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Verticillium wilt is the most serious cotton disease for the only species cultivated in Greece : *Gossypium hirsutum L.* During the last decade, the *Verticillium* problem was intensified, especially in Central and South Greece, mainly because of the continuous cotton cultivation at the same fields. The percentage and the severity of infestation depend on the environmental factors, as well as on the stage of plant growth (2, 3, 5). As temperature between 22 and 27° C and excessive soil moisture favour disease, there are great differences between years as well as within the same growing period. Usually, the first occurence of the disease happens in early July and the second and most possible during middle of August.

Wilt coefficients and cotton losses are affected by several factors. The actual yield reduction due to *Verticillium* wilt is very difficult to be calculated because yield is affected by many factors. Usually, there are estimations for yield losses. Marani and Yacobi (7) planted the same genotypes in infested and not infested fields and the difference of yield for each genotype at the two locations was used as an indication of yield loss due to *Verticillium*.

In Greece, during the period 1976-1979, several experiments were carried out on a highly naturally infested field of the Cotton and industrial Plants Institute aiming to : 1) the study of varietal effect and this of some cultural factors on the expression of *Verticillium* wilt and 2) the actual measurement of yield and quality cotton losses due to the disease (4). The percentage and the severity of plant infestation according to foliar disease symptoms were calculated at least twice a year (middle of July and middle of August).

Four degrees of wilt severity were used (1 = *Clorosis* of a few leaves at the bottom of the plant. 2 = *Clorosis* of many leaves up to the top of the plant. 3 = *Clorosis* and marginal *necrosis* of leaves. 4 = *Necrosis* of the whole lamina, defoliation, dead plant). Ten plants for each degree of infestation and each treatment were labeled during the first and second observation. At the early observation, all the infected plants were labeled in order to avoid labeling at the second observation an early infested plant. The ten plants of each category were harvested separately to be used for calculation of yield and quality losses.

The prevailed environmental factors differentiated greatly among the years the wilt percentage which was 10-26% in July and 28-59% in August (Table 1). Higher infestation was observed in 1979, also in the common cotton cultivation in Greece, but in the case of the above experimentation, it was also due to the fact that the same field was used the four years and *Verticillium inoculum* was most probably increased according to other research findings (1). The weighted mean degree of infestation was less differentiated among the treatments and was not always proportional to the percentage of infested plants which means that the product of these two coefficients is a more reliable disease criterion (Table 1). The aggravation of infected plants symptoms during the growing season was also

independent of wilt percentage and greater for the mild degrees of infection.

The varieties responded differently to the wilt infestation (Table 1). Early varieties were generally more susceptible to the early and late varieties to the late infestation. Similar reaction was also displayed between early and late sowing (4). Varietal yield was affected but not entirely by disease resistance. The resistant but late in maturity varieties 71810 and 71042-46 yielded more than the susceptible varieties 4S and Coker, but also the susceptible variety Sindos 80 was proved a high yielder. These results are in agreement with those from regional varietal trials conducted in infested areas of Greece.

The increased plant population in double rows and the sowing on beds restricted infestation but the yield was increased only by the first factor. Percentage of infected plants, in both early and late disease occurrence, was reduced up to 50% and yield increased up to 15% in the case of double row-high density (20-28 plants/m2) in comparison to the traditional single row-half plant population (4, 6). The reduction of wilt percentages due to the increase of plant population is rendered to the fact that a certain *fungus inoculum* in the soil attacks a certain number of plants which represents lower percentage as the plant population is increasing (8).

Early sowing (beginning of April) in spite of greater infestation and disease losses, yielded more than the late one (early May) (4). Several other results from recently conducted trials at the Cotton Institute prove that the beneficial effect of early sowing, under the conditions of restricted growing season of Greece, over-compensates the disadvantage of greater infestation and losses.

Yield losses, on the average of all the varieties tested, were proved proportional to the percentage, degree and duration of infestation. Cotton plants with infestation degrees in July 1, 2, 3, 4 yielded respectively 51.3, 40.6, 20.9 and 4.0% of healthy plants while those infected in August yielded respectively 88.7, 68.6, 45.9 and 26.6% (Figure 1). The plants infected in September showed even less yield reduction.

The average of all infested plants during early wilt occurrence yielded, in the average of the four years, 41.4% of the control while those infected in August yielded 55% (Figure 1).

Although early infected plants yielded less than lately infected, the yield loss per area due to August infection, was greater than to July, 12% and 10% respectively, because there was greater wilt percentage in August than in July, 27.2 and 18.5% and the infected plants had on the average higher disease degree, 2.6 and 2.1 respectively (Table 2). The percentage of yield reduction per unit area was calculated from the date presented on Table 2. The percentage of yield reduction due to a certain (July or August) infestation is the product **a** x **b** where **a** is the difference from 100 of the mean yield of infected plants, with the average degree of infestation, expressed as percentage of healthy plants yield and b is the percentage of infected plants.

The effect of *Verticillium* wilt infestation on technological characters was calculated in a similar way (4). Among these characters, only Micronaire index was lowered by 0.2 units due to the overall plant infestation.

The above losses must be considered as an extreme situation because such highly infested are out of cotton cultivation. The presented data prove the severity of *Verticillium* problem but also the exaggeration of the disease effect on the cotton cultivation.

The above data provide a quantitative basis for calculation of losses due to *Verticillium* wilt.

Management for control of disease: *Verticillium* can not be effectively controlled by chemicals. The approach to the integrated control is the use of resistant varieties in combination with rotation and appropriate cultural practices.

Although there are not immune *hirsutum* varieties, there is great variability among them and the effort for creation of resistant varieties is one of the most important breeding objectives. An intensive programme exists at the Cotton Institute of Greece for the development of resistant varieties. The negative correlation among resistance and other desirable characters as earliness is a handicap for the above objective. However, according to recent results, there are some new varieties with a combination of wilt resistance (Table 3) and other agronomic characters. New varieties are tested at a heavily infested field of the Institute (Table 3) and the most promising among them are evaluated at

regional trials conducted in infested areas in collaboration with the Hellenic Cotton Board.
Among the cultivation varieties, the late in maturity Zeta 5 and Zeta 2, selections from the American varieties Acala SJ5 and Acala SJ2 respectively, are resistant, Acala Sindos, a completely different variety from Acala SJ1, is moderate in earliness 4S, the early Sindos 80 and the very early Samos are susceptible. However, according to several experiments, the varietal yield is affected but not entirely by their degree of resistance. The adoption of the assumption that tolerant cultivars differentially select for aggressiveness of pathogen and consequently, lead to the breakdown of varietal resistance is the same reason as in California where Zeta 5, although more resistant than Zeta 2, is kept to be used only when the latter will cease to perform satisfactorily at the infested fields of South Greece.

Short or long term rotation with crops that do not contribute to new *inoculum*, such as cereals and especially rice, is the main solution and when the problem becomes very serious, the only factor for disease control.

Increased plant population and sowing on beds can contribute to the integrated control. However, increase in plant population over an optimum level becomes disadvantageous for other desirable agronomic characters, especially for varieties with excessive plant growth.

Early sowing, under the conditions of short growing season as in Greece, can contribute to yield increase even at highly infested fields althrough the wilt percentage and the percentage of yield losses are greater than in the late sowing.

Excessive nitrogen fertilization and irrigation, probably due to their usual result to crop lateness, increase losses. On the contrary, and according to some experimental data and observations, in Greece, fertilization with potassium and application of some plant growth regulators restrict *Verticillium infestation*.

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Varieties Year	Wilt Percentage (a) J	A	Degree of Infestation (b) J	A	Product a x b J	A	Total	Seed cotton g/m2	Mean date of maturity (sept.)	Mean boll weigth g	Lint %	Fibre length mm	Micro-naire	Pressley
71042-6	15	37	2,10	2,50	30	91	121	153	27,10	5,90	38,50	27,80	3,50	8,40
Coker C.I	22	49	2,10	2,60	43	126	169	126	27,40	5,40	39,70	27,70	3,30	8,20
71810	10	28	1,90	2,30	17	63	80	155	28,50	6,10	39,00	27,80	3,30	8,20
74427-30	18	38	1,90	2,40	31	92	123	140	26,90	5,40	39,40	27,50	3,70	7,90
45	19	45	2,10	2,70	39	122	161	124	26,20	5,00	38,20	27,70	3,20	8,10
71039	14	34	2,00	2,40	29	81	110	116	29,40	5,50	37,00	28,20	3,10	8,90
ASA 805	11	31	2,90	3,10	33	95	128	136	31,30	5,30	39,00	28,00	2,90	
Sindos 80	14	45	2,00	2,40	26	115	141	187	22,70	4,90	41,20	28,00	3,50	8,00
Mean	15	38	2,13	2,55	31	98	129	142	27,44	5,44	39,00	27,84	3,31	8,24
1976	13	28	2,60	2,80	33	79	112	135	33,10	5,60	37,30	28,20	3,00	
1977	17	29	1,50	2,10	25	81	106	114	27,60	5,80	37,30	27,20	3,30	8,40
1978	10	30	2,20	2,20	22	69	91	166	22,70	5,50	39,40	27,70	3,40	8,00
1979	26	59	1,80	2,80	45	167	212	151	24,70	5,10	42,10	28,00	3,80	
Mean	17	37	2,03	2,48	31	99	130	142	27,03	5,50	39,03	27,78	3,38	8,20

Table 1: Coefficients of Verticillium wilt infestation and agronomic - technological characters as affected by certain cotton varieties

J = July, A = August

Period of wilt occurence:	Seedcotton yield % of healthy plants								Wilt percentage		Mean degree of infestation		Mean yield of infested plants % of healthy		Percentage of yield reduction per unit area		
	July (J)				August (A)												
Degree of infestation:	1	2	3	4	1	2	3	4	J	A	J	A	J	A	J	A	Total
1976 Sowing: April 9	59,70	37,70	39,50	5,70	96,80	51,20	36,20	4,90	16,40	14,40	2,70	2,70	39,00	40,70	10,00	8,50	18,50
Sowing: May 5	50,20	39,90	13,40	5,90	83,60	42,00	38,50	6,00	8,80	16,70	2,50	2,70	26,70	39,60	6,50	10,10	16,60
1977 Sowing on beds	56,40	35,00	25,20		88,40	79,30	73,10	58,90	13,70	19,30	1,30	2,20	50,00	78,10	6,90	4,20	11,10
Flat sowing	47,50	23,10	9,50		90,20	88,10	65,10	57,30	19,10	25,80	1,60	2,60	32,90	74,30	12,80	6,60	19,40
1978	27,90	35,80	25,00	4,80	79,40	53,90	21,00	5,40	14,40	30,80	2,50	2,30	30,40	44,00	10,00	17,20	27,20
1979	70,50	58,60	14,70	1,40	95,90	91,10	56,20	37,30	30,40	39,80	1,80	2,90	61,00	59,70	11,90	16,00	27,90
Mean of years	51,30	40,60	20,90	4,00	88,70	68,80	45,90	26,60	18,50	17,20	2,10	2,60	41,40	55,00	10,00	12,00	22,00

Table 2: Effet of Verticillium wilt infestation on seedcotton yield (Average of varieties)

Ranking of resistance	Cotton strains-Origin	Wilt percentage	Years of evaluation
1	821226 (AS153-66 x Task.3)	4,50	84, 85
2	821275-7 (71440 x 71810)	6,10	85
3	83480-1 (Task.6)	7,50	84, 85
4	821214 (73468 x Task.Sem.)	9,60	85
5	811259 (71414 x 711467)	9,90	84, 85
6	82087 (DLT-90)	10,70	85
7	79359 (HG 6160 FB)	14,90	85
8	81443-4 (GSA 74)	15,00	82-84
"	821281 (71440 x Task.3)	15,00	85
10	81634 (Lamia)	15,30	82-84
11	811652 (Early Cotton WR)	15,40	84, 85
12	Thalia (75780-2, 4S180 x Delcot)	16,10	82-85
13	75900 (M.D. herb.277)	18,50	82, 83
14	831021+6 (71042 x Str.31)	19,40	85
15	811683 (14X)	19,70	85
16	811202 (4S 209 x P 5230)	19,80	82, 83-85
17	621213 (73468 x M.D. Anom)	20,20	85
18	79349 (UCK 73000)	20,60	82, 83
19	811729-31 (Ston 504)	21,10	82, 83
20	781289 (B 432)	21,50	83-85
21	801249 (4S12 x 71042)	22,10	83-85
22	831391 (Ac. C-1)	22,20	84, 85
"	74314 (Derider)	22,20	83-85
24	Skotoosa (771267 B 357)	22,30	83, 84
25	911670-1 & 79072 (Ac.SJ5 Ka .)	22,70	81-83
26	771153 (Early dwarf)	22,80	83, 84
27	Thalia (75780-L, 4S180 x Delcot)	22,90	82-85
28	831178 (4S 153 x Ac. SJ5)	23,20	85
46	811248 (4S180-370 x B4521)	29,10	84, 85
47	74390 (B 3996)	29,30	82
48	811225-33 (4S P.S. x Ston.213)	29,80	82-84
49	75896 (M.D.barb.277)	30,70	83, 84
50	771104-5 (T x SP21-74C)	30,90	81-83
"	Thalia (75780, 4S 180 x Delcot)	30,90	81
52	78579 (Alep.1 x Ac.SJ4)	31,80	82-84
53	Stonville Sindos (74359,5 Ston 213)	32,40	81, 82
54	741146 (Hancock)	32,50	81, 82
55	801254 (4S 12 x 71823)	32,60	84
56	Rhodos (74427, P 153F)	32,90	81, 82
57	781297 (Y-5103)	33,10	83, 84
58	79353-4 (H.G. 6141 N)	33,40	82-84
59	801236 (71440 x 71823)	33,50	85
60	831054 (PU K16 x Am. Vert.)	33,90	85
61	80256-7 (Ston 825N)	34,00	82, 83
62	74347 (McNair 1032)	34,40	81-83
63	771270-2 (PM 266)	34,50	81-83
64	80254-5 (Ston 731N)	34,60	81-83
65	76846 (Rilcot)	34,70	83, 84
"	791169-72 (EXD x PU)	34,70	81-83
66	801196-8 (71440 x 4SA827)	35,20	84, 85
67	801666-9 (McNair 235)	35,40	82-84
68	771144 (CEAJ-349)	35,40	81-83
69	811241 (4S180-370 x Ston.213)	35,70	82-84
70	76223 (74359, Ston.213)	35,80	81, 82
"	721021 (Har x Allen)	35,80	81, 82
73	Skotousa (771186-7 B-358)	36,50	81, 82

Table 3: Ranking of varietal resistance to Verticillium Wilt (1981-85)

29	831064 (71414 x Str.31)	23,40	85
30	811708 (Des 24)	24,00	84, 85
31	821272-3 (71440-536 x 71467)	24,10	85
32	811689 (DLT SR5)	24,40	84, 85
"	821201-2 (73468 x 71810-291)	24,40	84, 85
34	Delcot Sindos (Delcot 277)	24,50	81-83
	811314-5 (71440 x 71810)	24,50	82-85
36	Sindos 80 (73460, Pu x 2421)	25,20	82
37	831173-6 (73468 x Ac. SJ5)	26,10	85
38	811291 (73814 x M.D. Herb.)	26,20	84, 85
39	77225 (76223, Ston 213)	27,00	81-83, 85
"	831453 (Tamcot SP 37H)	27,00	85
41	811261 (71414 x 71810)	27,10	82-85
42	821178 (73468 x P153r)	27,60	85
43	811732-3 (Ston 6058)	28,30	83, 84
44	Acala Sindos (70146-68, Ac. SJ1)	28,40	81-83
45	Sindos 80 (73460-3 Pu x 2421)	28,60	83-85
74	Samos (74402, B 9736)	36,90	81-83
75	811193-4 (4S 209 x Ston.213)	37,10	84
76	4S A 805	37,50	81, 82
77	75798 (4S x SP)	37,80	84
"	71483 (XD-2421)	37,80	81-83
79	811200 (4S 209 x Y 104)	38,10	84, 85
80	Sindos 80 (73468-4 Pu x 2421)	39,50	84
81	Sindos 80 (73468, Pu x 2421)	39,70	81
82	Sindos 80 (73468-3, Pu x 2421)	40,30	82-84, 85
83	831049+50 (71440 x 73870)	41,20	85
84	4S (Control)	41,90	81-85
85	Aglaïa (75759, 4S 180 x Act. 35)	42,60	81, 82
86	75245 (Pee Dee)	43,10	84
87	74391 (B 6396)	43,40	83, 84
"	Sindos 80 (73461 Pu x 2421)	43,40	81, 82
89	Erato (71918, PU5)	51,10	81, 82

Table 3: Continued