Evaluation of some horticultural traits and resistance to Fusarium wilt of some watermelon hybrids

Merghany M.M.[1], El Lithy Y.T.E.[2], A.H.A Kheraba [1], Marwa A. Zyton[3], and Noura E.S.Ebrahim[2]
1 Veg.Crops,Dept.,Fac.Agric.,Cairo Univ., Egypt.
2 Veg.Res.Dept., Hort. Res. Inst., A..R.C., Egypt.
3 Plant Pathol. Dept. Fac. Agric., Cairo Univ., Egypt.

Abstract— Fusarium wilt is a major disease of watermelon in many parts of the world. Control of this disease is difficult because the soil borne causal agent *Fusarium oxysporum* f. sp. *niveum* (Fon) produces chlamydospores that remain infectious in the soil for many years. In this study, four lines, three testers of watermelon and their 12 F_1 hybrids which were developed through line X tester mating design were used to study the mean performance and heterosis for six horticultural traits and resistance to Fusarium wilt. Biochemical parameter such as phenolic content and three oxidative –reductive enzymes(PAL, PPO and PO) in three watermelon hybrids shown susceptible, moderatly resistant and resistant to the fungus *F.o.* f.sp. *niveum* were assessed. All parents and crosses were significant with positive value for all traits studied. With respect to heterosis effects, cross P_2xP_6 gave the highest values with significant effect for plant fresh weight, total yield/plant and fruit weight for mid-parent and better parent. Crosses $P_2\times P_7$, P3xP_5 and P_4xP_6 gave earliest female flower over mid-parent and better parent. In addition, cross P_4xP_6 gave the highest values with significant effect for rind thickness for mid-parent and better parent. Moreover, cross P_1x P_7 gave the highest values with significant effect for T.S.S. for mid-parent. Results showed that the lowest mean performance of seven parents and their twelve crosses of watermelon for the average of the severity of Fusarium wilt on the foliage growth and on the xylem vesicles were 21.9 % for parents line (Beni-Swif ; P_7) and 26.2 % for crosses (P_2xP_7). Also, data revealed that, in general, the three assessed enzymes, *i.e.* PAL, PPO and PO and total phenols were greatly increased in the shoot base of the hybrids by increasing the resistance of these hybrids.

Key words: Watermelon, lines, hybrids, mean performance, heterosis, Fusarium wilt, total phenols , oxidative-reductive enzymes.

1 INTRODUCTION

Watermelon, (*Citrullus lanatus*, Thunp.), is one of the most popular vegetable crops, especially in summer season in Egypt. All over the world, many investigators are interested in collecting their landraces or accession lines and estimate their agronomic traits or pathogenicity test in order to raise a new genotype for breeding programs (Dane *et al* ., 1998 and Khereba *et al* .,2007

Fusarium wilt [caused by *Fusarium oxysporum* f. sp. *niveum* (Fon)] is one the most serious soil-borne diseases of water-melon (Netzer, 1976 ; Martyn, 1985 and 1987and Mahdy *et al* ., 2014). Initial symptoms can vary with chlorosis of leaves being common followed by asymmetrical wilting for the plant. When infection takes place in seedling, noticeable stunting of the plant occurs followed by chlorosis and death. Necrosis of the stem, in the form of brown streaks in the vascular system produced by both fungal exudates as well as the dying plant tissues, are characteristic of Fusarium wilt (FW).

To date, the disease is best controlled through the use of wilt-resistant cultivars and crop rotations for a minimum of 5 to 7 years (Hopkins and Elmstrom, 1984). There are also opinions that the best solution is to develop highly tolerant cultivars (Martyn, and Mclaughlin, 1983).In order to test the resistance of new breeding material, it is necessary to have reliable screening methods.

Two U.S. PIs of *Citrullus Lanatus* var. *citroides* (PI 296341 and PI 271769) have been reported as resistant to Race- 2 of Fon (Dane *et al.,* 1998; Martyn and Netzer, 1991).

Survey 110 U.S. PIs of wild watermelon (*Citrullus Lanatus* var. *citroides*) for resistance to Race-2 (FW). Of these 110 accessions, 15 showed significantly higher resistance to Fon Race-2 than that found in the watermelon cultivars Sugar Baby or Charleston Grey as well as in the *C. Lanatus* var. *citroides* PI 296341 that was reported to contain resistance to FW. Wechter *et al.* (2012) studed the genetic behavior of some economic characters in watermelon. They found that all studied traits were influenced by both the additive and non-additive gene action. Some traits (number of branches, number of fruits/plant and T.S.S.) showed partial dominance. Meanwhile, four traits (leaves number, days to female flowering, total yield and fruit length) showed complete dominance. The stem length, average fruit weight and number of seeds/fruit showed over-dominance (El-Maghawry *et al.* 2001)

The aim of this research was to evaluate the level of resistance to *F. oxysporum* f. sp. *niveum* in selected inbred lines and hybrids of watermelon. In order to establish a breeding program for watermelon to find resistance source and produce some watermelon F_1 hybrids, which many give high yield in quantity and quality with resistance to Fusarium wilt**.**

2 MATERIALS AND METHODS

The experiment was conducted at Kaha Vegetable Research Farm (KVRF), Qalubia governorate, Egypt. The material for this study presented in Table (1) was comprised between seven genotypes. In summer season (2015) the best 4 inbred lines, based on evaluation of resistance to Fusarium wilt for lines (Suhag-1, Suhag-2. Sinaa, Bir El-Abd-2) were used as female parents; and the cultivars Giza-1, Crimson sweet and the line (Beni-Swif) were used as male parents.Their 12 crosses were developed through line x tester- mating design.

2.1. Evaluation of horticultural characters for parents and hybrids :

Parents	Skin color	Flesh color	Fruit shape
Suhag 1 (P1)	Green striped with dark green	red	Round
Suhag 2 (P2)	Light green	yellow	Round
Sinaa (P3)	dark green	red	Round
Bir El-abd2 (P4)	green	yellow	Round
Giza1 (P5)	green	red	Round
Crimson sweet (P6)	Green striped with dark green	rose	Round
Beni Swif (P7)	dark green	yellow	Round

In summer season (2016) , seeds of the seven parents (lines and testers) and twelve hybrids were planted at KVRF. The experimental design used was a randomized complete block design (RCBD) with three replicates.

Standard cultural practices were adopted as recommended by the Min. of Agric and Land Recl. Data were recorded for some characters, *i.e.* lant fresh weight, number of days to flowering, total yield per plant, fruit weight, rind thickness and total soluble solids (T.S.S.).

TABLE 1.

NAMES OF PARENTS AND DESCRIPING

2.2. Statistical analysis:

Analyses of variance were carried out using computer software program. The differences among means for all traits were tested for significance using the method described by Snedecor and Cochran (1980).

Estimates of heterosis based on mid parental value and better parent (BP) were determined for each F_1 hybrid according to the following equation (Sinha and Khanna, 1975)

$$\text{Mid-parent heterosis} = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} \times 100$$

$$\text{Heterobeltiosis (BP)} = \frac{\overline{F1} - \overline{BP}}{\overline{BP}} \times 100$$

Where: F_1 = Mean performance of the F_1 hybrid; MP = Mean performance of P_1 and P_2.
BP = Mean performance of the better parent

2.3. Evaluation of resistance to Fusarium wilt for parents and hybrids:

Evaluation of parents and hybrids was in summer season (2016) against infection with *F.o.* f.sp. *niveum,* the causal fungus isolate obtained from Mycol. Res. and Dis.Sur.Dept., Plant Pathol. Res. Instit., ARC.

In summer season (2016) five plants were planted in each plastic pot (35 cm. in diameter), three replicate for each line serve as treatment and three others serve as control, after one month of planting treatment replicate inoculated with spore suspension of the causal fungus ($1X10^6$ conidia/ml water) at the rate of 50 ml/pot (Abada and Ahmed, 2014). The plants were examined for severity of infection by the tested fungus one month after inoculation. The pots were irrigated when it was necessary and fertilized with recommended doses by Min. of Agric. and Land Recl.

2.4. Disease assessment:

Disease severity was assessed one month after inoculating watermelon seedlings of one month old using the devised scale (0 to 5) by Amini and Sidovich (2010) on the foliage growth using the following scale:

Where:

0 = No foliar symptoms.
1 = Chlorosis and/or wilt restricted to the first leaf.
2 = Chlorosis and/or wilt extending beyond the first leaf.
3 = Moderate to severe foliar symptoms usually with some absent leaves.
4 = Severe foliar symptoms on the entire plant.
5 = Dead plant.

Disease severity on foliage growth % = $\sum$ (nxv)/5N X 100

Where:

n = Number of infected leaves in each category.
V = Numerical values of each category.
N = Total number of the infected leaves.

The plants were also rated for vascular discoloration using the devised scale (0-5) by Ulloa *et al.* (2006) using the following scale:

Where:

0 = No discoloration.
1 = Light discoloration evident as spotty areas in the longitudinal section of the basal stem and the crown.
2= More continuous discoloration covering an area between one quarter and one half of the longitudinal section of the basal stem and the crown but with light in color.
3= Vascular discoloration (moderate in color) evident in a band encircling almost the entire basal stem and the crown.
4 = Vascular discoloration darker in color than in 1 or 2, and evident across most of the vascular tissue in the longitudinal section of the basal stem and the crown.
5= Plant severely damaged, vascular discoloration evident throughout the longitudinal-section of the basal stem and the crown.

Disease severity on the vascular % = $\sum$ (nxv)/5N X 100

Where:

n = Number of infected vascular in each category.
V = Numerical values of each category.
N = Total number of the infected vascular.

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2.4. Determination of the changes in the activity of oxidative-reductive enzymes in three hybrids shown susceptible, moderatly resistance and resistant to the causal fungus :

Determination of phenylalanine ammonia lyase (PAL) activity was determined in Laboratory analysis and measurement, Central Laboratory for Biotechnol. of Agric. Res. Cent., Plant Pathol. Res. Instit.; according to the method described by Zucker (1965). The determination of polyphenol oxidase (PPO) activity according to the method described by Esterbaner *et al.* (1977). Determination of peroxidase (PO) activity was determined according to the method described by Worthington (1972).

2.5. Determination of free, conjugated and total phenols in three watermelon hybrids shown susceptible, moderatly resistance and resistant to the causal fungus:

Free, conjugated and total phenols were determined in Laboratory analysis and measurement, Central Laboratory for Biotechnol. of Agric. Res. Cent., Plant Pathol . Res. Instit. according to the method described by Simons and Ross (1971).

3 RESULTS AND DISCUSSION

3.1. Evaluation of horticultural characters:

3.1.1. Mean performance:

a. Plant fresh weight:

Plant fresh weight indicated highly significant differences among parents and their twelve crosses as in Table (2). It ranged from 0.802 Kg/plant (Beni-Suif) to 1.163 Kg/plant (P_2xP_6). The ecotype Sohag-1 recorded the highest values in parents, while the highest values in Crosses (P_2xP_6). The obtained results are in agreement with those reported by El-Shoura (2007).

b. Number of days to first female flower anthesis:

Data presented in Table (2) indicate that, the parents, Sohag-1 and the hybrid P_3xP_5 gave the lowest values of NDF; this indicated the earliness of these parents and crosses. Similar results were obtained by Rajan *et al.* (2002) and El-Maghawry *et al.* (2001)

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c. Total yield/plant (k.g):

Data presented in Table (2) reveal that, the parents, Sohag-1 and the hybrid P_1xP_6 gave the highest values of total yield/plant. These results are in agreement with those reported by Rajan *et al.* (2002) and Gilli and Kumai (1988).

d. Fruit weight (kg):

Fruit weight indicated highly significant differences among parents and their twelve crosses as shown in Table (3). It ranged from 2.47 Kg (P_3xP_7) to 4.29 Kg (P_1xP_6). The ecotype Sohag-1 recorded the heaviest values in parents, while the heaviest values were found in crosses (P_1xP_6). Similar results were obtained by El-Maghawry *et al.* (2001).

e. Rind thickness:

Data presented in Table (3) show that, the parents, Giz-1 and the hybrid P_4xP_6 gave the highest values of rind thickness. These results are in agreement with those reported by Khereba *et al.* (2007).

f. Total soluble solids (T.S.S.):

T.S.S. indicated highly significant differences among parents and their twelve crosses as shown in Table (3). The ecotype Giza-1 recorded the highest values in parents, while the highest value was found in crosses (P_1xP_7). Similar results were obtained by El-Maghawry *et al.* (2001) and Khereba *et al.* (2007).

3.1.2. Heterosis:

a. Plant fresh weight (kg):

Obtained heterosis values based on mid-parent that presented in Table (4) show that, nine F_1 hybrids were significantly differed in plant fresh weight. Estimated heterosis percentages relative to better parent (B.P.) showed that, five crosses showed significant positive values, suggesting over-dominance for large parent. This result sre in agreement with those repoted by El-Shoura (2007)

b. Number of days to first female flower anthesis:

The estimated heterosis values based on mid-parent are presented in Table (4). Data show that, seven F_1 hybrids gave significant negative differed in plant fresh weight, suggesting dominance towards the short period, since they significantly decreased number of days to first female flower anthesis. Estimated heterosis percentages relative to better parent showed that, three crosses showed significant negative values, suggesting over-dominance for short period. These results are in agreement with those reported by Rajan *et al.* (2002).

TABLE 2

MEAN PERFORMANCE OF SEVEN PARENTS AND THEIR TWELVE CROSSES OF WATERMELON FOR PLANT FRESH WEIGHT, NUMBER OF DAYS TO FIRST FEMALE FLOWER ANTHESIS AND TOTAL YIELD /PLANT

Genotypes	Plant fresh weight	No. of days to first female flower anthesis	Total yield/plant (k.g)
Sohag 1 (P1)	1.097	47.83	8.42
Sohag 2 (P2)	0.964	56.50	6.87
Sinaa (P3)	0.928	52.13	6.30
Bir El- abd2(P4)	0.934	58.73	7.07
Giza1(P5)	0.907	54.73	6.70
Crimson sweet(P6)	0.873	63.46	6.56
Beni Swif (P7)	0.802	56.53	6.79
P1xP5	1.050	50.76	8.24
P1xP6	1.113	55.73	9.02
P1xP7	0.923	54.06	8.24
P2xP5	1.050	58.46	6.56
P2xP6	1.163	62.40	8.43
P2xP7	1.063	53.80	7.30
P3xP5	1.087	49.90	6.52
P3xP6	0.860	56.06	6.19
P3xP7	0.960	58.20	5.72
P4xP5	1.047	55.03	6.15
P4xP6	0.977	57.30	8.21
P4xP7	0.937	59.56	6.57
LS.D (0.05)	0.061	0.903	0.40
LS.D (0.01)	0.087	1.29	0.58

c. Total yield/plant (k.g):

Results shown in Table (4) show that, heterosis values from mid-parents (M.P.) showed significant values for the six crosses. Estimated heterosis percentages relative to better parent showed that, four crosses showed significant positive values, suggesting over-dominance for large parent. Similar results were obtained by Rajan *et al.* (2002).

TABLE 3

MEAN PERFORMANCE OF SEVEN PARENTS AND THEIR TWELVE CROSSES OF WATERMELON FOR FRUIT WEIGHT, RIND THICKNESS AND TOTAL SOLUBLE SOLIDS (TSS)

Genotypes	Fruit weight (kg)	rind thickness	TSS
Sohag 1 (P1)	4.24	1.38	8.53
Sohag 2 (P2)	3.49	1.28	8.93
Sinaa (P3)	2.74	1.10	8.50
Bir El- abd2(P4)	3.55	1.24	9.40
Giza1(P5)	3.14	1.53	10.16
Crimson sweet(P6)	3.14	0.94	9.10
Beni Swif (P7)	3.47	1.29	9.53
P1xP5	4.18	1.52	9.37
P1xP6	4.29	1.55	9.27
P1xP7	4.01	1.36	9.70
P2xP5	2.82	1.61	9.50
P2xP6	4.20	1.23	9.40
P2xP7	3.38	1.29	9.47
P3xP5	2.79	0.95	8.70
P3xP6	2.60	0.92	8.77
P3xP7	2.47	1.42	8.90
P4xP5	2.74	0.97	9.50
P4xP6	3.75	1.68	8.80
P4xP7	2.89	1.14	9.40
LS.D (0.05)	0.28	0.061	0.168
LS.D (0.01)	0.41	0.087	0.242

TABLE 4

Average degree of heterosis (ADH) % based on mid-parent (M.P.) and better-parent of 12 F_1 hybrids for some watermelon characters

Crosses	Plant fresh weight (kg)		Number of days to first female flower anthesis		Total yield /plant (kg)	
	MP	BP	MP	BP	MP	BP
P1xP5	5.21	-3.67	-1.01**	6.21	9.01**	-1.83
P1xP6	13.37**	2.14	0.15**	16.60	20.42**	7.38**
P1xP7	-2.39	-15.29	3.67	13.11	8.65**	-1.83
P2xP5	12.17**	8.92*	-2.72**	6.89	-3.38	-4.51
P2xP6	26.58**	20.67**	4.0	10.44	25.44**	22.70**
P2xP7	20.42**	10.30**	-4.78**	-4.78**	6.93*	6.30*
P3xP5	18.37**	17.09**	-6.55**	-4.22**	0.15	-2.83
P3xP6	-4.55	-7.32	-2.99**	7.61	-3.88	-5.78
P3xP7	10.98**	3.44	7.18	11.71	-12.62	-15.70
P4xP5	13.64**	12.06**	-2.93**	0.61**	-10.64	-13.04
P4xP6	8.03*	4.56	-6.22**	-2.39**	20.47**	16.05**
P4xP7	7.91*	0.28	3.41	5.43	-5.33	-7.20

Sohag 1 (P1), Sohag 2 (P2), Sinaa (P3), Bir El- abd2(P4), Giza1(P5), Crimson sweet(P6), Beni Swif (P7)

*,**: significant and highly significant at 0.05 and 0.01 level, respectively

Mp: mid-parent Bp: Better parent

d. Fruit weight (Kg.):

The obtained heterosis values based on mid-parent are presented in Table (5). Results show that, four F_1 hybrids were significantly differed in fruit weight. Estimated heterosis percentages relative to better parent showed that, two crosses showed significant positive values, suggesting over-dominance for large parent. Similar results were obtained by El-Maghawry et al. (2001) and Khereba *et al.* (2007).

e. Rind thickness:

Estimates of heterosis values based on mid-parent are presented in Table (5). Results show that, six F_1 hybrids gave significant differed in rind thickness. Estimated heterosis percentages relative to better parent showed that, four crosses showed significant values, suggesting over-dominance towards larger parent. These results are in agreement with those found by Khereba *et al.* (2007).

f. Total soluble solids (T.S.S.):

Results presented in Table (5) reveal that, heterosis values from mid-parents (M.P.) showed significant values four crosses. Estimated heterosis percentages relative to better parent showed that, three crosses showed significant positive values, suggesting over-dominance for large parent. Similar results were obtained by El-Maghawry *et al.* (2001) and Khereba *et al.* (2007).

TABLE 5

Average degree of heterosis (ADH) % based on mid-parent (M.P.) and better-parent of 12 F_1 hybrids for some watermelon characters

Crosses	Fruit weight (kg)		Rind thickness		T.S.S	
	MP	BP	MP	BP	MP	BP
P1xP5	13.36**	-1.34	4.47*	-0.44	0.21	-7.90
P1xP6	16.26**	1.18	33.62**	12.08**	5.10**	1.83*
P1xP7	4.15	-5.42	1.87	-1.21	7.42**	1.78*
P2xP5	-14.93	-19.20	14.59**	5.23*	-0.52	-6.59
P2xP6	26.69**	20.34**	10.81**	-3.64	4.27**	3.29**
P2xP7	-2.87	-3.15	0.389	0.25	2.60**	-0.66
P3xP5	-4.98	-11.04	-27.75	-38.12	-6.85	-14.45
P3xP6	-11.56	-17.19	-9.80	-16.36	-0.34	-3.66
P3xP7	-20.45	-28.81	18.82**	10.07**	-1.27	-6.61
P4xP5	-17.98	-22.72	-29.96	-36.8	-2.96	-6.58
P4xP6	12.20**	5.72*	54.12**	35.21**	-4.86	-6.38
P4xP7	-17.66	-18.59	-9.88	-11.36	-0.63	-1.36

Sohag 1 (P1), Sohag 2 (P2), Sinaa (P3), Bir El- abd2(P4), Giza1(P5), Crimson sweet(P6), Beni Swif (P7)

*,**: significant and highly significant at 0.05 and 0.01 level, respectively

mid-parent Bp: Better parent

3.2. Evaluation of resistance to Fusarium wilt for parents and hybrids:

Fusarium wilt of watermelon is a soilborne disease. The fungus attacks seed, seedlings, and roots. The fungus spreads from roots through the vascular system as microconidia reaching all parts of the plant. The fungus is persistent in the soil and is spread long distances on infected seed. Once a host is infected, the fungus increases dramatically. Both macroconidia and chlamydospores are produced on the surface of tissue killed by the organism.

Data shown in Table (6) indicate that the performance of seven parents and their twelve crosses of watermelon for disease severity on the foliage growth were ranged between 24.3-48.9% for crosses (P_4xP_5) and (P_1xP_5); Respectively. The highest percentages of disease severity on the foliage growth were 24.8, 27.0 and 29.5% for parents P_7, P_4 and P_5, respectively. Meanwhile, the lowest percentages of disease severity on the foliage growth were 24.3, 24.4, and 34.7 % for crosses (P_4xP_5), (P_2xP_7) and (P_4xP_7), respectively. Meanwhile, the performance of seven parents and their twelve crosses of watermelon for disease severity on the xylem vesicles were ranged between 14.30- 60% for parent P_6 and crosses (P_1xP_5), respectively. In addition, the lowest percentages of disease severity on the xylem vesicles were 14.30, 19.0, and 27.0% for parents P_6, P_7 and P_4, respectively. In addition, the lowest percentages disease severity on the xylem vesicles were 28, 28.8, and 30% for crosses (P_4xP_7), (P_2xP_7) and (P_4xP_5), respectively. Meanwhile, parents P_7, P_6 and P_4 and crosses (P_2xP_7), (P4xP_5), (P_4xP_7), (P_2xP_5) and (P_3xP_7) showed the lowest percentages of disease severity on the average, respectively. From these data we can classified the plants according to the disease resistance : resistant plant showed 20-30% disaese severity in the average, moderatly resistance plant showed >30-40% disaese severity in the average and the susceptible plant showed >40% disaese severity in average. (Elmstrom and Hopkins 1981and Swiader *et al* 2002)

TABLE 6

Mean performance of seven parents and their twelve crosses of watermelon for disease severity on the foliage growth and xylem vesicles

Treatments		Pal mg/g fw	PPO activity mg/g fw	PO activity mg/g fw
P1xP5	control	0.0113	0.0155	0.0483
susceptible	treatment	0.0151	0.0215	0.0493
P2xP5	control	0.0429	0.0273	0.0548
moderately resistance	treatment	0.0548	0.0277	0.0765
P2xP7	control	0.0483	0.0311	0.1107
resistant	treatment	0.0765	0.0550	0.1840

Genotype				
Sohag 1 (P1)				
Sohag 2 (P2)	43.80	31.70	37.75	--
Sinaa (P3)	44.20	47.80	45	--
Bir El- abd2 (P4)	27.0	27.00	27	R
Giza1 (P5)	29.50	29.40	29.45	--
Crimson sweet (P6)	38.30	14.30	26.30	R
Beni Swif (P7)	24.80	19.00	21.9	R
P1xP5	48.90	60.00	54.45	S
P1xP6	43.20	57.00	50.1	S
P1xP7	46.20	38.50	42.35	--
P2xP5	40.00	36.00	38.0	mR
P2xP6	42.70	56.70	49.7	--
P2xP7	24.40	28.80	26.2	R
P3xP5	40.70	44.30	42.5	--
P3xP6	38.60	41.90	40.25	--
P3xP7	36.30	40.00	38.15	mR
P4xP5	24.30	30.00	27.15	R
P4xP6	38.30	41.80	40.05	--
P4xP7	34.70	28.00	31.35	mR
LS.D (0.05)	3.09	2.02	----	
LS.D (0.01)	4.45	2.91	-----	

S; suseptible, mR; moderately resistance and R; resistant.

3.3. Determination of changes in the activity of oxidative-reductive enzymes in three hybrids shown susceptible, medium resistance and resistant to the causal fungus:

Table (7) shows the changes in the activity of oxidative-reductive enzymes, *i.e.* phenylalanine ammonia lyase (PAL), polyphenol oxidase (PPO) and peroxidase (PO) in different hybrids (P_1xP_5, P2xP_5, P2xP_7) shown susceptible, moderatly resistance and resistant to fungus *fusarium oxysporum* f.sp. *niveum*, respectively. Data reveal that, in general, the three enzymes, *i.e.* PAL, PO and PPO were greatly increased in the shoot base of the hybrids by increasing the resistance of these hybrids. The three enzymes, *i.e.* PAL, PO and PPO were greatly increased in plant treated with fusarium than control plants. It is well known that PAL is a key enzyme of phenylpropanoid metabolism which leads to the synthesis of phenols (Massala *et al*. 1980 and Mahdy *et al.* 2014). PO is a key enzyme in the biosynthesis of lignin and other oxidised phenols (Bruce & West 1989). PO catalyzes the oxidation of hydroxy cinnamyl alcohols into free radical intermediates, which subsequently are coupled into lignin polymers (Gross, 1980). It is well known that PPO is a copper containing enzyme, which is responsible for oxidization of phenolics to highly toxic quinines. This enzyme is also involved in terminal oxidation of diseased plant tissue, and this role of this enzyme is attributed in disease resistance (Kosuge, 1996).

TABLE 7

Determination of changes in the activity of oxidative-reductive enzymes in three hybrids shown susceptible, medium resistance and resistant to the causal fungus

3.4. Determination of free, conjugated and total phenols in three watermelon hybrids shown susceptible, moderatly resistance and resistant to the causal fungus:

Table (8) shows the amount of free, conjugate and total plenols in three watermelon hybrids shown susceptible, moderatly resistance and resistant to Fusarium wilt. Free plenols, being 4.745, 5.343 and 5.443 for susceptible, moderately resistance and resistant plants infected by FW, respectively.and being 4.235, 4.839 and 4.771 for control plants. Meanwhile, conjugated phenols being 2.163, 3.120and 4.478 for susceptible, moderately resistance and resistant plants infected by FW, respectively.and being 2.070, 2.286 and 3.810 for control plants, respectively. Total plenols being 6.908, 8.463 and 9.921 for susceptible, moderately resistance and resistant plants infected with FW, respectively.and being 6.305, 7.125 and 8.581 for control plants. In general the amount of free plenols was more than conjugat plenols in all infected plants with FW and control plants. Also, total plenols in infected plants were more than in the contol and increase in resistant plants than susceptible plants.

Phenolic compounds play three main roles in resistance against pathogens; direct attacks on pathogens through antimicrobial compounds, defence of plant cell walls as physical barriers, and induction of resistant responses as molecular messengers (Nicholson and Hammerschmidt 1992). It is well known that phenolic compounds are fungi toxic in nature. Moreover, phenolic compounds increase the physical and mechanical strength of host cell wall resulting in inhibition or fungal invasion (Anand *et al.*, 2007).

TABLE 8

Values of free, conjugated and total phenols in three watermelon hybrids shown susceptible, moderatly resistance and resistant to the causal fungus

Treatments		Amount of phenolic compounds as mg/g fresh weight		
		Free	Conjugated	Total
P1xP5	control	4.235	2.070	6.305
susceptible	treatment	4.745	2.163	6.908
P2xP5	control	4.839	2.286	7.125
moderately resistance	treatment	5.343	3.120	8.463
P2xP7	control	4.771	3.810	8.581
resistant	treatment	5.443	4.478	9.921

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