EFFECT OF DOWNY MILDEW DISEASE ON CHEMICAL COMPOSITION OF MAIZE TASSELS AND ON INFECTION DEVELOPMENT OF COMMON SMUT DISEASE

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ABSTRACT

Maize common smut disease caused by *Ustilago maydis* was distributed in the same fields which were infected by downy mildew disease caused by *Prenosclerospora sorghi*, especially on tassels of susceptible maize genotypes. Length of susceptible plants were significantly decreased comparing with healthy ones.

Analysis of total phenols (free and conjugated) in maize tassels indicated significant increase of free phenols in infected tassels with downy mildew disease comparing with healthy tassels. However, the reverse was found in case of conjugated phenols. Moreover, total and reducing sugars were significantly increased in tassels infected with downy mildew disease comparing with healthy tassels, the reverse was also true in case of non-reducing sugars. On the other hand, protein, ash, oil, free fatty acid (F.F.A) and acid value (A.V) were significantly increased in tassels infected with downy mildew disease, comparing with healthy ones.

As a result of infecting maize plants by downy mildew disease, which significantly increase total and free phenols, total and reducing sugars, protein, ash, oil, free fatty acids and acid value in tassels of infected plants. The tassels became very suitable to be invaded by *Ustilago may*dis causal organism of common smut disease of maize.

INTRODUCTION

Field observation during the late several years indicated positive and active correlation between common smut and downy mildew diseases in maize, Malaguti et al (1978) and El-Zeir and Tolba (1999) showed that 21 % of inoculated maize seedlings in

the field by *Peronosclerospora sorghi* (the causal organism of downy mildew disease of maize) were stunted and died prematurely, 36 % had phyllody of tassels, while, the rest had chlorotic striped, erect leaves, and only 8.5 % of the seedling developed into healthy plants. Shetty and Ahmad (1980) concluded that resistant varieties of maize and sorghum, may accumulate phenols faster than susceptible ones in response to infection by *Peronosclerospora sorghi.* Stossl (1983) showed that phenols have been found in all investigated plants. Some occur constitutively and are thought to function as preformed inhibitors associated with nonhost resistance, and others are formed in response to the ingress of pathogen. El- Shanawani et al., (1990) indicated that phenolic contents were higher in cucumber cultivars resistant to powdery mildew disease than its respective content in the susceptible ones. Powdery mildew infection generally induce formation of free, conjugated and total phenols in plant tissues. Fahmy (1990) showed no indications that phenolic compounds have any correlation with resistance and /or susceptibility to smut disease of maize. Nazim et al (1991) found that the susceptible maize inbred lines (Giza 7 and 35) and hybrids (SC.103, DC 202 and DC 204) were characterized by higher level of total carbohydrates and lower level of total and free phenols than in resistant inbred lines (Giza 58, 62 and 63) and hybrids (SC 105 and 107). The amount of total and free phenols in tested maize cultivars differed in their response to smut infection. Ralph (1992) concluded that phenolic compounds have long been associated with passive and active defense responses of plants. Because of their universal presence in vascular plants and their accumulation in both resistant and susceptible plants. De-Leon (1994) showed that, the environmental variations play a serious role in the development of infection by downy mildew disease. Tolba (1996) revealed that the healthy maize plants of both resistant and moderate resistance for smut disease were characterized by higher level of total and free phenols and lower level of total and reducing sugars comparing with the susceptible ones, while the infection with common smut disease resulted in high significant increase of total, free and conjugated phenols in susceptible maize plants as compared with resistant and moderate resistant ones. El-Rafai, Elham, et al (2003) showed that coating

and soaking of tomato seeds with spores of the *Trichoderma hamatum* gave the highest increase of phenolic compounds (free and conjugated) and the lowest percentage for sugars content of tomato leaves infected with the concerned pathogen. On the other hand, Purushotham et al (1996) indicated that, the tested fungi (*i.e Aspergillus flavus, Aspergillus niger and Penicillium sp.*) caused a significant decrease in total charbohydrate content of seeds. Maximum reduction in carbohydrate content was observed in infected seeds with *Aspergillus flavus*. Tolba and El-Sayed, Soad (2002) showed that colonization of grain rot fungi led to a reduction in grain components i.e. endosperm and ash %, while, fat %, crude protein %, free fatty acid % (F F A) and acidity were increased. The decrease in endosperm content due to fungal nutrition and stimulated of seed respiration, while, the increase of protein and fat % attributed to the increment of the total protein within the host- pathogen complex.

The objective of this study was to determine the dangerous correlation which observed between both of downy mildew disease and common smut disease (especially on tassels) in maize plants.

MATERIALS AND METHODS

Two experiments were performed at Sakha research station during 2003 season and were repeated during 2004 season. The first experiment was planted in downy mildew disease nursery, the second experiment was sown under natural infection. The maize cultivars which were used included two single crosses i.e. SC.10 and SC.122; two three way crosses i.e. TWC.310 and 324; two open pollinated varieties i.e. Giza 2 and Balady; and three inbred lines i.e. 7, 34 and 63. Each experiment was designed in complete block random with four replicates, each maize genotype was sown in a plot ($10.5m^2$) consisted of 3 rows, 5 m. long and 70 cm. apart. Three grains were planted in hill at 25 cm. apart and thinned to one plant/hill after 21 days of planting. All cultural practices were applied at the proper time and as recommended. The reading of downy mildew disease infection were taken as percentage of infection after 35 days of sowing. However, the common smut disease was recorded after 80 days of sowing in two tested experiments. Samples of infected tassels from the field of downy

mildew disease nursery and samples of healthy tassels from field of natural infection were randomly taken 20 days after silking stage from each experiment and at each maize genotype. These samples were air dried, then used to determine the chemical composition of maize tassels

1-Chemical composition of maize tassels:

The dried tassel samples were grounded to fine powder to pass through 2 mm. mesh for chemical analysis i.e. crude protein (N % × 5.75), ash % as well as oil content by soxhlets extraction method according to the procedures of the A.O.A.C. (1990) and expressed as a percentage of dry weight of the sample.

2- Determine of phenols and sugars in maize tassels

A- Plant extraction : Samples of maize tassels infected with downy mildew and healthy were taken at random, 10 g. of fresh weight were cut into small pieces and immediately dipped into boiling 95 % ethanol for ten minutes, to stop further enzymatic activities. The extraction was then resumed in soxhlet apparatus by using 75 % ethanol for 8 hours. The combined ethanolic extracts were filtered and evaporated to near dryness on a warm water bath (60°C). The extract was redissolved in 5 ml. of 50 % isopropyl, then used for chemical analysis.

B- Determination of phenolic compounds: Total and free phenols were determined by using the colorimetric analysis method described by Tolba (1996). Conjugated phenols were determined from subtracting the free phenols from the total phenols. Phenolic compounds were expressed as mg. Catechol per 10 grams fresh weight based on the standard curve for catechol.

C- Determination of sugars: Total and reducing sugars were determined colorimetrically using picric acid method described by Tolba (1996). The sugar content was expressed as mg. glucose per 10 g. fresh weight from a standard curve prepared for glucose. Non-reducing sugars were determined from the differences between the total and reducing sugars.

Analysis of variance computed according to Senedecor and Cochron (1982) and treatment means were compared by Duncan's multiple range test, (Duncan, 1955). Correlations performed according to Singh and Chaudhary (1979).

RESULTS AND DISCUSSION

The relationship between downy mildew and common smut diseases in maize presented in Table (1) indicated significant increase of tassels infection percentage by both downy mildew and smut disease during 2003 season (11.90 and 10.90 %, respectively) comparing with 2004 season (9.00 and 8.60 %, respectively). Also, the infection percentages of downy mildew and smut diseases were very high under downy mildew disease nursery comparing with under downy mildew natural infection.

Table (1) Mean of infection percentage of some maize genotypes which were affected by downy mildew and smut diseases under both of natural and artificial downy mildew diseases infection during 2003 and 2004 growing seasons.

Items	General downy mildew infection (%)	Tassel downy infection (%)	Tassel smut infection (%)	General smut infection (%)	length of plant (cm.)
Effect of years					
Y1	18.00	11.90 a	10.90 a	11.90 b	187.80
Y2	17.40	9.00 b	8.60 b	13.10 a	183.70
F test	N.S	**	**	**	N.S
Effect of treatments					
(T1) Under field disease nursery	34.50 a	20.30 a	19.00 a	24.10 a	156.50 b
(T2) Under natural infection	0.900 b	0.600 b	0.600 b	0.900 b	215.00 a
F test	**	**	**	**	**
Effect of genotypes					
(1) S.c 10	15.40 d	8.30 c	8.10 cd	9.80 e	294.60 a
(2) S.c 122	4.80 f	2.30 d	2.40 e	3.30 f	277.10 b
(3) Twc 310	25.20 c	16.10 b	14.90 b	18.90 c	248.80 c
(4) Twc 324	15.70 d	9.40 c	9.10 c	10.60 de	201.70 e
(5) Giza 2	30.70 b	17.00 b	16.00 b	20.80 b	234.60 d
(6) Balady	36.60 a	20.60 a	19.00 a	26.00 a	149.60 f
(7) Line 7	11.90 e	8.20 c	7.30 d	9.10 e	90.80 g
(8) Line 34	15.40 d	9.50 c	9.10 c	11.50 d	96.70 g
(9) Line 63	3.70 f	2.60 d	2.20 e	2.60 f	77.90 h
F test	**	**	**	**	**
LSD	2.261	1.414	1.262	1.53	9.04

Table (1) cont.

Effect of interaction between years and genotypes					
Y1×(1)	17.00	9.80	9.70	10.50	296.70
Y1×(2)	5.00	2.70	2.80	3.20	281.70
Y1×(3)	23.50	17.30	16.00	17.50	255.00
Y1×(4)	16.20	11.30	10.70	12.00	203.30
Y1×(5)	30.50	19.50	18.00	18.80	238.30
Y1×(6)	36.30	23.50	21.30	23.00	151.70
Y1×(7)	13.00	8.80	7.50	8.50	91.70
Y1×(8)	16.80	10.80	10.00	11.30	93.30
Y1×(9)	3.50	3.00	2.50	2.70	78.30
Y2×(1)	13.80	6.70	6.50	9.20	292.50
Y2×(2)	4.70	2.00	2.00	3.30	272.50
Y2×(3)	26.80	14.80	13.80	20.30	242.50
Y2×(4)	15.20	7.50	7.50	9.20	200.00
Y2×(5)	30.80	14.50	14.00	22.80	230.80
Y2×(6)	36.80	17.70	16.70	29.00	147.50
Y2×(7)	10.80	7.50	7.20	9.70	90.00
Y2×(8)	14.00	8.20	8.20	11.70	100.00
Y2×(9)	3.80	2.20	1.80	2.50	77.50
F test	**	**	**	**	**
LSD	3.20	2.00	1.78	2.16	12.79

Means followed by the same lower case letter within a character are not significantly different, P= 0.05 N.S= Not significant, ** = highly significant
1 to 9 = maize genotypes i.e. S.C 10, S.C122, TWC 310, TWC 324, Giza 2, Balady, Line 7, Line 34, Line 63, respectively.
Y1 = 2003 growing season Y2 = 2004 growing season

As for effect of genotypes, the results in Table (1) showed the lowest infection percentages which were recorded on S.C 122 and Line 63, while, the highest infection percentages were recorded on Giza 2 and Balady cultivars. The rest of the tested maize genotypes were recorded as intermediate percentage of infection.

Regarding the interaction between years and genotypes, the results presented in Table (1) showed increasing of downy mildew and smut infection on most of tested maize genotypes during 2003 season, comparing with 2004 season, this result may be due to differences of environmental condition during the two tested years. On the other hand, the length of infected plants were decreased as compared with healthy plants in all tested maize genotypes and at the two tested years. Similar results were obtained by Malaguti et al (1978). Shetty and Ahmad (1980) and De-leon (1994).

The presented results in Table (2) showed high infection percentage by downy mildew disease especially on tassels, that is

Table (2) Infection means of downy mildew and smut diseases as general and on tassels, and length of plants of nine maize genotypes were planted under natural and/ or field diseases nursery during 2003 and 2004 growing seasons.

Items	General downy mildew infection (%)	Tassel downy infection (%)	Tassel smut infection (%)	General smut infection (%)	length of plant (cm.)
Effect of interaction between Years and Treatments					
y1×t1	34.70	22.90	21.10	22.90	158.90
y1×t2	1.30	0.80	0.80	1.00	216.70
y2×t1	34.30	17.60	17.00	25.30	154.10
y2×t2	0.600	0.400	0.300	0.900	213.30
F test	**	**	**	**	**
LSD	1.508	0.9429	0.8410	1.020	6.029
Effect of interaction between Treatments and genotypes					
T1× (1)	30.80	16.50	16.20	19.70	273.30
T1 × (2)	9.70	4.70	4.80	6.50	261.70
T 1× (3)	48.80	31.30	29.00	36.30	200.80
T1 × (4)	31.00	18.50	17.80	20.80	108.30
T1 × (5)	59.80	33.20	31.00	40.20	194.20
T1 × (6)	70.50	39.20	36.20	49.30	119.20
T1 × (7)	23.00	16.00	14.30	17.30	85.00
T1 × (8)	29.30	18.00	17.50	21.30	91.70
T1 × (9)	7.30	5.20	4.30	5.20	74.20
T2 × (1)	0.00	0.00	0.00	0.00	315.80
T2 × (2)	0.00	0.00	0.00	0.00	292.50
T2 × (3)	1.50	0.80	0.80	1.50	296.70
T2 × (4)	0.30	0.30	0.30	0.30	295.00
T2 × (5)	1.50	0.80	1.00	1.50	275.00
T2 × (6)	2.70	2.00	1.80	2.70	180.00
T2 × (7)	0.80	0.30	0.30	0.80	96.70
T2 × (8)	1.50	1.00	0.70	1.70	101.70
T 2 × (9)	0.00	0.00	0.00	0.00	81.70
F test	**	**	**	**	**
LSD	3.20	2.00	1.78	2.16	12.79

Means followed by the same lower case letter within a character are not significantly different, P= 0.05 ** = highly significant

1 to 9 = maize genotypes i.e. S.C 10, S.C122, TWC 310, TWC 324, Giza 2, Baladv, Line 7, Line 34, Line 63, respectively.

T1 = under field disease nursery T2 = under natural infection

led to high infection percentage by smut disease, especially on tassels, under artificial downy mildew disease nursery (t_1)during 2003 (y_1) and 2004 (y_2) growing seasons. While the reverse was true under natural infection (t_2) during the two tested years (y_1 and y_2).

Regarding the effect of interaction between treatments and genotypes, the presented data in Table (2) indicated high infection percentage by downy mildew disease ranged from 7.30 to 70.50 %. However, on tassel it was ranged from 5.20 to 39.20 % at all tested maize genotypes. Under downy mildew disease nursery (t1), high infection percentage by smut disease ranged from 5.20 to 49.30 % was observed as well as on tassels ranged from 4.30 to 36.20 %. While under natural infection (t_2), the reverse was true. The lowest infection by downy mildew disease as well as smut disease was recorded on SC 122 and Line 63 maize genotypes. The highest infection was recorded on Giza 2 and Balady maize genotypes. On the other hand, the increasing of percentage of infection by downy mildew disease as well as smut disease under downy mildew disease nursery, led to reduction of length of infected plants ranged from 74.20 to 273.30 cm. as compared with natural infection . These results were in the same line with reported data by El-Zeir and Tolba (1999), they found that 21 % of inoculated maize plants by downy mildew causal organism, were stunted, 36 % had phyllody of tassels, while, the rest had chlorotic striped, erect leaves, and only 8.5 % of the plants developed into healthy plants.

As for chemical analysis (i.e. phenols and sugars) in maize tassels infected and non-infected by downy mildew disease, data presented in Table (3) showed that, tassel sugars and phenols contents were significantly less during 2004 comparing with 2003 growing season. Moreover, the healthy tassels were contained low level of reducing and total sugars (108 and 239.8 mg. /10 g. of fresh weight) comparing with infected tassels (194.10 and 293 mg./g. fresh weight), the reverse was true in case of non-reducing sugars. On the other hand, the healthy tassels were contained low level of free and total phenols (24.20 and 49.90 mg./10g. fresh weight) comparing with infected tassels (31.90 and 56.30 mg./10 g.

fresh weight), the reverse was also true in case of conjugated phenols.

Data in Table (3) indicated significant decrease in total, reducing and non-reducing sugars contents in tassels of resistant maize genotypes i.e. SC 122 (208.10, 127.80 and 80.30 mg./g. fresh, respectively) and line 63 (201.20, 115.80 and 86.30 mg./10g. dry weight, respectively). In the reverse, significant increase in total, reducing and non-reducing sugars contents were observed in tassels of susceptible maize genotypes i.e. Giza 2 (295.80, 163.60 and 132.20 mg./10 g. fresh weight, respectively) and Balady (318.60, 215.60 and 112.20 mg./10g. fresh weight, respectively). On the other hand, the phenols component (total, free and conjugated phenols) had the same trend of sugars component, here,

Table (3) Means of sugars and phenolic compounds in tassels of nine maize genotypes were planted under natural and / or field downy mildew diseases during 2003 and 2004 growing seasons.

Items	Total sugar	Reducing sugar	Non-reducing sugar	Total phenol	Free phenol	Conjugated phenol
Effect of years						
Y1	274.20 a	154.90 a	119.50 a	56.20 a	29.50 a	26.70 a
Y2	258.50 b	147.20 b	113.20 b	49.90 b	26.60 b	23.30 b
F test	**	**	**	**	**	**
Effect of treatments						
T1 Healthy	239.80 b	108.00 b	131.50 a	49.90 b	24.20 b	32.00 a
T2 Infection	293.00 a	194.10 a	101.10 b	56.30 a	31.90 a	18.00 b
F test	**	**	**	**	**	**
Effect of genotypes						
(1) S.c 10	253.00 c	132.00 c	121.00 cd	53.90 bc	28.80 bc	25.10 bc
(2) S.c 122	208.10 d	127.80 c	80.30 f	39.60 d	20.80 d	18.50 d
(3) Twc 310	292.80 b	155.90 b	136.90 a	57.30 ab	33.40 a	23.90 c
(4) Twc 324	283.70 b	159.20 b	123.70 bc	53.60 bc	27.40 c	26.10 a-c
(5) Giza 2	295.80 b	163.60 b	132.20 ab	53.10 c	26.80 c	26.30 a-c
(6) Balady	318.60 a	215.60 a	112.20 e	60.00 a	31.30 ab	28.80 a
(7) Line 7	296.80 b	156.20 b	140.60 a	54.30 bc	26.80 c	27.40 ab
(8) Line 34	247.40 c	133.70 c	113.80 de	54.60 bc	29.60 bc	25.00 bc
(9) Line 63	201.20 d	115.80 d	86.30 f	51.30 c	27.40 c	23.90 c
F test	**	**	**	**	**	**
LSD	15.08	8.73	8.77	3.83	3.135	2.702

Table (3) cont.

Effect of interaction between years and genotypes						
Y1×(1)	254.80	134.80	120.00	57.80	31.20	26.70
Y1×(2)	212.80	132.70	80.20	42.30	22.20	19.70
Y1×(3)	291.20	157.30	133.80	60.30	34.70	25.70
Y1×(4)	288.80	162.50	126.30	56.70	29.20	27.30
Y1×(5)	302.50	165.20	137.30	55.70	28.30	27.30
Y1×(6)	340.20	220.30	119.80	61.50	31.80	29.70
Y1×(7)	296.70	155.80	140.80	58.20	28.00	30.20
Y1×(8)	265.20	143.50	121.70	57.70	30.50	27.20
Y1×(9)	215.70	122.20	95.20	56.00	29.30	26.70
Y2×(1)	251.20	129.20	122.00	50.00	26.50	23.50
Y2×(2)	203.30	122.80	80.50	36.80	19.50	17.30
Y2×(3)	294.50	154.50	140.00	54.30	32.20	22.20
Y2×(4)	278.50	155.80	121.00	50.50	25.70	24.80
Y2×(5)	289.00	162.00	127.00	50.50	25.20	25.30
Y2×(6)	297.00	210.80	104.50	58.50	30.70	27.80
Y2×(7)	296.80	156.50	140.30	50.30	25.70	24.70
Y2×(8)	229.70	123.80	105.80	51.50	28.70	22.80
Y2×(9)	186.70	109.30	77.30	46.70	25.50	21.20
F test	**	**	**	**	**	**
LSD	21.32	12.34	12.40	5.411	4.434	3.821

Means followed by the same lower case letter within a character are not significantly different, P= 0.05 ** = highly significant
1 to 9 = maize genotypes i.e. S.C 10, S.C122, TWC 310, TWC 324, Giza 2, Balady, Line 7, Line 34, Line 63, respectively. T1 = healthy tassels T2 = infected tassels
Y1 = 2003 growing season Y2 = 2004 growing season

the phenolic component were significantly decreased in tassels of resistant maize genotypes i.e. S.C 122 (39.60, 20.80 and 18.50 mg./10g. fresh weight, respectively) and line 63 (51.30, 27.40 and 23.90 mg./10g fresh weight, respectively). While, total, free and conjugated phenols were significantly increased in tassels of susceptible maize genotypes i.e. Balady 60.00, 31.30 and 28.80 mg./10g. fresh weight, respectively. Similar results were obtained by Nazim et al (1991), Tolba (1996) and El-Rafai, Ilham et al (2003), they found that, infection of some maize genotypes with common smut disease resulted in high significant increase of total, free and conjugated phenols in susceptible maize plants as compared with resistant and moderate resistant ones. On the other hand, results in Table (3) also showed that, mean of phenolic and sugars component in tassels of tested maize genotypes were

characterized by stability during the two tested years (2003 and 2004) in most of tested maize genotypes.

Regarding the interaction between years and treatments, the results in Table (4) showed that, significant decrease in main of total sugars, reducing sugars, total phenols and free phenols in healthy tassels (244.00, 110.40, 52.30 and 26.10 mg./g. fresh weight respectively) while, the non-reducing sugars and conjugated phenols were significantly increased (133.60 and 33.90 mg./10 g. fresh weight respectively) during the two tested years (2003 and 2004 seasons). While, the reverse was true in case of infected tassels during the same tested years. The results in Table (4) and fig. (1) and (2) also showed significant increase of total and reducing sugars and significant decrease of non- reducing sugars in infected tassels (T_2) of all tested maize genotypes, the reverse was true in case of healthy tassels (T_1). Total, reducing and non-reducing sugars were ranged from 174.70 to 308.50, 67.30 to 195.70 and 103.80 to 150.70 mg./10 g. fresh weight in healthy tassels, respectively, while ranged from 227.70 to 328.70, 164.20 to 235.50 and 56.80 to 113.70 mg./10g. fresh weight in infected tassels, respectively. On the other hand, the total and free phenols were increased, while, conjugated phenols were decreased as result of infection of tassels by the tested diseases. Here, Total, free and conjugated phenols in healthy tassels were ranged from 38.00 to 58.20, 16.30 to 28.70 and 24.30 to 34.80 mg./g. fresh weight , respectively, while, in infected tassels ranged from 41.20 to 61.80, 25.30 to 38.30 and 12.70 to 24.30 mg./10 g. fresh weight, respectively. These results concluded that, invading of plant tissues by the causal organism of downy mildew disease led to stimulation of infected tissues to transform the non-reducing sugars and conjugated phenols to reducing sugars and free phenols, respectively, and led to increasing of total sugars and phenols in infected plant tissues. These condition were very suitable for invading of this tissues by causal organism of smut disease (*Ustilago maydis*). Similar results were obtained by Stossl (1983), El-Shanawani et al (1990) and Tolba (1996), they found that phenols have been found in all plants investigated to date. Some occur constitutively and are thought to function as performed inhibitors associated with nonhost resistance and others are formed

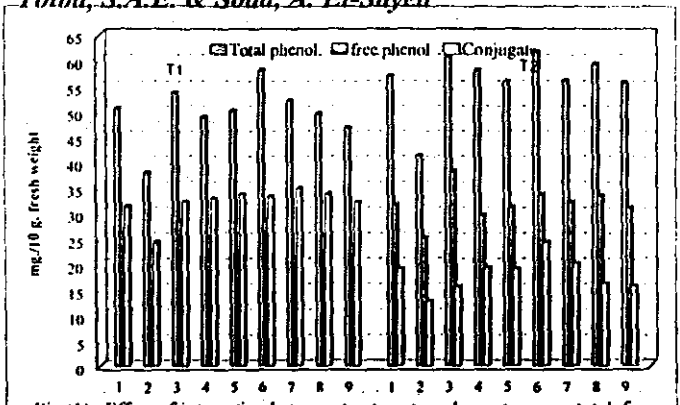

Fig (1) : Effect of interaction between treatments and genotypes on total, free and conjugated phenols.

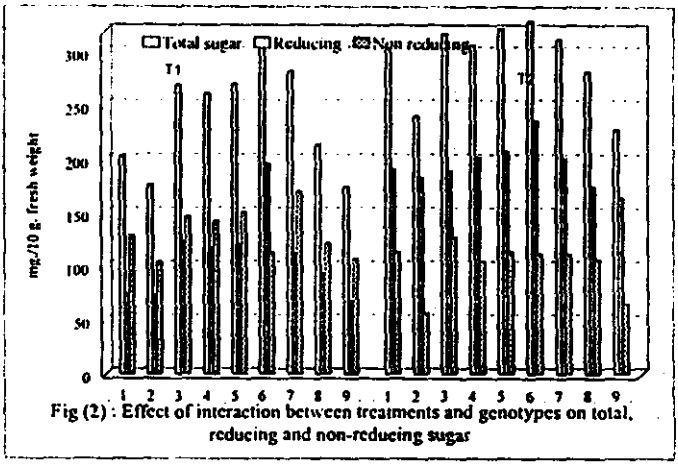

Fig (2) : Effect of interaction between treatments and genotypes on total, reducing and non-reducing sugar

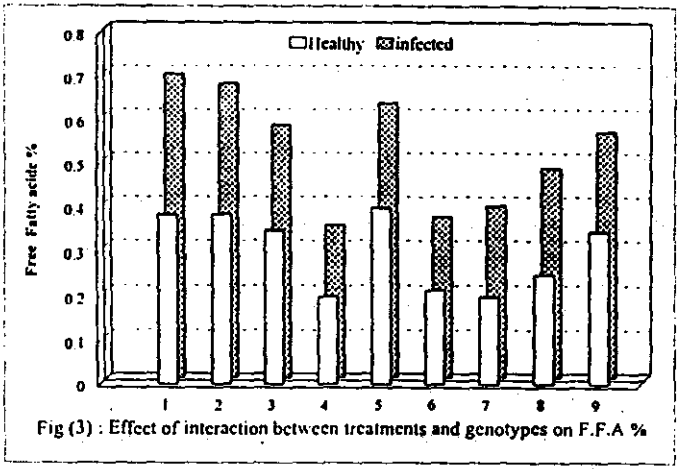

Fig (3) : Effect of interaction between treatments and genotypes on F.F.A %

T1 = healthy maize tassels
T2 = infected maize tassels
1 to 9 = maize genotypes i.e. S.C 10, S.C 122, T.WC 310, T.WC 324, Giza 2, Balady, Line 7, Line 34, Line 63, respectively
F.F.A % = free fatty acids %

Table (4) Mean of sugar and phonolic compounds in tassels of nine maize genotypes were planted under natural and or/ field downy mildew diseases nursery during 2003 and 2004 growing seasons.

Items	Total sugar	Reducing sugar	Non-reducing sugar	Total phenol	Free phenol	Conjugated phenol
Effect of interaction between years and treatments						
y1×t1	244.00	110.40	133.60	52.30	26.10	33.90
y1×t2	304.40	199.40	105.30	60.20	32.80	19.50
y2×t1	235.50	105.60	129.50	47.40	22.30	30.10
y2×t2	281.60	188.80	96.90	52.40	31.00	16.40
F test	**	**	**	**	**	**
LSD	10.05	5.82	5.85	2.55	2.09	1.80
Effect of interaction between treatments and genotypes						
T1× (1)	202.50	73.80	128.70	50.70	26.00	31.20
T1 × (2)	176.00	72.20	103.80	38.00	16.30	24.30
T 1× (3)	269.00	122.70	146.30	53.80	28.50	32.30
T1 × (4)	261.30	116.80	142.80	49.00	25.20	32.80
T1 × (5)	270.50	119.80	150.70	50.20	22.30	33.70
T1 × (6)	308.50	195.70	112.80	58.20	28.70	33.20
T1 × (7)	281.70	111.50	170.20	52.30	21.30	34.80
T1 × (8)	213.70	92.50	121.20	49.70	25.70	33.80
T1 × (9)	174.70	67.30	107.30	46.80	23.70	32.20
T2 × (1)	303.50	190.20	113.30	57.20	31.70	19.00
T2 × (2)	240.20	183.30	56.80	41.20	25.30	12.70
T2 × (3)	316.70	189.20	127.50	60.80	38.30	15.50
T2 × (4)	306.00	201.50	104.50	58.20	29.70	19.30
T2 × (5)	321.00	207.30	113.70	56.00	31.20	19.00
T2 × (6)	328.70	235.50	111.50	61.80	33.80	24.30
T2 × (7)	311.80	200.80	111.00	56.20	32.30	20.00
T2 × (8)	281.20	174.80	106.30	59.50	33.50	16.20
T 2 ×(9)	227.70	164.20	65.20	55.80	31.20	15.70
F test	**	**	**	**	**	**
LSD	21.32	12.34	12.40	5.41	4.43	3.82

Means followed by the same lower case letter within a character are not significantly different, P= 0.05 ** = highly significant

1 to 9 = maize genotypes i.e. S.C 10, S.C122, TWC 310, TWC 324, Giza 2, Balady. Line 7, Line 34, Line 63, respectively. T1 = healthy tassels T2 = infected tassels

Y1 = 2003 growing season Y2 = 2004 growing season

in response to the ingress of pathogen. Moreover, infection of maize plants with smut disease resulted in high significant increase of total, free and conjugated phenols in susceptible maize plants as compared with resistant ones.

As for protein, ash, oil, free fatty acid (F.F.A)and acid value (A.V) in healthy and infected tassels of maize plants, results in Table (5) and Fig. (3) showed that increasing of protein, ash, F.F.A and A.V, and decreasing of oil in infected tassels comparing with healthy ones. The tassels of each of tested maize genotype were significantly differed in it's contents of protein, ash, oil, F.F.A and A.V. Moreover, the results in Table (5) also showed that, some of these components (i.e. protein, ash, oil, F.F.A and A.V) were significantly differed in the same maize genotype from 2003 season to 2004 season.

Table (5) Mean of chemical components of maize tassels of nine maize genotypes were healthy and /or infected by downy mildew and smut diseases during 2003 and 2004 growing seasons.

Item	Protein %	Ash %	Oil %	F F A %	A V
Effect of years					
Y1	10.85	10.60 b	1.93	0.3941 b	0.7981 b
Y2	11.00	10.82 a	1.96	0.4273 a	0.8667 a
F test	N.S	*	N.S	* *	* *
Effect of genotypes					
(T1) Healthy	10.39 b	10.28 b	2.32 a	0.3017 b	0.6255 b
(T2) Infection	11.46 a	11.14 a	1.56 b	0.5197 a	1.0393 a
F test	* *	* *	* *	* *	* *
Effect of genotypes					
(1) S.c 10	9.87 cd	10.43 de	1.94 ab	0.5358 a	1.0692 a
(2) S.c 122	9.64 d	10.13 ef	1.82 bc	0.5252 a	1.0443 a
(3) Twc 310	10.10 cd	11.08 ab	1.92 ab	0.4594 b	0.9203 b
(4) Twc 324	12.13 a	10.50 de	1.73 c	0.2709 d	0.5270 e
(5) Giza 2	11.99 a	10.65 cd	2.03 a	0.5109 a	1.0249 a
(6) Balady	10.12 c	9.97 f	1.97 ab	0.2885 d	0.6179 d
(7) Line 7	11.85 a	11.03 bc	2.01 a	0.2935 d	0.6279 d
(8) Line 34	10.82 b	11.45 a	2.09 a	0.3610 c	0.7568 c
(9) Line 63	11.82 a	11.15 ab	1.98 ab	0.4513 b	0.9035 b
F test	* *	* *	* *	* *	* *
LSD	0.4687	0.3999	0.1803	0.2576	0.07728

Table (5) cont.

Effect of interaction between years and genotypes					
Y1×(1)	10.02	9.91	1.84	0.5281	1.0501
Y1×(2)	9.38	10.00	1.86	0.5194	1.0262
Y1×(3)	10.01	11.16	1.81	0.3758	0.7534
Y1×(4)	12.08	10.36	1.72	0.2691	0.5102
Y1×(5)	11.89	10.61	2.12	0.4921	0.9903
Y1×(6)	10.57	9.96	1.97	0.3002	0.5841
Y1×(7)	11.21	11.08	1.94	0.2915	0.6566
Y1×(8)	10.67	10.98	2.10	0.3362	0.7410
Y1×(9)	11.81	11.32	2.02	0.4350	0.8709
Y2×(1)	9.71	10.96	2.04	0.5435	1.0884
Y2×(2)	9.90	10.26	1.78	0.5310	1.0623
Y2×(3)	10.19	11.00	2.03	0.5430	1.0872
Y2×(4)	12.18	10.63	1.74	0.2726	0.5439
Y2×(5)	12.09	10.69	1.95	0.5297	1.0595
Y2×(6)	9.68	9.97	1.97	0.2768	0.6516
Y2×(7)	12.48	10.98	2.08	0.2956	0.5992
Y2×(8)	10.96	11.93	2.09	0.3858	0.7725
Y2×(9)	11.83	10.98	1.94	0.4676	0.9362
F test	*	*	*	* *	* *
LSD	0.6628	0.5656	0.255	0.03643	0.1093

Means followed by the same lower case letter within a character are not significantly different. P= 0.05 ** = highly significant
1 to 9 = maize genotypes i.e. S.C 10, S.C122, TWC 310, TWC 324, Giza 2, Balady, Line 7, Line 34, Line 63, respectively. T1 = healthy tassels T2 = infected tassels
Y1 = 2003 growing season Y2 = 2004 growing season
F.F.A. = Free fatty acids A.V.= Acid value

On the other hand, the results presented in Table (6) added that, the infected tassels were contained higher levels of protein, ash F.F.A and A.V and lower levels of oil than healthy tassels during both of the two tested years (i.e. 2003 and 2004 seasons).

In additional, this result was also showed with all tested maize genotypes. Here, the protein, ash, oil, F.F.A, and A.V in healthy tassels of tested maize genotypes were ranged from 9.12 to 11.54, 6.54 to 11.06, 2.11 to 2.55, 0.1987 to 0.3990 and 0.3647 to 0.7980 %, respectively, while in infected tassels of tested maize genotypes were ranged from 10.16 to 12.71, 10.19 to 11.85, 1.48 to 1.70, 0.3430 to 0.6896 and 0.6894 to 1.3746 %, respectively. Similar results were obtained by Tolba and Soad (2002), they showed that, colonization of grain rot fungi on maize led to a reduction of grain endosperm, while fat, crude protein, F.F.A % and A.V were

increased, the increase of protein and fat % may be attributed to the increment of the total protein within the host-pathogen complex.

Table (6) Mean of chemical components of maize tassels of nine maize genotypes were healthy and /or infected by downy mildew and smut diseases during 2003 and 2004 growing seasons.

Items	Protein %	Ash %	Oil %	F F A %	A V
Effect of interaction between year and treat					
y1×t1	10.28	10.09	2.27	0.2818	0.5855
y1×t2	11.42	11.11	1.59	0.5065	1.0106
y2×t1	10.50	10.48	2.38	0.3216	0.6654
y2×t2	11.51	11.16	1.53	0.5330	1.0681
F test	*	*	*	*	*
LSD	0.3125	0.2666	0.1202	0.01717	0.05152
Effect of interaction between treatments and genotypes					
T1× (1)	9.37	9.97	2.35	0.3820	0.7638
T1 × (2)	9.12	9.93	2.15	0.3831	0.7664
T 1× (3)	9.62	10.57	2.30	0.3467	0.6932
T1 × (4)	11.54	10.14	2.11	0.1987	0.3647
T1 × (5)	11.51	10.11	2.44	0.3990	0.7980
T1 × (6)	9.74	9.54	2.26	0.2138	0.5275
T1 × (7)	11.28	10.60	2.50	0.1987	0.4604
T1 × (8)	10.08	11.06	2.55	0.2483	0.5648
T1 × (9)	11.23	10.63	2.26	0.3453	0.6906
T2 × (1)	10.36	10.90	1.53	0.6896	1.3746
T2 × (2)	10.16	10.33	1.48	0.6673	1.3222
T2 × (3)	10.58	11.59	1.53	0.5722	1.1475
T2 × (4)	12.71	10.85	1.35	0.3430	0.6894
T2 × (5)	12.47	11.19	1.63	0.6227	1.2517
T2 × (6)	10.51	10.39	1.68	0.3632	0.7082
T2 × (7)	12.41	11.47	1.52	0.3884	0.7954
T2 × (8)	11.56	11.85	1.63	0.4738	0.9487
T 2 × (9)	12.42	11.68	1.70	0.5573	1.1165
F test	*	*	*	* *	* *
LSD	0.6628	0.5656	0.255	0.03643	0.1093

Means followed by the same lower case letter within a character are not significantly different, P= 0.05 *= significant ** = highly significant
1 to 9 = maize genotypes i.e. S.C 10, S.C122, TWC 310, TWC 324, Giza 2, Balady, Line 7, Line 34, Line 63, respectively. T1 = healthy tassels T2 = infected tassels
Y1 = 2003 growing season Y2 = 2004 growing season

Table (7) Correlation between means of both downy mildew and smut diseases, and some tested characters (sugar, phenol, protein, ash and oil quality) of maize.

Variable		X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
Downy mildew	X1	0.964**	0.97**	0.979**	-0.227*	-0.052	-0.333**	0.493**	-0.0648	-0.288**	0.716**	-0.34**	-0.5200**	0.676**	-0.560**	-0.524**
Tassel downy mildew	X2	1.00	0.993**	0.957**	-0.249*	-0.037	-0.337**	0.530**	-0.0274	-0.267**	0.742**	-0.348**	-0.496**	0.655**	-0.585**	-0.549**
Tassel smut	X3		1.00	0.965**	-0.242*	-0.052	-0.346**	0.522**	-0.0464	-0.281**	0.745**	-0.338**	-0.501**	0.660**	-0.590**	-0.557**
Smut infection	X4			1.00	-0.249*	-0.043	-0.319**	0.487**	-0.0623	-0.294**	0.703**	-0.353**	-0.491**	0.661**	-0.559**	-0.517**
Length of plant	X5				1.00	0.165	0.232*	-0.135	-0.0324	0.106	-0.388**	-0.232*	-0.117	-0.378**	0.556**	0.526**
Total sugar	X6					1.00	0.825**	0.259**	0.5962**	0.572**	-0.218*	0.319**	0.165	-0.416**	0.135	0.150
Reducing sugar	X7						1.00	-0.305**	0.5455**	0.635**	-0.567**	0.350**	0.251*	-0.697**	0.400**	0.403**
Non reducing sugar	X8							1.00	0.1156	-0.121	0.635**	-0.09	-0.174	0.519**	-0.505**	-0.485**
Total phenol	X9								1.00	0.649**	-0.086	0.232*	0.249*	-0.340**	0.043	0.073
Free phenol	X10									1.00	-0.405**	0.233*	0.397**	-0.522**	0.315**	0.297**
Conjugate phenol	X11										1.00	-0.282**	-0.447**	0.778**	-0.746**	-0.734**
Protein %	X12											1.00	0.383**	-0.352**	0.119	0.088
Ash %	X13												1.00	-0.398**	0.357**	0.340**
Oil %	X14													1.00	-0.593**	-0.566**
F. F. A %	X15														1.00	0.967**
A. V	X16															1.00

* and * * = significant at 0.05 and 0.01 levels, respectively.

As for correlation between the tested characters. The presented results in Table (7) showed that, significant positive correlation between infection of maize tassels by downy mildew and common smut diseases, and both of non-reducing sugar, conjugated phenols and oil %. Significant positive correlation was also showed between infection of maize tassels by downy mildew disease and tassels infection by common smut disease. The results indicated that increasing of non-reducing sugar, conjugated phenols and oils in tissues of maize tassels which infected by downy mildew disease, led to infection of the same tassels with common smut disease. In the reverse, the results in Table (7) showed significant negative correlation between infection of maize tassels by downy mildew disease or common smut disease and both of length of plant, reducing sugars, free phenol, ash, free fatty acid and acid value. These results indicated that increasing of free phenol, reducing sugar, ash, and the bad oil characters (by increasing of free fatty acid and acid value) in susceptible maize plants especially in tassels tissues, led to infection reduction of maize tassels by downy mildew disease as well as common smut disease. Similar results were obtained by El-Shanawani et al (1990) and Ralph (1992), they found that phenolic compounds were accumulated in both the resistant and susceptible plants, the relative contribution of any group or class of phenols to express resistance or the ultimate restriction of pathogen development in susceptible plants remains in question .

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الملخص العربي

مرض البياض الزغبي وتأثيره على المكونات الكيميائية للنورات المذكرة وأيضا على مدى الإصابة بمرض التفحم العادي في الذره الشامية

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**قسم بحوث تكنولوجي البذور- معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية

لوحظ خلال عدة سنوات ماضيه أن مرض تفحم الذره الشامية المتسبب عن الفطر يوستيلاجو مايدس قد انتشر في حقول الذره الشامية المصابة بمرض البياض الزغبي في الذره المتسبب عن الفطر بيرونوسكليوسبورا سورجي، وخاصة على النوره المذكرة لنبات الذره. بناء على ذلك تم تنفيذ هذه الدراسة لمناقشة هذا الموقف.

دلت النتائج المتحصل عليها أن الطرز الوراثية من الذره الشامية المختبرة قد سجلت أقل نسبة اصابه أو انعدام الإصابة بمرض التفحم العادي تحت ظروف الحقول المنزرعة بالذره الشامية والمصابة طبيعيا بمرض البياض الزغبي ، ولكن نسبة الإصابة بمرض التفحم العادي ازدادت تحت ظروف زراعة الذره الشامية في حقول العدوى بمرض البياض الزغبي وخاصة على النوره المذكرة لأصناف الذره الشامية القابلة للإصابة. كذلك لوحظ أن الأصناف القابلة للإصابة كانت أقل معنويا في طول سيقانها مقارنه مع الأصناف السليمة.

التحليل الكيماوي للفينولات (الكلية والحرة والمرتبطة) في النوره المذكرة لنباتات الذره بينت زيادة معنوية للفينولات الكلية والحرة في النوره المذكرة المصابة بالبياض الزغبي مقارنة بالنورات المذكرة السليمة أو الخالية من الإصابة بينما كان العكس صحيح بالنسبة للفينولات المرتبطة . وفوق ذلك فإن السكريات الكلية والمختزلة قد زادت زيادة

معنوية في النورات المذكرة المصابة بمرض البياض الزغبي مقارنة بالنورات المذكرة الخالية من الإصابة، بينما العكس صحيح في حالة السكريات الغير مختزله. وعلى الجانب الآخر فإن المكونات الكيمائية من البروتين والرماد (العناصر المعدنية) والزيت والأحماض الدهنية الحرة ورقم الحموضة قد زادت زيادة معنوية في النورات المذكرة المصابة بمرض البياض الزغبي مقارنة بالنورات الخالية من الإصابة.

مما سبق يتضح أن إصابة نباتات الذره الشامية بمرض البياض الزغبي يؤدي إلى زيادة معنوية في الفينولات الحرة والكلية وكذلك في السكريات المختزلة والكلية وكذلك زيادة معنوية في البروتين والرماد والزيت والأحماض الدهنية الحرة ورقم الحموضة في النورات المذكرة للنباتات المصابة، وهذا يترتب عليه أن هذه النورات المذكرة تكون مناسبة جدا للمهاجمة والإصابة بالمسبب المرضي لمرض التفحم العادي في الذره الشامية المتسبب عن الفطر يوستيلاجو مايدس. وعلى ذلك يمكن القول بأنه يوجد ارتباط موجب بين كل من مرض البياض الزغبي ومرض التفحم العادي في الذره الشامية.