotypes to enhance crop productivity. The expression of mid parent heterosis showed greater magnitude in cross hybridization including one parent affected by UV- radiation.

The results presented herein providing some information about the importance of genetic variability in constructed superior hybrids for qualitative and quantitative traits. It was noticed that the heterotic performance of all hybrids in relation to mid parental values was positive for all traits of yield components. The aim of heterosis studied was to identifying the best heterotic combinations and its exploitation for commercial production. These results agreed with **Solanki *et al*. (1982)**, who obtained maximum heterosis (42.12%) for the number of fruits formed per plant in cucumber hybrid. In addition, **Jahan *et al*. (2012)** found desirable level of mid parent heterosis in six hybrids for fruit yield per plant and only one hybrid of mid parent heterosis showed significant positive values for all the yield related traits including fruit yield per plant. Varietal effects and heterosis for fruits formed per plant and fruit weight were also observed in pumpkin by **Gwanama *et al*. (2001)**.

The yield is the most important trait leading plant breeders to produce superiored hybrids in terms of fruit form which determined its component as the yield of fruits, fruits weight and the number of fruits per plant which indicated the genetic, physiological and nutritional status of the plant. All hybrids gave marketable yield components in relation to the mid parent. The variation in the yield traits indicated that this trait correlated with the number of female flowers, branches number and plant length, all of these controlled by a number of genes which affected on the number of fruits formed per plant. The superiority of the hybrids could be due to the influence of gene action. The results also agreed with **Pandey *et al*. (2005)**, who found that number fruits per plant, fruit weight and fruits yield per plant were most heterotic traits. The same authors also showed 100.08% heterosis for fruit weight over the better parent. On the other hand, significant and negative heterosis observed in traits indicated reduction in genotype performance. **Singh *et al*. (1970)** found hybrid vigor in cucumber for number of fruits per plant and total yield. Similar findings were also shown by **Bairagi *et al*. (2002)** in cucumber.

Overall from the present findings it may be stated that heterosis can be exploited in summer squash for developing superior hybrids. In cucumber, **Soliman (2015)** showed heterosis over high parents in most hybrids for number of fruits per plant, average fruit weight, fruit length and total yield per plant. The phenomenon of hybrid vigor obtained from hybridizations between genetically dissimilar parents particularly in cross pollinated crops as seen in summer squash. For these reasons UV- irradiation was used in this study to create, as well as increase the genetically dissimilar between the parents used in hybridization in order to obtain superior hybrids in yield productivity. The nature of gene action related to the expression of quantitative traits was important in the improvement of vegetable cultivars as summer squash. Development of high yielding hybrids depends on genetically dissimilar parent genotypes. The success of hybrids depends on the magnitudes of genetic variation in the parental lines intered hybridization. Therefore, a broad genetic base should be utilized for better magnitudes in hybrid success. This agreed with **Ene *et al*. (2019)**, who found that most of F_1 cucumber hybrids are larger and more hybrid vigor than their parental lines which indicated that this supported the role of dominance gene effects (non- additive).

Homogeneity assays

The coefficient of variation among different genotypes was estimated for the traits that appeared significant differences between genotypes **(Table 6)**. Coefficient of variance for fruit length was varied from 0.192 to 18.75 compared with the mid parent value 0.662 as a control.

Table 6. Coefficient of variation across ten genotypes for qualitative and physiological traits.

Genotypes ♂ × ♀	Fruit length	Fruit diameter	Shape index of fruit	Total chlorophyll in fruits	Total chlorophyll in leaves
Unirradiated P_1	0.365	0.444	1.51	46.82	2160.56
Unirradiated P_2	0.959	3.132	2.63	9.33	356.80
M_1~P_1	0.192	0.489	0.92	14.22	530.46
M_1~P_2	3.147	1.275	0.09	15.55	11.46
P_1× P_2	3.028	1.427	4.31	9.10	73.09
P_1× M_1~P_1	1.776	0.203	1.07	44.32	101.20
P_1× M_1~P_2	0.454	5.877	8.79	22.76	421.41
P_2× M_1~P_1	1.800	3.412	6.99	32.95	41.67
P_2× M_1~P_2	18.759	1.590	2.42	71.59	645.05
M_1~P_1× M_1~P_2	3.967	0.189	0.39	3.02	222.21

Notes

M_1 = First irradiated generation.

M_1~P_1 = First irradiated generation derived from P_1.

M_1~P_2 = First irradiated generation derived from P_2.

This indicated high heterogeneity among the genotypes compared to the mid parent. Regarding fruit diameter coefficient of variation varied from 0.189 to 5.877 in relation to the mid parent value which equal 1.788. These values are close to heterogeneity for expressing genes related to fruit diameter. This indicated that UV- irradiation induced similar effects on the genes controlled fruit diameter among different genotypes. The shape index of fruit was varied from 0.09 to 8.79 in relation to the mid parent value which equal 2.07. This indicated high heterogeneity among the population genotypes if compared to the control. These heterogeneity in the shape index of fruits reflected that UV- irradiation induced mutations as a consequence showed variations in expressing genes controlled fruit shape index.

In addition, the variance coefficient of total chlorophyll in fruits was varied from 3.02 to 71.59 compared to mid parent value 28.07. These values are close to heterogeneity in the expressing genes formed total chlorophyll in fruits. This indicated that the genes formed total chlorophyll in fruits were dis similar affected by UV- irradiation. Regarding total chlorophyll in leaves the genotypes coefficient of variance was varied from 11.46 to 2160.56 compared with the mid parent value 1258.68. These values reflected high heterogeneity in chlorophyll formation genes in leaves due to the effects of UV- irradiation.

These results indicated high homogeneity among the genotypes due to similar effects of UV- irradiation. Similar genetic effects of UV- radiation reflected that these traits provides great scope for further mutation breeding followed by selection. Therefore, induced mutations by UV- irradiation could be used to generate genetic variability that successfully utilized to improve fruits quality and yield components of summer squash. The obtained results indicated that mutagenesis by physical mutagens as UV- radiation is a potential tool to be employed in summer squash improvement. On the other hand, the development of high yielding varieties requires the existing genetic variations for yield and its components. The results obtained in this study agreed with **Khan (1985)**, who stated that induction of mutations affecting quantitative traits can be utilized by the estimation of genotypic coefficient of variation in the mutagen treated populations. The results are also harmony with **Wani and Khan (2006)**, who found that variability in the treated population of mungbean with ethylmethane sulphonate or hydrazine hydrate was higher than the control for all quantitative traits as fertile branches per plant, pods per plant, 100- seed weight and seed yield per plant. The same authors demonstrated that the increase in number of pods per plant was due to increase in the number of flowers per plant. The degree of homogeneity determined upon coefficient of variability was used to assess the magnitude of variation within every genotype.

The results obtained herein also agreed with **Snedecor and Cochran (1980)**, who decided that estimated coefficient of variance values ranged lower than or near to the check value indicating high homogeneity in these traits. However, higher values than that of the check exhibited high heterogeneity. Therefore, **El-Morsy *et al*. (2021)** found some genotypes of tomato achieved high homogeneity for their resistance to yellow leaf curl virus because they were gave the lowest variations with coefficient of variance (CV%) lower than or close to the check variety which reflected that they are more phenotypically uniform than other genotypes. The results obtained in this study are confirmed with those founding's by **Mahmoud and Khalil (2019)**, who constructed new commercial lines of tomato via selection from F_2 generations and the selected lines were high homogenous for the traits under investigation because they exhibited low CV % values.

A close correspondence was obtained by **Ahmed *et al*. (2017)**, who found that the number of days from transplanting to 50% flowering of tomato genotypes recorded higher values of CV % than those of the check cultivars indicated high heterogeneity. The same authors found that plant height and fruit shape index in some tomato genotypes could be considered the highest homogenous since they recorded the lowest variation values than those of the check cultivars. Overall, the degree of heterogeneity and homogeneity (CV %) differed among the genotypes under investigation for the same trait and from trait to another by the some genotype. Thus, the results are in accordance with those of **Berry and Rafique Uddin (1988)**, who found that the selected lines from F_2, F_3 and F_4 generations of tomato became higher in homogeneity after F_6 generation. This precision in genotypic evaluation is important for the correct recommendation of the genotypes suitable for cultivation.

In conclusion, the results indicated that hybridization between two genotypes one of them subjected to UV-irradiation extracted superior hybrids in the performance of fruits productivity. All hybrids obtained in this study showed positive heterosis in fruits productivity varied from one genotype to another. In this way superiority of hybrid performance for the variables of yield components was established. So these hybrids especially extracted from wild type variety with irradiated variety were identified as promising for commercial cultivation. Performance of these hybrids needs to subjected evaluated in multi location prior to commercial applied.The results reflected that superior genotypes contributing toward the improvement of total yield per plant suggesting that mutation breeding followed by hybridization procedure will help in eventually increasing fruits yield in summer squash.

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آداء الهجن المتأثرة بالأشعة فوق البنفسجية بالنسبة لصفات الجودة والمحصول فى قرع الكوسة

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تعتبر الثمار الغير ناضجة فى قرع الكوسة الصيفي هي الثمار القابلة للأكل حيث ينتمى هذا النبات إلى عائلة هامة هي العائلة القرعية. لذلك كان الهدف الرئيسي من هذه الدراسة هو تقييم آداء ستة من الهجن بالنسبة لمتوسط الآباء في صفات النمو والمحصول. تم الحصول على هذه الهجن من معاملة بذور صنفين من قرع الكوسة بالأشعة فوق البنفسجية. خضعت النباتات الناتجة عن البذور المعاملة والغير معاملة بالإشعاع إلى نظام التهجين نصف الدوار. أظهر الهجين $P_1 \times M_1\sim P_1$ أفضل آداء في المساحة الورقية للنبات متبوعاً بالهجين $P_2 \times M_1\sim P_1$. بينما تميز الهجين $P_2 \times M_1\sim P_1$ بأفضل آداء في خفض عدد الأيام اللازم لظهور أول زهرة مؤنثة بقيمة 0,87 متبوعا بالتركيب الوراثي الناتج عن التلقيح الذاتي $P_2 \times M_1\sim P_2$ بقيمة 0,95 لذلك تم الحصول على أفضل آداء للهجن فى النضج المبكر للثمار بواسطة الهجن المستخلصة من التهجينات التالية $P_2 \times M_1\sim P_1$ متبوعاً بـ$P_1 \times M_1\sim P_2$ ، $P_2 \times M_1\sim P_2$. كما أظهر الهجين $P_1 \times M_1\sim P_2$ أعلى آداء فى التعبير الجيني لكلوروفيل A في الأوراق متبوعا بالهجين $P_2 \times P_1$. بالإضافة إلى ذلك تميز الهجين $P_2 \times M_1\sim P_2$ بأفضل آداء فى التعبير الجيني لكلوروفيل B و الكلوروفيل الكلي في كل من الأوراق والثمار. كما تميز الهجين $P_1 \times M_1\sim P_2$ بتعبير أفضل في صفات جودة الثمار مثل قطر الثمرة، حجم الثمرة، دليل شكل الثمرة. علاوة على ذلك تميزت كل الهجن المتحصل عليها من هذه الدراسة بتعبير جيني أفضل من متوسط الآباء في صفات مكونات المحصول.