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EFFICIENCY OF SUSCEPTIBILITY INDEX AS A SELECTION PARAMETER FOR APHIDS RESISTANCE AMONG BREAD AND DURUM WHEAT GENOTYPES

EMAD A. ISMAIL

Agronomy Department, Faculty of Agriculture, Cairo University, Giza, Egypt

ABSTRACT

Fourteen imported spring bread and seven durum wheat genotypes, in addition to two local check cultivars (Sakha 61 and Beni-Suif 1) were planted under aphid-infested and aphid-controlled (by insecticides) conditions during 2002/03 and 2003/04 seasons. The objectives of this research were to assess the yield loss caused by aphids and test the efficiency of susceptibility index (SI) as a selection parameter for resistance to aphids. Numbers of different aphid species per tiller were estimated at the peak infestation in addition to yield and its components for each genotype. Results showed that there was a consistent reduction in stem length, spike length, kernel weight per spike and grain yield in aphid-infested plots compared to the control. Sakha 61 suffered major yield loss due to aphids (>50% and 70%, in the two seasons, respectively), while Beni-Suif 1 was less affected. Two introduced bread genotypes and the local check durum genotype (Beni Suif-1) consistently had high yield under aphid-controlled conditions, high yield index (Ys%) under infested conditions, low yield reductions due to aphids and low SI. Peak number of aphids per tiller was not consistent between seasons and was not correlated with yield or its components, thus it could not be used for identification of resistant genotypes. Genotypes were classified into four groups based on SI along with Ys %, which were efficient in distinguishing between genotypes in both seasons. These groups were: resistant R (Ys>100 and SI<1), susceptible S (Ys>100 and SI>1), moderately resistant MR (Ys<100 and SI<1), and highly susceptible (Ys<100 and SI>1).

Key words: *Aphids, Susceptibility index, Wheat genotypes, Yield index, Yield loss.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop in the world and in Egypt. The cultivated area of wheat in 2001 reached 1,029,591 ha (Statistical year book, 2002) which yielded 6,624,868 tons with an average of 6.4 tons/Ha.

In Egypt wheat suffers from infestation with different cereal aphid species (El-Lathy 1999) which represent a major biotic stress on wheat production. The number of cereal aphids varies sharply from year to year, region to region and crop to crop. Therefore, forecasting outbreaks and damage can not be easily achieved. Early infestation of aphids is often associated with major losses in yield of winter cereals (Pike and Schaffner 1985, Burton *et al.* 1985, Kieckhefer and Kantack 1988 and Ismail *et al.* 2003). In addition, aphids have an important role in pathogenic virus transmission (Barley Yellow Dwarf virus), (Waziery 1996 and Hoffman and Kolb 1998).

Resistance to aphids in released varieties can be overcome either through developing new biological races (or biotypes) which can withstand the unsuitable nutritional status of the resistant host plant or as a result of change in aphids feeding site, i.e. mesophyll instead of phloem tissue (Ahman and Petterson 1985).

El-Hariry (1979) and Tantawi *et al.* (1986) recorded four aphid species: Green bug (*Schizaphis graminum* Rondani), Bird cherry-oat aphid (*Rhopalosiphum padi* Linnaeus), Corn leaf aphid (*Rhopalosiphum maidis* Fitch) and English grain aphid (*Sitobion avenae* Fabricius) on wheat plants at different localities of Egypt. *S. graminum* was most predominant in Upper Egypt and that the peak abundance of *R. padi* occurred in late April and disappeared about mid May when the plants were in the yellowing stage of growth (Tantawi *et al.*, 1986). On the other hand, several workers found that infestation of different aphid species generally begins in mid-January and reach its peak around mid-March (Ali and Darwish 1990, Al-Ansary 1993, Slman 1993 and El-Lathy 1999).

In Egypt, aphid infestation is often overlooked, and when first observed, simple measures such as spraying with dilute detergent solution is suggested. However, by the time the insect population reaches a visible threshold, a fraction of yield potential would have been already lost, in addition to the spread of barley yellow dwarf virus transferred by aphids for which spraying with insecticides will not control its damage.

Breeding for aphid resistance is probably the best way to keep the insect/virus complex under control. Abdel-Malek *et al.* (1966), du Toit (1989a, b) and Porter *et al.* (2000) referred to existence of resistance genes in wheat varieties against different aphid species. Tantawi *et al.* (1986) showed that Giza 160 and Sakha 61 were rated moderately resistant to *R. Padi* and *S. graminum* infestation. However, selection parameters for aphid resistance have not been thoroughly investigated. The number of aphids per tiller (as an indicator of reproduction rate of aphids) may be used as a parameter for resistance. However, the reproduction rate of the cereal aphids sharply varies according to environmental conditions. In addition, Alsuhaibani (1996) and Mohamed (2000) found no variation in the number of aphids per tiller among wheat varieties. Therefore, number of aphids per tiller alone did not distinguish between genotypes. Webster and Porter (2000) used total number of aphids produced per plant, selection preferences, and plant damage ratings to derive a Plant Resistance Index (PRI). Therefore, damage or yield loss due to aphids should also be used as an indicator for resistance, but documenting studies for this loss are few in Egypt. Fischer and Maurer (1978) comparing yield performance under both stress and non-stress conditions suggested the use of susceptibility index (SI) to measure the tolerance of different genotypes to drought stress. In this index, an estimate for stress intensity is included, which makes it more accurate compared to the percent loss in yield due to stress alone. Index value below unity (SI<1) refer to greater resistance in the genotype. Guttieri *et al.* (2001) found that sensitivity indices for yield were correlated to cultivar yield potential.

The objectives of this research were: (1) assess and document the yield loss caused by aphids among some bread and durum wheat genotypes and (2) test the efficiency of susceptibility index as a selection parameter for resistance to aphids among these wheat varieties.

MATERIALS AND METHODS

Genotypes

Fourteen spring bread and seven durum wheat genotypes imported from ICARDA wheat nurseries during 1998, with high potential good productivity, yield stability, and disease resistance were examined for their response to aphid infestation. In addition, two widely grown Egyptian bread and durum cultivars (Sakha 61 and Beni-Suif 1, respectively) were used as checks. Table (1) lists the parentage of tested genotypes and their sources.

Treatments and experimental design

Field experiments were conducted during 2002/03 and 2003/04 growing seasons at the Faculty of Agriculture Research Station, Cairo University, Giza in clay loam soil. Experiments were laid out in a split plot design with two replications during the first season and three during the second one. Main plots had two treatments; namely aphid-infested and aphid-free (control). Insecticides (Malathion and Nasrthwait during 2002/03 and 2003/04, respectively) were used at a rate of 150 cm^3/100 L/Feddan to control aphids in the aphid-free plots. Spraying took place after sampling to avoid field entry after spraying. Multiple spraying was necessary to control aphids in designated plots. Wheat genotypes were randomly distributed in the subplots. Each plot consisted of three rows, 1.5m long and 20 cm apart. Single vacant row separated adjacent plots.

Table 1.Parentage and sources of genotypes tested for aphids resistance.

Entry No.	Name/Pedigree	Source
	Bread wheat	
1	Tevee's' / KAUZ'S'	ICARDA
2	Mexipak 65 (long-term check)	ICARDA
3	Cham-6(Improved check)	ICARDA
4	Ald's' / Hauc's' // CHIL	ICARDA
5	Mayon's' // Crow's' / Vee's'	ICARDA
6	KAUZ'S' / 657CI. 23R-3-6-2-2-1-2	ICARDA
7	Tevee's' // Crow's' / Vee's'	ICARDA
8	Mon's' / Ald's' // Aldans's' / Ias58	ICARDA
9	Cham-4 (Improved check)	ICARDA
10	Vee's'/ Tsi/ 6/ 21931/ 3/ Ch53/ An// Gbs/4 / An64/ 5/Iwp501	ICARDA
11	Shuha's' // Seri82	ICARDA
12	CHIL // Vee's' / Tsi	ICARDA
13	Vee's' // Koel's' / Vee's'	ICARDA
14	Karawan's' / 3/ Bage / Hork // Aldan	ICARDA
15	Sakha (61) Local. check	EGYPT
	Durum wheat	
16	Gidara-1	ICARDA
17	Omrabi-5 (check)	ICARDA
18	Lahn // Gs/stk/3/Gil-3	ICARDA
19	Bicrederaa-1	ICARDA
20	Haurani (check)	ICARDA
21	Bcr/3/Ch1/Gta/Stk/4/Bcr/Lks4	ICARDA
22	Ossl-1/Stj-5	ICARDA
23	Beni Suif 1(Local check)	EGYPT

Recommended practices of fertilization and hand weed control were applied. Planting dates were November 30th 2002 and December 3rd 2003. No artificial infestation with aphids was required and natural infestation was abundant during both seasons. However, spreader rows of susceptible barley were planted around the plots to guarantee the occurrence of aphid infestation.

Field measurements

Populations of aphids were closely observed and sampled at the appropriate time. Five random tillers per plot were carefully clipped at ground level and carefully placed in a plastic bag, sealed and taken to the lab for aphid count. In 02/03 season, two samples were taken at the peak time around mid and late March ((Ali and Darwish 1990,Al-Ansary 1993, Slman 1993, El-Lathy 1999 and Mohamed 2000). In 03/04, aphid populations exhibited an earlier build up during February, due to a sudden increase in temperature (Fig. 1). One sample was taken in early March, after which weather conditions changed back to normal cool temperature. This change in temperature rendered the aphids population to dramatically decrease and therefore, no further samples were taken.

Aphid infestation was abundant during both seasons, and all samples taken from aphid-infested plots had high numbers of aphids. Number of total aphids per tiller was significantly variable among genotypes. Despite spraying with insecticides, few numbers of aphids were still detected in aphid-controlled plots. These numbers were too low to have any significant effect on yield.

Prior to harvest, stem length was measured from ground to top of the spike excluding the awns in 4 random tillers in each plot. Also, ten random spikes were collected from each plot to determine yield components, particularly spike length, kernel weight per spike, and 1000-kernel weight. At maturity, one-meter row from the middle of each plot was harvested and both number of spikes and grain yield were estimated.

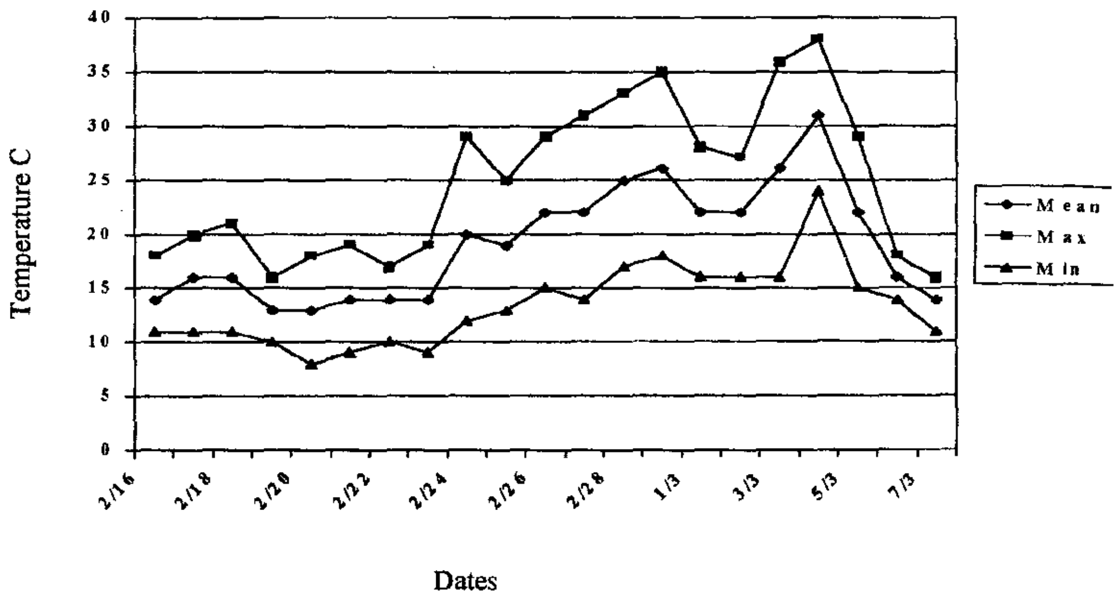

Fig. 1. Mean, maximum and minimum temperature during 2004 showing the sudden change in temperature starting February 24th.

Statistical analyses

Data were subjected to statistical analyses of variance using SAS procedure PROC GLM (SAS Institute, Inc. 1996). Means of genotypes were separated using Duncan Multiple Range Test at 0.05 probability level. Simple correlations were estimated among grain yield, yield components and aphids populations. Due to the morphological differences between bread and durum wheat genotypes, data for each group were analyzed separately and in combination. Percent reduction in grain yield was calculated and was presented graphically. Yield index (Ys %) which compares mean grain yield of each genotype to mean of all genotypes under aphid-infested conditions was also calculated. Susceptibility index (SI, which compares grain yield under aphid-infested and aphid-controlled conditions, including stress intensity factor) was calculated according to Fischer and Maurer (1978) as follows:

Susceptibility index (SI) = 1-(Yd/Yp)/D

Where, Yd = yield under stress (aphids- infested) conditions

Yp = potential yield under control (non-infested) conditions

D= stress intensity = 1- (mean Yd of all genotypes/mean Yp of all genotypes)

A test of homogeneity of data of both years showed significant difference in variance precluding a combined over-years analysis, accordingly data for each year were presented separately.

RESULTS AND DISCUSSION

Yield loss assessment

Treatment X genotype interaction was significant for all studied traits in both seasons (Tables 2 and 3). Data in Table (2) represent the means of stem length, spike length, kernel weight per spike and weight of 1000 kernels in bread and durum wheat genotypes in two seasons. Significant differences among genotypes were found in stem length and significant reduction due to aphids was recorded. In 02/03, stem length ranged from 90.7 to 113.4 cm for bread wheat and from 92.2 to 128 cm for durum wheat under controlled condition, 73.2 to 100.7 cm for bread wheat and 88.8 to 108.2 cm in durum wheat under aphid-infestation. In the second season, stem length for bread wheat ranged from 82.8-107.2 cm under control and 73.1-96.9 cm in aphid-infested treatment, while for durum wheat, it ranged from 98.1-121.9 and 88.0-115.2 in aphid-infested treatment. Durum wheat

Table 2. Stem length, spike length, kernel weight per spike and 1000 kernel weight under control and aphids-infested conditions in bread and durum wheat genotypes during 2002/03 and 2003/04 seasons.

	Stem length (cm)				Spike length (cm)				Kernel weight per spike (g)				1000 Kernels weight (g)			
Genotypes	02 / 03		03 / 04		02 / 03		03 / 04		02 / 03		03 / 04		02 / 03		03 / 04	
Bread wheat	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids
1	91.2	79.2	87.8	75.8	8.5	7.0	9.4	8.2	1.5	0.9	1.6	1.1	39.6	38.6	37.8	35.4
2	92.8	80.7	94.8	86.0	9.0	7.0	7.9	7.1	1.3	0.7	1.2	1.3	39.5	33.8	45.8	35.6
3	107.7	100.7	96.4	87.5	9.5	9.0	9.6	9.5	1.4	1.3	1.1	1.0	40.8	36.6	50.8	36.0
4	100.4	73.2	91.9	82.2	9.0	7.0	9.9	9.5	1.2	0.7	1.3	1.0	41.1	32.2	37.8	38.7
5	90.7	91.3	92.3	85.1	8.5	8.0	10.1	7.2	1.0	0.9	1.3	1.1	44.2	38.6	38.1	36.5
6	104.7	100.1	104.8	95.3	8.5	9.0	9.8	9.2	1.2	1.0	1.6	0.7	42.9	35.9	54.8	38.9
7	102.7	95.0	95.2	87.0	8.5	7.0	7.9	6.1	1.4	1.2	1.3	0.8	43.6	42.3	38.3	40.9
8	102.9	93.8	85.0	75.1	10.5	8.0	8.9	7.3	1.4	1.2	1.2	0.8	38.2	35.0	49.3	44.4
9	97.7	88.7	82.8	73.1	8.5	7.0	9.9	9.4	1.4	1.0	1.1	0.7	42.2	36.2	46.4	41.0
10	104.7	95.7	91.5	82.1	8.0	8.0	8.7	8.2	1.8	1.6	1.0	0.9	39.6	39.4	43.8	40.4
11	108.8	99.8	103.8	93.9	9.5	9.0	8.4	8.0	1.9	1.6	1.2	1.3	42.9	41.6	52.8	40.7
12	105.9	96.2	100.0	94.6	12.0	12.0	9.8	7.3	1.9	1.5	1.3	0.9	45.3	43.3	42.8	40.2
13	107.7	99.7	107.2	96.9	10.0	9.0	8.2	7.5	1.7	1.7	1.2	1.0	51.2	49.3	42.0	38.9
14	113.4	94.4	105.5	96.2	10.5	9.5	9.6	8.4	1.9	1.5	1.6	1.5	44.6	42.1	44.6	40.5
15- Sakha 61	102.3	98.8	94.7	83.1	9.0	7.5	8.5	6.1	1.3	1.0	1.3	0.5	43.0	42.5	40.3	38.2
Mean	95.4	85.9	89.3	80.7	8.7	7.8	8.5	7.5	1.4	1.1	1.2	0.9	39.7	36.3	41.6	36.5
% Reduction	10.0		9.6		10.7		11.8		19.9		21.9		8.6		12.2	
LSD (0.05)																
Genotypes (G)	9.8	8.2	7.3	8.2	1.4	2.0	NS	1.2	NS	0.6	0.3	0.3	NS	NS	5.8	2.7
Treatments (T)	6.1		5.4		1.0		1.0		0.4		0.2		NS		3.1	
Durum wheat																
16	111.7	91.9	107.2	97.5	7.0	5.5	7.5	7.0	1.8	1.4	1.4	1.0	51.6	48.5	45.1	40.3
17	126.0	108.2	110.9	96.9	6.5	5.0	7.4	7.3	1.8	1.8	1.5	1.5	56.8	52.9	54.2	49.0
18	92.2	94.2	103.2	92.8	6.0	6.0	7.3	7.0	1.9	1.5	1.8	1.7	52.2	51.9	41.8	39.7
19	103.2	91.3	98.1	88.0	6.0	5.5	6.7	6.5	1.7	1.8	1.3	1.4	56.8	54.0	48.8	46.8
20	113.2	91.5	102.1	90.8	6.0	5.5	6.6	5.2	1.4	1.4	1.4	1.2	47.6	46.4	48.2	45.9
21	98.8	88.8	107.8	98.7	6.0	5.0	7.5	7.3	1.3	1.1	1.5	1.3	53.3	52.0	46.5	44.0
22	98.7	89.2	114.1	104.2	6.5	5.5	6.9	6.7	1.5	1.4	1.6	1.6	49.1	48.9	55.0	53.4
23- Beni Suif 1	128.0	98.6	121.9	115.2	7.5	5.0	7.7	7.1	2.0	1.8	2.1	1.6	46.7	45.0	51.2	49.4
Mean	109.0	94.2	108.2	98.0	6.4	5.4	7.2	6.8	1.7	1.5	1.6	1.4	51.8	49.9	48.8	46.1
% Reduction	13.6		9.4		16.5		6.1		8.9		9.6		3.5		5.7	
LSD (0.05)																
Genotypes (G)	9.3	8.1	8.4	7.8	NS	NS	1.7	1.2	NS	NS	0.3	0.4	5.9	NS	6.1	2.8
Treatments (T)	5.7		5.5		NS		1.0		NS		0.2		NS		3.3	
G X T	5.8		5.3		1.1		1.0		0.5		0.2		5.8		3.1	

Table 3.Number of spikes in one meter, grain yield in one meter and aphids count under control and aphids-infested conditions bread and durum wheat genotypes during 2002/03 and 2003/04 season.

	No. spike/1m				Grain yield/1m (g)				Sample 1 No. aphids/tiller				Sample 2 No. aphids/tiller	
Genotypes	02 / 03		03 / 04		02 / 03		03 / 04		02 / 03		03 / 04		02 / 03	
Bread wheat	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids	Control	Aphids
1	121.5	112.0	121.6	110.3	115.1	83.1	87.1	52.4	1.0	12.0	1.9	21.6	1.3	28.7
2	98.5	91.0	71.4	86.6	89.4	81.3	96.7	47.5	3.5	61.7	4.2	35.2	3.0	102.2
3	130.5	104.0	119.6	129.1	95.7	90.6	108.7	81.3	2.3	39.0	2.8	62.4	1.0	33.3
4	87.0	77.0	80.8	78.2	94.6	46.4	90.4	27.1	1.3	27.2	6.1	35.6	2.0	41.7
5	77.0	68.0	124.9	129.1	99.2	55.9	81.7	80.3	0.8	42.2	1.7	25.4	3.0	41.2
6	59.0	79.0	97.4	83.0	110.2	59.2	106.4	50.5	1.3	75.6	2.3	71.4	3.0	45.6
7	100.5	101.5	142.8	135.7	148.9	107.9	106.9	73.5	0.8	41.0	5.6	51.2	5.3	107.0
8	97.5	67.0	99.8	96.3	68.0	50.0	96.9	69.8	1.0	29.6	6.5	36.0	1.5	88.0
9	63.5	101.0	167.1	159.1	175.8	98.3	80.5	55.3	4.5	76.3	5.0	73.4	3.0	35.8
10	82.5	86.0	137.7	148.4	158.9	75.7	82.9	59.6	1.0	18.8	4.5	21.8	1.0	58.2
11	77.5	77.0	88.4	95.1	114.0	99.6	81.2	54.2	2.0	49.8	7.1	52.4	1.0	76.5
12	79.5	63.0	74.8	40.2	109.6	75.7	105.8	76.6	8.0	147.5	6.1	126.5	1.5	34.6
13	92.5	105.0	107.7	103.6	133.0	123.1	98.1	50.0	5.0	73.0	3.7	50.8	1.0	31.7
14	96.5	76.0	84.5	36.1	95.9	88.0	120.1	99.1	3.8	88.0	2.3	66.8	1.5	61.7
15- Sakha 61	69.0	64.0	69.6	45.5	90.3	42.8	46.1	12.0	0.8	50.8	2.8	60.4	1.5	90.7
Mean	84.2	80.5	101.2	95.4	107.2	75.6	89.6	58.5	2.4	52.1	4.0	48.7	1.9	52.4
% Reduction	4.4		5.8		29.4		34.7							
LSD (0.05)														
Genotypes (G)	NS	26.0	36.3	11.0	45.2	33.5	15.3	16.2	2.4	40.4	3.2	21.9	2.9	48.9
Treatments (T)	23.7		18.6		30.0		10.9		96.7		10.8		117.3	
Durum wheat														
16	121.0	107.0	167.9	162.3	54.7	44.6	136.2	53.8	5.5	111.0	2.8	161.6	0.8	66.9
17	107.0	88.0	138.3	143.6	99.5	93.4	87.0	52.2	2.5	38.9	7.1	19.0	4.0	34.7
18	71.5	92.0	96.0	108.4	120.4	102.9	85.4	59.3	5.0	95.7	2.8	86.6	1.0	42.3
19	52.0	68.0	71.6	61.9	74.5	65.4	81.0	79.2	1.5	26.0	3.8	32.6	1.5	35.8
20	121.0	135.0	109.2	87.7	110.2	79.7	119.7	67.2	3.5	66.7	8.0	76.2	1.8	170.7
21	85.5	101.0	82.2	90.4	86.5	65.9	99.5	69.4	1.5	40.3	3.7	48.2	1.5	27.2
22	56.5	65.0	90.7	71.1	87.6	74.1	92.7	47.1	3.5	24.5	9.3	37.6	1.0	44.2
23- Beni Suif 1	62.5	80.5	74.3	82.0	98.3	88.8	105.3	85.4	6.0	133.7	3.8	139.6	1.0	73.5
Mean	84.6	92.1	103.8	100.9	91.4	76.8	100.8	64.2	3.6	67.1	5.2	75.2	1.6	61.9
% Reduction	-8.8		2.7		16.0		36.3							
LSD (0.05)														
Genotypes (G)	41.0	37.7	37.6	11.5	33.9	NS	15.8	16.8	3.3	72.8	NS	37.1	2.9	49.1
Treatments (T)	25.5		16.8		21.8		11.1		167.4		17.9		112.9	
G X T	23.7		18.4		24.7		10.8		121.3		13.5		112.7	

genotypes were generally taller than bread wheat genotypes. The reductions in stem length averaged 10 and 9.6 % for bread wheat and 13.6 and 9.4 for durum wheat in the two seasons, respectively. These reductions in stem length are probably a result of combined aphid damage and the effect of barley yellow dwarf virus (BYDV) which is transferred by aphids to wheat plants and results in stunting. It is worth noting that honeydew and purpling of flag leaves, (which is a sign of BYDV) were clearly observed among the infested genotypes at different magnitude. Waziery (1996) and Hoffman and Kolb (1998) had similar conclusion.

Spike length was significantly different among wheat groups. During the first season spike length ranged from 8 – 12 cm and 6- 7.5 cm, for bread and durum wheat genotypes, respectively under controlled conditions. While it ranged from 7.9 –10.1 cm and 6.6 – 7.7 cm, respectively during the second season under controlled conditions. Under aphid-infested conditions, reduction in different magnitude also occurred. However, aphids significantly affected spike length in both seasons only in bread genotypes. Spike length in durum wheat genotypes was reduced only in the second season. However, the reductions were not significant in most durum genotypes. Although the high populations of aphids is not visually observed until after booting stage, it seems that the ability of aphids to transfer the dwarfing virus at early stages of wheat growth had played a major role in the reduction of stem and spike lengths.

In the first season, aphids did not significantly affect kernel weight per spike in durum genotypes, while kernel weight was significantly reduced by aphids in bread genotypes (averaging 19.9 %). During the second season, both bread and durum wheat suffered significant reduction in weight of kernels per spike in aphid-infested plots but in different magnitude, where some genotypes were not affected (ex. genotypes number 2, 11, 17, 18, 19, and 22), while others suffered major reductions. Weight of 1000 kernel was significantly reduced by aphid infestation treatment, only in the second season for both wheat groups. Percent reductions ranged from approximately 10 to 20 percent due to aphids in bread wheat and 4 to 17 % in durum wheat for the above mentioned traits.

Table (3) represents the means of number of spikes in one meter length, grain yield and number of aphids per tiller in bread and durum wheat. Number of spikes showed no specific trend in aphid-infested plots because of inconsistent response of genotypes to aphids. In most cases, the difference between control and infested plots was not significant. The reason for this is because the build-up of aphid populations occurs around mid to late March (boot stage) when the spikes would have already been formed, hence the effect of aphids on number of spikes would be limited. However, the effect of aphids on spike components is expected to be higher. Kieckhefer and Kantack (1988) reported similar findings.

Grain yield was significantly reduced by aphids in several bread and durum wheat genotypes in both seasons. The average percent of yield reductions were 29.4 and 34.7% for bread wheat and 16 and 36.3 % for durum wheat in the two seasons, respectively.

During the first season, genotypes 7, 9, 11, 13 and 18 had the highest grain yield under both controlled and infested conditions (Table 3). While in the second season genotypes 3, 12, 14 and 23 (B. Suif 1) were the highest in yield under both controlled and infested conditions.

Figure (2) shows the percent yield loss due to aphids in both seasons. Genotypes 3, 14, 19 and 23 were lowest in yield reduction in both seasons. Sakha 61 (the bread check, genotype 15) suffered more than 50% and 70 % yield loss during the two seasons, respectively. In contract, B. Suif 1 (the durum check, genotype 23) lost about 10% and 20 %, in two seasons, respectively. Sakha 61 (genotypes 15), 3 and 5 consistently had the highest yield reduction due to aphids in both seasons.

Four aphids species were recorded during the first season namely; Green bug (*Schizaphis graminum* Rondani), Bird cherry-oat aphid (*Rhopalosiphum padi* Linnaeus), Corn leaf aphid (*Rhopalosiphum maidis* Fitch) and English grain aphid (*Sitobion avenae* Fabricius). While additional species was also identified during the second season (namely Russian wheat aphids (*Diuraphis noxia* Mordvilko). The most predominant species of aphids were *S. graminum* and *R. padi*. Several researchers (El-Hariry, 1979 and Tantawi *et al.*, 1986) presented similar findings. These two species are probably the most damaging to wheat plants. A sudden increase in temperature occurred in late February during 2003/04 (Fig. 1) and lasted for eleven days. This sudden shift in weather pattern resulted in early-accelerated build up of aphids, particularly Bird cherry-oat aphids, which usually reaches its peak around late April when temperature becomes more suitable for its reproduction. That may explain the higher yield losses during this season compared to first one in most genotypes (Fig. 2) and hints to the potential increase of aphid damage in Egypt in the coming years as global warming increases.

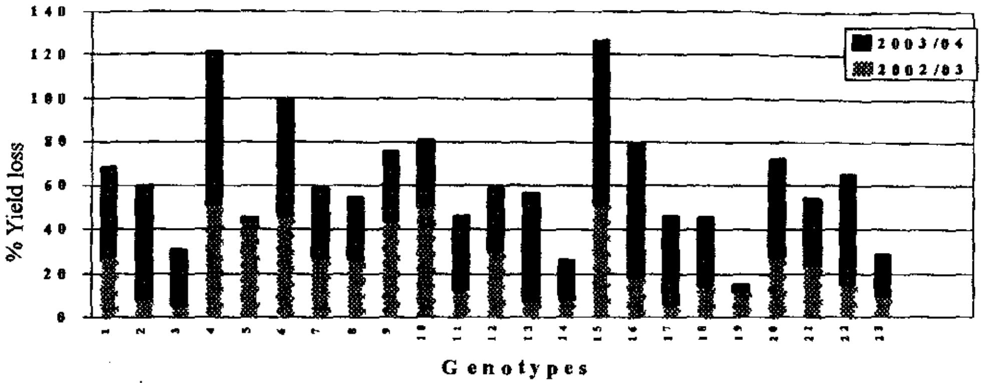

Fig. 2. Percent grain yield loss due to aphids in wheat genotypes during 2002/03 and 2003/04 seasons.

Trait correlations

Table (4) presents simple correlation coefficients among studied traits under controlled and aphids-infested conditions. A significant negative correlation was found between number of aphids per tiller and grain yield in both seasons (r= -0.314* and –0.392** for the two samples in the first season and - 0.428** in the second season. Burton, *et al.* (1985) found similar results. Significant negative correlation was also recorded between number of aphids per tiller and kernel weight per spike in both seasons (Table 4). The reason for this negative correlation is that the correlation analysis included grain yield and aphid numbers under both controlled and infested conditions. Since the number of aphids was extremely low and yield was high under controlled conditions and vice versa under infested conditions, the correlation coefficients were significantly negative.

Figure (4) shows that the least yield reduction due to aphids in both seasons was shown by two bread wheat genotypes (3 (Cham 6) and 15 and two durum wheat genotypes which are number 19 (Becrederaa-1) and Beni-Suif 1. Tantawi *et al.* (1986) concluded that bread wheat varieties were more susceptible to aphids (*S. graminum* and *R. padi*) compared with durum wheat. However, results of this work do not support this conclusion. This is probably because the number of durum wheat genotypes they used was few.

Tantawi *et al.* (1986) also concluded that Sakha 61 was rated as moderately resistant to *R. padi* and *S. graminum*. In this study, Sakha 61 scored almost the highest yield loss in both seasons (more than 50 and 70% in first and second seasons, respectively) which would classify it as susceptible to highly susceptible variety. This difference in rating is probably related to differences in aphid intensities in each study.

Table 4. Correlation coefficients over treatments (controlled and infested) in bread and durum wheat in two seasons 2002/2003 (above diagonal) and 2003/2004 (below diagonal).

	1	2	3	4	5	6	7	8
1.Stem length (cm)		0.214	0.667**	0.404**	0.036	**0.300***	**-0.317***	**-0.433****
2. Spike length (cm)	-0.160		0.071	**-0.433****	-0.080	0.234	-0.111	**-0.298***
3. Kernel weight / spike (g)	0.692**	-0.056		**0.589****	-0.036	**0.366****	-0.130	**-0.320***
4. 1000 kernel weight (g)	**0.599****	-0.157	0.447**		-0.025	0.094	-0.088	-0.240
5. Number of spikes/1m	-0.192	0.177	-0.156	-0.070		0.061	-0.005	0.119
6. Grain yield /1m (g)	**0.507****	0.210	**0.469****	**0.387****	0.124		**-0.314***	**-0.392****
7. Aphids/tiller	-0.115	**-0.325***	**-0.237***	-0.253	-0.091	**-0.428****		**0.605****

***, ** Significant r at 0.05 and 0.01, respectively.**
7 is the number of aphids in the first sample.
8 is number of aphids in the second sample.

2. Susceptibility index (SI)

Table (5) presents the classification of the tested wheat genotypes based on susceptibility index (SI), and yield index (Ys %) (expressed as percent of mean grain yield of all genotypes under aphid infestation in 2002/03 and 2003/04 seasons. Susceptibility index is used in this investigation to characterize the relative resistance/tolerance of wheat genotypes to aphid infestation. Low SI (SI < 1) is synonymous to higher resistance/tolerance and SI >1 is synonymous to susceptibility. A highly significant negative correlation was found between SI and Ys % (-0.52 ** and –0.849** for the two seasons, respectively).

SI ranged from 0.12 to 2.04 and 0.0 to 1.95 during 2002/03 and 2003/04 seasons, respectively. Genotypes 3, 14, 19 and 23 had the lowest SI values in both seasons, while genotypes 4, 6 and 15 had the highest SI in both seasons. The remainder of the Treatments and experimental design genotypes was not consistent between the two seasons.

Table 5. Classification of bread and durum wheat genotypes based on susceptibility index (SI), and yield index (Ys%) in two seasons (2002/03 and 2003/04).

	2002 / 2003			Resistance	2003 / 2004			Resistance
Genotypes	SI	Ys %	Groups	class*	SI	Ys %	Groups	class
Bread wheat								
1	1.09	106.7	2	S	1.07	85.9	4	HS
2	0.30	104.3	1	R	1.39	77.9	4	HS
3	0.12	116.3	1	R	0.68	133.3	1	R
4	1.96	59.5	4	HS	1.92	44.4	4	HS
5	1.70	71.7	4	HS	0.00	131.6	1	R
6	1.79	75.9	4	HS	1.44	82.8	4	HS
7	0.99	138.5	1	R	0.84	120.6	1	R
8	0.93	64.2	3	MR	0.75	114.5	1	R
9	1.69	126.2	2	S	0.83	90.7	3	MR
10	1.91	97.1	4	HS	0.74	97.7	3	MR
11	0.43	127.8	1	R	0.88	88.8	3	MR
12	1.15	97.2	4	HS	0.74	125.6	1	R
13	0.30	158.0	1	R	1.34	81.9	4	HS
14	0.29	112.9	1	R	0.47	162.4	1	R
15- Sakha 61	2.04	54.9	4	HS	1.95	19.7	4	HS
Durum wheat								
16	0.68	57.2	3	MR	1.67	88.2	4	HS
17	0.22	119.9	1	R	1.08	85.5	4	HS
18	0.57	132.0	1	R	0.81	97.2	3	MR
19	0.43	83.9	3	MR	0.01	129.9	1	R
20	0.97	102.2	1	R	1.20	110.2	2	S
21	0.91	84.5	3	MR	0.81	113.8	1	R
22	0.63	95.0	3	MR	1.34	77.2	4	HS
23- Beni Suif 1	0.35	114.0	1	R	0.50	140.1	1	R
Mean	0.93				0.98			
LSD (0.05)	1.32				0.74			

* R = resistant, MR= moderately resistant, S = susceptible and HS= highly susceptible

Ys % ranged from 54.9 to 158 and 19.7 to 162.4 during the two seasons, respectively. Genotypes 3, 7, 14 and 23 (B. Suif 1) had the highest Ys % in both seasons, while 4, 6, 15 were the lowest in both seasons. The other genotypes were not consistent between seasons.

Data of Ys and SI were used to group the studied genotypes based on yield potential under aphids-infestation and degree of susceptibility. The results were presented graphically (to facilitate the interpretation) by plotting the mean values of Ys % and SI for each genotype (modified from Gavuzzi *et al.* (1993), and Bayoumi, *et al.* (2002), Figures 3 and 4. Accordingly, wheat genotypes were classified into four groups:

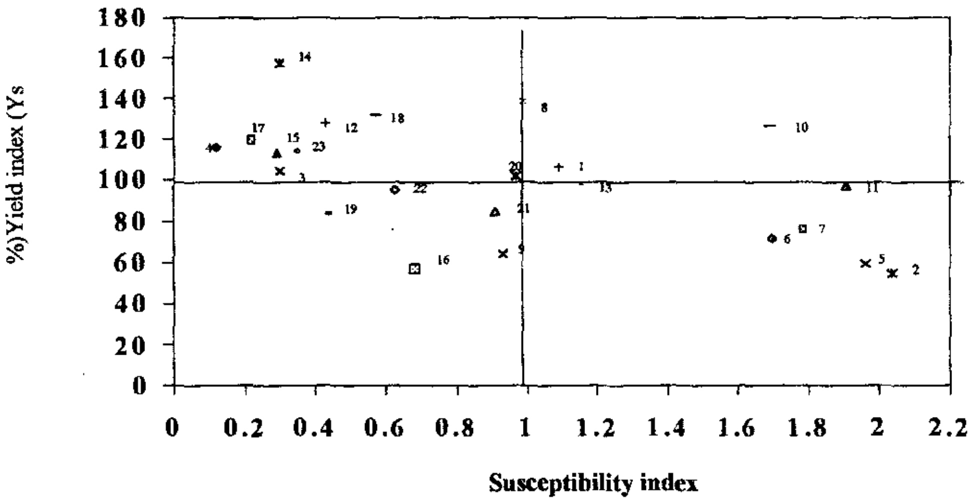

Fig.3 . Classification of 23 wheat genotypes according to grain yield index (Ys %) in aphids-infested plots and susceptibility index (SI) in 2002/2003 season.

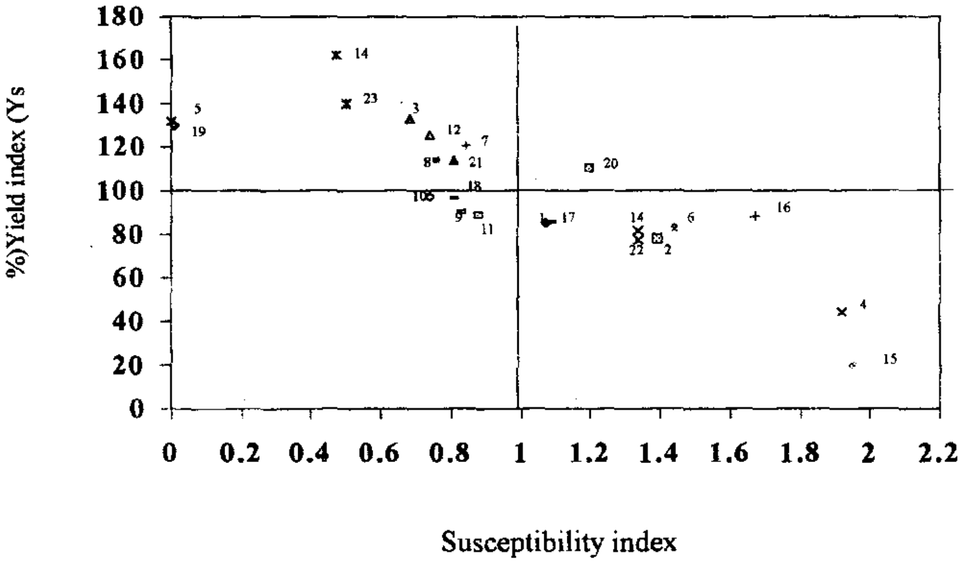

Fig. 4 . Classification of 23 wheat genotypes according to grain yield index (Ys %) in aphid-infested plots and susceptibility index (SI) in 2003/2004 season.

1- Group 1, resistant (R), included the genotypes 3, 7, 14, and 23 in both seasons with yield index (Ys %) above 100 and SI<1. These genotypes had high yield and were less affected by aphids. Other genotypes were also included in this group, but they were not consistent in both seasons.

2- Group 2, susceptible (S), included the genotypes 1 and 9 during the first season and genotype 20 during the second season, with yield index (Ys %) above 100 and SI > 1. These genotypes had high yield, but they suffered major yield losses due to aphids.

3- Group 3, moderately resistant (MR), included the genotypes 1, 8, 19, 21 and 22 during the first season and 9, 10, 11 and 18 during the second season, with yield index <100 and SI < 1. These genotypes had low yield, but suffered less yield loss due to aphids. They are also considered less adapted.

4- Group 4, highly susceptible (HS), included genotypes number 4, 6 and 15 consistently in both seasons, with yield index < 100 and SI > 1. There were the genotypes with low yield potential and also suffered major yield loss due to aphids.

It is clear that the susceptible (S) and the moderately resistant (MR) groups did not include the same genotypes in both seasons. It is worth noting that the genotype 19 (Bicrederaa-1) was in group 3 (MR) in the first season and group 1 (R) in the second season, while genotype no. 18 showed opposite trend (Fig. 3 and 4). This indicates the need for testing genotypes over seasons to assess their real merit in respect to aphid resistance.

CONCLUSIONS

Yield loss due to aphid infestation was documented in this investigation, reaching 34.7% for bread wheat and 36.3% for durum wheat. Percent yield loss alone was not an efficient criterion for identifying adapted resistant genotypes, because it does not show yield potential under controlled conditions. Yield index (Ys%) identified the genotypes with the highest yield under infested conditions compared to the mean of all the genotypes, but it also does not consider yield potential under controlled conditions. SI compares yield under both control and infested conditions and relates it to mean of all genotypes (D).

Both Ys and SI could be used to classify wheat genotypes considering both yield potential and susceptibility to aphids-infestation. This procedure identified three genotypes as 3 (Cham 6, ICARDA improved check), 14 (Vee's//Koel's / Vee's) and 23 (Beni-Suif 1, the local durum check).

Although number of aphids per tiller significantly negatively correlated with grain yield (over controlled and infested conditions together, Table 4), no significant correlation could be found between aphids per tiller at the peak infestation and SI, Ys%, percent yield loss or grain yield under infested conditions only. This is because aphids populations are highly affected by the environment and their numbers will change dramatically depending on the time of sampling. This indicates that number of aphids at a given time is not reliable as a selection criterion for aphid resistance. However, accumulated aphids per tiller over the whole season along with percent damage caused by aphids may be more reliable. Further investigations are required.

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اختبار كفاءة دليل القابلية للإصابة كمعيار للانتخاب لمقاومة المن فى أصناف قمح الخبز والديورم

عماد عبد الجواد اسماعيل

قسم المحاصيل كلية الزراعة - جامعة القاهرة - الجيزة

تسبب حشرة المن أضرار مباشرة لمحصول القمح كما قد تنقل فيروس التقزم للنبات. ولكن خطورة هذه الحشرة غير واضح فى مصر نظرا لعدم ظهور الضرر الا عند زيادة أعداد الحشرة بدرجة كبيرة وقلة الدراسات التى تقدر الفقد فى محصول القمح الذى يسببه المن والفيرس كل على حدة. يمكن استخدام المبيدات للسيطرة على الحشرة ولكنها لاتقضى على الفيرس. لذا تعتبر التربية للمقاومة افضل وسيلة للسيطرة على الحشرة والفيرس الذى تنقله معا وتحديد افضل معايير للانتخاب من الأهمية بمكان.

تهدف هذه الدراسة الى :(١) تقدير كمية الفقد فى المحصول الذى يسببه المن و(٢) اختبار كفاءة دليل القابلية للإصابة كمعيار للانتخاب للمقاومة للمن بين أصناف القمح.

تم زراعة أربعة عشر صنفا من اقماح الخبز الربيعة و سبعة أصناف من قمح الديورم المستجلبة من الايكاردا بالإضافة الى اثنين من الأصناف المصرية (سخا ٦١ و بنى سويف-١) فى موسمى ٢٠٠٢/٢٠٠٣ و ٢٠٠٣/٢٠٠٤ تحت ظروف الإصابة بالمن مقارنة بظروف عدم الإصابة (الكونترول). تم تقدير أعداد الانواع المختلفة من حشرات المن على اشطاء القمح فى فترة الذروة (أعلى كثافة حشرية من الموسم) وكذلك تم تقدير المحصول ومكوناته فى نهاية الموسم.

أظهرت النتائج حدوث نقص فى طول الساق و طول السنبلة ووزن حبوب السنبلة ووزن المحصول الكلى تحت ظروف الإصابة بالمن مقارنة بالكونترول. حدث نقص كبير (اكثر من ٥٠% و ٧٠% فى الموسمين على التوالى) فى محصول الصنف سخا ٦١ بينما لم يتأثرصنف الديورم بنى سويف ١ بدرجة كبيرة. اظهر اثنان من أصناف قمح الخبزالمستجلبة وصنف الديورم المحلى (بنى سويف -١) أعلى محصول تحت ظروف الكونترول وأعلى نسبة فى دليل المحصول تحت ظروف الإصابة واقل نسبة نقص فى المحصول بسبب الإصابة بالمن مع انخفاض دليل الإصابة فى كلا الموسمين. اختلفت أعداد المن بالنسبة للأصناف فى الموسمين ولم تكن أعداد الحشرات فى وقت الذروة مرتبطة بصفات المحصول ومكوناته وبالتالى لايعتبر مؤشرا جيدا على المقاومة. أمكن تقسيم الأصناف الى اربع مجموعات على اساس دليل القابلية للإصابة مع دليل المحصول واللذان اظهرا معا كفاءة فى التمييز بين الأصناف فى كلا الموسمين. هذه المجموعات هى: مقاوم (دليل المحصول اكبر من ١٠٠ ودليل الإصابة اقل من ١) ، قابل للإصابة (دليل المحصول اكبر من ١٠٠ ودليل الإصابة اكبر من ١) ، متوسط المقاومة (دليل المحصول اقل من ١٠٠ ودليل الإصابة اقل من ١) وشديد القابلية للإصابة (دليل المحصول اقل من ١٠٠ ودليل الإصابة اكبر من ١).