# RESULTS AND DISCUSSION

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#### 1. Greenhouse Experiment

#### 1.1. Quantitative Evaluation of Plant Reaction:

#### 1.1.a. Number of galls:

The results presented in Table 1 indicate that the parental pepper germplasm showed significant difference concerning number of galls counted on the roots of the individual plants. Using number of galls as a criterion to evaluate resistance to root knot nematode in pepper has been reported (Dukes and Fery, 1997; Souza et al., 2002; Thies et al., 2003). The plants of the parental pepper germplasm Murch, Mirch, and No.4791 showed no galls on their roots, while number of galls counted on roots of the parental pepper germplasm Yellow Wax, Aswany, California Wonder and Domalik Buber were 101.00, 14.67, 101.00 and 0.33, respectively, (Table 1). Furthermore, all F<sub>1</sub> hybrids which involved one of the parents which showed either no galls or very small number of galls, had similar behavior to that parent (Table 1). This indicated the dominance of resistance to root knot nematode measured by number of galls formed on plant roots after artificial inoculation. Dominance of resistance to the rootknot nematode in pepper has been reported by Souza et al. (2002).

The results presented in Table 2 show significant general and specific combining ability which indicate the presence of both additive and non- additive type of gene action in the inheritance of this character. In addition, the GCA/SCA

Table (1): Means of number of galls, number of eggs, R-factor, gall index (GI) and Plant reaction for the inoculated plants of different parental genotypes and its F1 hybrids evaluated in the greenhouse experiments.

Quantitative Evaluation Qualitative Evaluation	Quantitati	Quantitative Evaluation		Qualitative	Qualitative Evaluation
Genotypes	No. of galls	No. of Eggs	R-factor	Gall index	Plant reaction
Yellow wax	101.00	8266.67	1.65	S	Highly susceptible
Yellow Wax X Aswany	20.33	2200.00	0.44	3	Susceptible
Yellow Wax X California Wonder	101.00	6766.67	1.95	5	Highly susceptible
Yellow Wax X Murch	0.33	23.33	0.00	-	Resistant
Yellow Wax X Domalik Buber	1.00	126.67	0.03	1	Resistant
Yellow Wax X Mirch	0.00	0.00	0.00	0	Highly Resistant
Yellow Wax X No.4791	0.33	46.67	0.01	1	Resistant
Aswany	14.67	1700	0.34	3	Susceptible
Aswany X California Wonder	22.67	2533.33	0.51	3	Susceptible
Aswany X Murch	0.00	0.00	0.00	0	Highly Resistant
×	1.00.	63.33	0.01	1	Resistant
×	0.00	0.00	0.00	0	Highly Resistant
Aswany X No.4791	29.0	26.67	0.01	1	Resistant
California Wonder	101.00	12633.33	2.19	S	Highly Susceptible
California Wonder X Murch	0.00	0.00	0.00	0	Highly Resistant
California Wonder X Domalik Buber	1.00	70.00	0.01	_	Resistant
	0.33	30.00	0.01	-	Resistant
California Wonder X No.4791	0.00	0.00	0.00	0	Highly Resistant
1	0.00	0.00	0.00	0	Highly Resistant
Murch X Domalik Buber	0.00	0.00	0.00	0	Highly Resistant
Murch X Mirch	0.00	0.00	0.00	0	Highly Resistant
Murch X No.4791	0.00	0.00	0.00	0	Highly Resistant
Domalik Buber	0.33	53.33	0.01	1	Resistant
Domalik Buber X Mirch	0.00	0.00	0.00	0	Highly Resistant
Domalik Buber X No.4791	0.33	33.33	0.01	1	Resistant
	0.00	0.00	0.00	0	Highly Resistant
Mirch X No.4791	0.00	0.00	0.00	0	Highly Resistant
No.4791	0.00	0.00	0.00	0	Highly Resistant
L.S.D 5%	1.58	1270.45	0.17		
L.S.D 1%	2.10	1693.94	0.22		

Table (2): Mean square values of number of galls and number of eggs for the different sources of variance in the greenhouse experiment.

Sources of Variance	df	No. of galls	No. of eggs
Genotypes	27	2969.13**	31898650.44**
Parents	6	6945.11**	78760615.87**
Hybrids	20	1511.24**	14411347.62**
Parents Vs hybrids	1	9000.14**	100472914.29**
Error	54	0.92	599260.49
General combining ability (GCA)	6	2620.40**	27839909.82**
Specific Combining ability (SCA)	21	535.37**	5716590.24**
Error	54	0.31	199753.50
GCA/SCA	4.89	4.87	GCA/SCA

<sup>\*\*</sup> significant at 1% level of significance

ratio was (4.89) which indicate that the additive type of gene action was more important than the non- additive type in the inheritance of this character. These results agreed with that of **Souza et al.**, (2002) who reported additive gene action for the inheritance of resistance to root-knot nematode in pepper.

The parental pepper germplasm Murch, Domalik Buber, Mirch and No.4791 had relatively high desirable combining ability effects (-11.582, -11.175, -11.582, -11.471, respectively), while the parental pepper germplasm Aswany had general combining ability effect equal to -3.397, (Table 3). The results indicate that the previously mentioned parental pepper germplasm which had the highest desirable general combining ability effects (> -11.0) can be considered as good combiners for forming hybrids with high resistance to root knot nematode.

The F<sub>1</sub> hybrids which showed the highest desirable specific combining ability effects were Yellow Wax X Murch (-25.648), Yellow Wax X Domalik Buber (-25.389), Yellow Wax X Mirch (-25.759), California Wonder X Murch (-26.204), California Wonder X Domalik Buber (-25.611), California Wonder X Mirch (-25.870), and California Wonder X No.4791 (-26.315), (Table 4). These F<sub>1</sub> hybrids are recommended to be planted in areas where infection with root nematode are likely to occur.

The analysis of homogeneity of Wr-Vr over arrays indicated no evidence for violating the assumptions required for the validity of Jinks-Hayman analysis (Table 5). In Addition, the regression coefficient (b) for the Wr-Vr was significantly different from 0 and, in the same time, it was not significantly different from unity Table 5 which indicate the absence of epistatic interaction.

Table(3): General combining ability effects (gi) for number of galls and number of eggs for the different parental genotypes in the greenhouse experiment.

	Measur	ements
Genotypes	No. of galls	No. of eggs
Yellow Wax	24.492	1995.714
Aswany	- 3.397	- 279.101
California Wonder	24.714	2992.381
Murch	- 11.582	- 1190.212
Domalik buber	- 11.175	- 1148.360
Mirch	- 11.582	- 1189.471
No.4791	- 11.471	- 1180.952
L.S.D 5%	0.343	275.856
L.S.D 1%	0.459	369.647

Table (4): Specific Combining ability effects (Sij) of the different  $F_1$  hybrids for number of galls and number of eggs in the greenhouse experiment.

	Measur	rements
Genotypes	No. of galls	No. of eggs
Yellow Wax X Aswany	-13.833	- 858.519
Yellow Wax X California Wonder	38.722	3436.667
Yellow Wax X Murch	- 25.648	- 2124.074
Yellow Wax X Domalik Buber	- 25.389	- 2062.593
Yellow Wax X Mirch	- 25.981	- 2148.148
Yellow Wax X No.4791	- 25.759	- 2110.000
Aswany X California Wonder	- 11.722	- 1521.852
Aswany X Murch	1.907	127.407
Aswany X Domalik Buber	2.500	148.889
Aswany X Mirch	1.907	126.667
Aswany X No.4791	2.463	144.815
California Wonder X Murch	- 26.204	- 3144.074
California Wonder X Domalik Buber	- 25.611	- 3115.926
California Wonder X Mirch	- 25.870	- 3114.815
California Wonder X No.4791	- 26.315	- 3153.33
Murch X Domalik Buber	9.685	996.667
Murch X Mirch	10.093	1037.778
Murch X No.4791	9.981	1029.259
Domalik Buber X Mirch	9.685	995.926
Domalik Buber X No.4791	9.907	1020.741
Mirch X No.4791	9.981	1028.519
L.S.D 5% (Sij – Sij)	1.170	942.228
L.S.D 1% (Sij – Sij)	1.568	1262.858
L.S.D 5% (Sij – Sik)	1.480	1191.834
L.S.D 1% (Sij – Sik)	1.984	1597.058

Table (5): Manual plotting for parabola limits and regression line, calculated statistics, and tested hypothesis in the diallel pepper crosses for number of galls according to Jinks-Hayman analysis.

Parents	VR	Wr-Parabola	Wr-Regression	
Yellow Wax	2274.77810	2294.81880	2299.25120	
Aswany	106.80953	497.26053	176.70151	
California Wonder	2270.05300	2292.43530	2294.62500	
Murch	0.01587	6.06190	72.14518	
Domalik Buber	0.21693	22.40990	72.34203	
Mirch	0.01587	6.06190	72.14518	
No.4791	0.06878	12.61885	72.19698	
Calculated Statistics		Value		
Regression Coefficient (b)		0.9790	05 ± 0.05	
Intercept (a)		72.	12964	
Parental Mean			31.0	
ean of N ^ 2 Progeny		10	.5102	
Mean of N ^ 2 Progeny - Parental Mea	n	-20.4898		
Variance of Parents ( VoLo )		23	15.037	
Variance of the Means of Arrays VoL	1	227.5462		
Mean Covariance of Arrays With Non	-Recurring Parents (VoLo1)	722.7725		
Mean Variance of Arrays (V1L1)		664.5655		
Tested Hypot	hesis	Calculated t.05	Significance k	
Ho: Wr-Vr is homogenious		0.2795716	ns	
Ho: b = 0 ( not significantly different to	rom zero )	19.21832	**	
Ho: b = 1 (not significantly different f	rom unity )	0.4112386	ns	

k ns = not significant

<sup>\*\* =</sup> significant at 1% level of significance

The regression line of the Vr-Wr manual plotting intersected the Wr axis above the origin (a=72.12964), (Table 5), which indicated partial dominance. The mean of (N<sup>2</sup>) progeny-parental mean) was-20. 4898 Table 5 which indicated the partial dominance toward low number of galls counted on roots of pepper plants after artificial inoculation with root-knot nematode . Furthermore, the sign of h which measured the direction of dominance was positive (+1679.18), (Table 6). This result indicated that dominance acted in the direction of the parent with higher expression of resistance to root knot nematode measured by number of galls on roots of inoculated plants. In addition, the results presented in Table 6 show that the degree of dominance, i.e.,  $(H_1/D)^{1/2}$ , averaged over all loci, was less than 1.0 (0.95) which, indicated very high partial dominance (close to complete dominance) toward high degree of resistance to root knot nematode measured by number of galls . Dalmasso et al. (1985) reported several dominant genes conferring resistance to root-knot nematode in plants of Solanaceae family.

The relative values of the Vr and Wr Table 5 showed that the parental cultivars Murch and Mirch had the lowest values which indicated that these parental cultivars contained the most dominant genes. On the other hand, the parental cultivars Yellow Wax had the highest Vr-Wr values and, hence, contained the most recessive genes. In addition, the high values of Vr-Wr associated with the parental cultivars Yellow Wax and California Wonder were close to each Table 5 which indicate that these cultivars have similar genotypes concerning

Table (6): Estimates of genetic component of variation and heritability values in the diallel pepper crosses for number of galls and number of eggs according to Jinks - Hayman analysis.

Component	No. of galls	No. of eggs
D	2314.74	26049740.00
H <sub>1</sub>	2081.40	22134950.00
H <sub>2</sub>	1747.48	17680260.00
F	1738.56	21132870.00
h	1679.18	18647310.00
$(H_1/D)^{1/2}$	0.950	0.921
H <sub>2</sub> /4H <sub>1</sub>	0.210	0.200
$((4DH_1)^{1/2} + F) / ((4DH_1)^{1/2} - F)$	2.311	2.572
h (N.S)h <sub>ns</sub>	51%	50.3 %
h (B.S)h <sub>bs</sub>	99.9 %	97.8 %

the studied character. However, the parental cultivars Aswany, had a unique intermediate value of Vr-Wr (Table 5). On the other hand, the parental cultivars Murch, Domalik Buber, Mirch, and No. 4791 had, in general, low values of Vr-Wr (Table 5). This result indicate that these four parents had similar genotypes. However, the value of Vr-Wr associated with parent Domalik Buber was relatively little higher than those values associated with parents Murch, Mirch, and No. 4791, (Table 1). These results are supported by the results presented in Table 1, which categorized parental cultivars Yellow Wax California Wonder as "highly susceptible" while the parent Aswany was categorized as "susceptible". Furthermore, the parents Murch, Mirch, No. 4791 were categorized as the "highly resistant" while parent No. 4791 was categorized as "resistant".

According to Jinks-Hayman analysis Table 6 the ratio of H2/4H1 was less than 0.250 which indicates the unequal distribution of alleles which decrease the expression of the character and that which increase it over loci. In addition, the ratio which measured the total numbers of dominant to recessive alleles in all parents, i.e.  $((4DH_1)^{1/2} + F) / ((4DH_1)^{1/2} - F)$ , was > 1.0 (2.311) which indicate that the seven parents used in this study carried more dominant than recessive alleles. This conclusion was supported by the positive value of F (1738.56) which indicated that there were more dominant than recessive alleles in the parents used in this study.

The results presented in Table 6 indicate very high broad sense heritability estimate (99.9%) and above intermediate narrow sense heritability estimate (51.0%) which indicate the

important role for both the additive and non-additive gene action in the inheritance of resistance to root knot nematode measured by number of galls. However, the additive type represent the greatest portion. Souza et.al.,(2002) estimated the broad and narrow sense heritability, using number of galls in evaluation, by 77% and 72%, respectively. It is worth mentioning here that, since the seven parental pepper germplasm used in the present study were chosen and they did not truly represent a random sample of all pepper germplasm, conclusions drawn from the analysis of the present data can be applied only to the seven parents used in this study and their hybrids.

#### 1.1.b. Number of Eggs:

The results presented in Table 1 indicated significant differences among the different parental pepper germplasm concerning number of eggs counted after the artificial inoculation with root knot nematode. The parental germplasm California Wonder had the highest number of eggs (12633.33) followed by Yellow Wax (8266.67), Aswany (1700.00), and Domalik Buber (53.33), (Table 1). While, with the parental germplasm Murch, Mirch, and No.4791, no eggs were found. Using number of eggs as a quantitative criterion for measuring degree of resistance or susceptibility, it can be mentioned that the parental cultivars California Wonder, Yellow Wax and Aswany are susceptible to the root knot nematode. Castagnone et al. (1992) classified the pepper cultivar California Wonder as susceptible. In addition, the criterion of using number of eggs was successful in showing different degrees of susceptibility

among the different susceptible parental germplasm. **Zamora** and Bosland (1994), Peixoto et al. (1995) and Souza et al. (2002) reported that number of eggs was a dependable method for evaluation of resistance to the root-knot nematode in pepper. On the other hand, the other parental germplasm Murch, Mirch, No.4791 and Domalik Buber were resistant, even though the parental germplasm Domalik Buber had very small number of eggs (53.33). All F<sub>1</sub> hybrids which involved one or two resistant parents showed resistance Table 1 which indicate the dominance of resistance to the root knot nematode. Dominance of resistance to root knot nematode in pepper has been reported (Souza et al., 2002).

The results presented in Table 1 indicated significant general and specific combining ability effects. In addition, the ratio GCA/SCA was 4.87. These results indicated the presence of both the additive and non-additive type of gene action. However, the additive type of gene action was more important. Similar results were obtained by Souza et al. (2002) who reported quantitative mode of inheritance for resistance to root knot nematode in pepper, using number of egg masses per root system to evaluate the plants. In addition they indicated the involvement of additive gene action in the inheritance of this character. It is worth mentioning were that different modes of inheritance for resistance to plant parasitic nematode, i.e., monogenic, oligogenic, and polygenic, have been reported in several recent reviews (Sidhu and Webster, 1981; Bingefors, 1982; Fassuliotis, 1987; Roberts, 1990; Simmonds, 1991; Di-

Vito, 1992 and 1993; Fery and Thies, 1998 a and b; Souza et al., 2002).

The parental germplasm which had the highest desirable general combining ability effects were, in descending order, Murch (-1190.212), Mirch (-1189.471), No.4791 (-1180.952), and Domalik Buber (-1148.360), while Aswany had relatively small desirable general combining ability effects (-279.101), (Table 3). These results indicated that these parental germplasm can be considered as good combiners in forming pepper hybrids with high resistance to root knot nematode measured by number of eggs.

The F<sub>1</sub> hybrids which showed the highest desirable specific combining ability effect, in descending order, were California Wonder X No.4791 (-3153.33), California Wonder X Murch (-3144.074), California Wonder X Domalik Buber (-3115.926), California Wonder X Mirch (-3114.815), Yellow Wax X Mirch (-2148.148), Yellow Wax X Murch (-2124.074), Yellow Wax X No.4791 (-2110.000), Yellow Wax X Domalik Buber (-2062.593), (Table 4). These results indicated that the previously mentioned F1 hybrids were characterized by high resistance to root knot nematode measured by number of eggs.

The results presented in Table 7, proved the homogenity of Wr-Vr, which indicated the validity of Jinks-Hayman analysis. Further prove for the validity of these assumptions was indicated by the regression coefficient (b =  $0.9814488 \pm 0.07565601$ ) which was found to be significantly different from zero and not significantly different from 1 (Table 7).

Table (7): Manual plotting for parabola limits and regression line, calculated statistics, and tested hypothesis in the diallel pepper crosses for number of eggs according to Jinks-Hayman analysis.

Parents	VR	Wr-Parabola	Wr- Regression
Yellow Wax	18159654.00	21834728.00	18841750.0000
Aswany	1345562.2500	5943550.00	2339578.5000
California Wonder	28648074.00	27424672.00	29135596,0000
Murch	77.77775	45187.84600	1019054.3100
Domalik Buber	1957.14355	226675.93800	1020898.8100
Mirch	128.57143	58098.63700	1019104.1900
No.4791	395.76724	101932.78100	1019366.4400
Calculate	d Statistics	Va	lue
Regression Coefficient (b)		0.981	4488
Intercept (a)		10189	78.00
Parental Mean		3230	5.19
Mean of N ^ 2 Progeny		1071	.292
Mean of N ^ 2 Progeny - Pare	ental Mean	- 2164	4.898
Variance of Parents ( VoLo )		262535	530.00
Variance of the Means of Ari	rays VoL1	23574	47.00
Mean Covariance of Arrays V (VoLo1)	Vith Non-Recurring Parents	77707	64.00
Mean Variance of Arrays ( V	ILI)	68794	07.00
Tested H	lypothesis	Calculated t . 05	Significance k
Ho: Wr-Vr is homogenious		0.05378999	ns
Ho: $b = 0$ (not significantly d	ifferent from zero )	12.97252	**
Ho: b = 1 (not significantly di	fferent from unity )	0.2452042	ns

k ns = not significant

<sup>\*\* =</sup> significant at 1% level of significance

The regression line of Wr-Vr intersected the Wr axis above the origin Table 7 which indicated partial dominance. In addition, mean of "N^2 progeny-parental mean" was–2164.898 Table 7 which indicated that the partial dominance was toward high resistance expressed by low number of eggs counted on galls found on roots of pepper plants inoculated with root knot nematode. Moreover, the value of h, i.e., +1.865, Table 6 indicated that the dominance acted in the direction of the parent with the higher expression of resistance to the root knot nematode by number of eggs. The degree of dominance measured by  $(H_1/D)^{1/2}$  was less than one (0.921), Table 6, which indicated the high parental dominance toward high degree of resistance to root knot nematode measured by number of eggs.

The relative values of the Vr and Wr Table 7 showed that parent Murch had the lowest values and, therefore, contained the most dominant genes; while parent California Wonder had the highest Vr-Wr values and, hence, contained the most recessive genes. In addition, among the parents which had high values of Vr-Wr and can be considered to have similar genotype, i.e., Yellow Wax, Aswany and California Wonder, the parent Aswany had relatively lower Vr-Wr values (Table 7). Moreover, the parents which had similar genotype, because of having low Vr-Wr values, the parental cultivar Domalik Buber had relatively higher value (Table 7). These results are supported by the results presented in Table 1, whereas parent Aswany was categorized as "susceptible" while the other susceptible parents were categorized as "very susceptible", and parent Domalik Buber was categorized as "resistant" while other

resistant cultivars were categorized as "very resistant". Such differences could be due to the effects of the used nematode race and/or to response of the different parents to the initial population of nematode which was used in artificial inoculation. This conclusion is supported by the findings of Peter et al. (1984), Roberts (1990), Di-Vito et al. (1992), Thies and Fery (2000), and Khan et al. (2002) who reported significant pepper genotype x nematode race interaction. In addition, the initial population densities of root knot nematode required for inducing infection following the artificial inoculation, differed with different pepper germplasm and surrounding environmental condition (Di-Vito, 1986; Khelu et al., 1989; Marwoto, 1989; Di-Vito et al., 1991; Mekete et al., 2003).

The estimated genetic parameters obtained by Jinks-Hayman analysis in Table 6 show that the ratio  $H_2/4H_1$  is equal to 0.200 which indicate the unequal distribution of alleles responsible for the expression of root knot nematode measured by number of eggs over loci (Table 6). In addition, the ratio  $((4DH_1)^{1/2} + F)/((4DH_1)^{1/2} - F)$  was greater than one, i.e., 2.572, which indicate that the involved parental germplasm carried more dominant than recessive alleles. This conclusion is supported by the positive value of F showed in Table 6, i.e., 2.113, which indicated that there were more dominant than recessive alleles in the parental germplasm used in the present study.

The broad and narrow sense heritability estimates were 98.8% and 50.3%, respectively (Table 6). These results

indicated the large influences of the genetic variance on the expression of resistance to the root knot nematode measured by number of eggs. Furthermore, the additive genetic variance component is relatively large comparing to the other types genetic variance components which indicate high progress which can be achieved by selecting individual plants based on their reaction to infection with root knot nematode.

## 1.2. Qualitative Evaluation of Plant Reaction:

Using gall index (GI) and R-factor (Tables B and C), the different plant reactions expressed by the different parental pepper germplasm and its F<sub>1</sub> hybrids and recorded in the present study were highly resistant (HR), resistant (R), susceptible (S), and highly susceptible (HS) (Table 1). The parental pepper germplasm showed various plant reactions, i.e., Yellow Wax (HS), Aswany (S), California Wonder (HS), Murch (HR), Domalik Buber (R), Mirch (HR), and No.4791 (HR). All F<sub>1</sub> hybrids which involved either one or two resistant parent(s) showed certain degree of resistance Table 1, which indicated the dominance of resistance to the root knot nematode over susceptibility. In addition, these results show that the qualitative evaluation for plant reaction of the different parents and its F<sub>1</sub> hybrids which are presented in Table 1, can be considered as a support for the quantitative evaluation for degree of resistance measured by number of galls or number of eggs which are presented in the same (Table 1). Furthermore, the qualitative evaluation for plant reaction to artificial inoculation with root knot nematode was made on quantitative bases, i.e., gall index (GI) and R- factor, which give the qualitative evaluation

presented in Table 1 high accuracy. These results agreed with those of Peter et al. (1984) and Yadav and Mathur (1993), who reported several degrees of resistance and susceptibility to root knot nematode in pepper.

### 2. Field Experiment:

#### 2.1. Root Phenols Content:

The results presented in Table 8 show that root phenols content in the inoculated plants of the parents and its F1 hybrids were higher than that of the uninoculated plants. In addition, the increase percentage of root phenols content due to inoculation were higher in the parents which showed different degrees of resistance, i.e., Murch "highly resistant" (34.96%), Domalik Buber "resistant" (39.35%), Mirch "highly resistant" (29.69 %), and No.4791 "highly resistant" (50.51 %), comparing to parents which showed the highest degree of susceptibility, i.e., Yellow Wax (8.60%) and California Wonder (19.78 %). These results indicated that the high increase in root phenols content of resistant parents after inoculation with root knot nematode act as a defense mechanism. Root phenols content in tomato roots has been reported as a defense mechanism against root knot nematode (Bajaj and Mahajan,1977; Hassan and Saxena, 1977; Wiliski et al., 1977; Okophyi and Sadykin, 1978; Narayana, 1979; El- Sheif et al., 1980; Narayana and Reddy, 1980; Ganguly and Dasgupta, 1982; Bajaj et al., 1983; Okophyi, 1983; Bajaj et al., 1986; Aggour et al., 1998). In addition it has been reported by Sadykin and Okophy (1985), Okophy et al. (1987), and Aggour et al. (1998) that root

Table (8): Means of root phenols content, leaf chlorophyll content (SPAD Reading) and total plant yield for the inoculated and uninoculated plants of different parental genotypes and its F1 hybrids evaluated in field:

					Character				
Genotypes	Root Phen	Root Phenols Content (mg/100g.f.w)	g/100g.f.w)	Leaf	Leaf Chlorophyll Content	ontent	Plan	Plant Total Yield (gm)	E)
	Inoculated	Uninoculated	Increase%	Inoculated	Uninoculated	Decrease%	Inoculated	Uninoculated	Decrease%
Yellow Wax	19.93	18.17	8.60	51.53	58.47	12.04	625.00	1000.00	37.51
Yellow Wax X Aswany	20.23	19.80	2.41	64.23	67.23	1+'+	783.33	1341.67	19.61
Yellow Wax X California Wonder	18.20	16.50	10.38	60.27	68.93	12.57	450.00	1183.33	12.12
Yellow Wax X Murch	21.80	19.37	12.64	62.07	26.60	9.65	1816.67	1833.33	-3.52 "
Yellow Wax X Domalik Buber	24.33	16.97	43.80	67.30	68.20	1.31	1300.00	1290.00	1.98
Yellow Wax X Mirch	22.30	17.47	27.57	60.23	57.70	-4.39"	1150.00	1133.33	-3.91 W
Yellow Wax X No.4791	24.10	13.73	76.46	63.57	63.80	0.28	1166.67	1163.33	10.64
Aswany	23.50	18.03	30.52	57.73	60.13	4.02	508.33	508.33	11.00
Aswany X California Wonder	19.17	16.43	18.94	58.73	59.73	1.07	625.00	858.33	14.08
Aswany X Murch	23.07	14.47	59.76	61.90	62.70	1.17	958.33	2911.67	1.92
Aswany X Domalik Buber	22.13	17.13	29.34	62.13	61.87	-0.43 "	758.33	766.67	-1.33 "
Aswany X Mirch	22.50	14.83	51.62	64.33	64.03	- 0.21 "	641.67	616.67	-0.28 "
Aswany X No.4791	22.57	17.63	28.12	06.19	61.83	-0.14 w	741.67	783.33	4.35
California Wonder	17.80	14.87	19.78	54.47	61.40	11.28	425.00	768.33	29.39
California Wonder X Murch	22.93	14.23	61.14	59.67	57.97	" 16.1 -	1491.67	1466.67	-1.77 "
California Wonder X Domalik Buber	23.70	14.73	60.95	69.03	66.83	- 3.35 W	1358.33	1350.00	1.15
California Wonder X Mirch	21.80	15.53	41.33	61.73	62.63	17.1	1333.33	1341.67	0.24
California Wonder X No.4791	22.20	15.00	48.17	62.50	60.47	-3.33 "	1200.00	1211.67	4.23
Murch	23.20	17.20	34.96	57.03	57.23	0.45	766.67	758.33	1.18
Murch X Domalik Buber	20.30	15.60	30.29	65.00	65.53	0.21	1366.67	1366.33	1.89
Murch X Mirch	19.47	13.07	90.64	57.23	57.27	0.54	1183,33	1233.33	-0.17 w
Murch X No.4791	21.70	14.60	48.65	62.57	62.93	0.58	1191.67	1175.00	-3.29 W
Domalik Buber	22.10	15.87	39.35	69.27	06.89	- 0.15 W	741.67	758.33	2.02
Domalik Buber X Mirch	21.50	17.83	20.89	68.33	68.27	- 0.11 W	1108.33	1113.33	5.07
Domalik Buber X No.4791	21.03	17.83	18.26	64.13	64.90	1.15	1058.33	1091.67	3.52
Mirch	21.57	14.97	29.69	59.83	60.23	131	766.67	800.00	4.78
Mirch X No.4791	22.07	14.40	17.51	61.93	58.83	- 0.61 W	1141.67	1200.00	0.77
No.4791	21.83	14.40	50.51	62.70	61.80	0.00	1325.00	1371.67	13.69
L.S.D 5%	1.69	1.36	15.08	2.32	1.90	3.51	68.21	90.27	17.54
L.S.D 1%	2.26	1.82	20.20	3.10	2.55	4.70	90.94	120.96	25.06

"These negative values were considered as zero, .i.e., no change has occurred in leaf chlorophyll content, or plant total yield due to inoculation with root knot nematode.

phenols content is a dependable method for differentiating susceptible and resistant cultivars in tomato. Eventhough, the parental genotype Aswany showed relatively low degree of susceptibility to root knot nematode susceptible (Table 8), inoculation resulted in relatively high increase in root phenols content (30.52 %), (Table 8). These results indicated that the activation of this defense mechanism which occurred in the plants of the susceptible parent Aswany, resulted in less degree of susceptibility, i.e., susceptible, comparing to the degree of susceptibility showed by other susceptible parents which was higher, i.e., highly susceptible. Furthermore, the number of galls and number of eggs counted in case of the susceptible parent Aswany were less than those counted in case of the other susceptible parental cultivar, i.e., Yellow wax and California wader. In addition, these results indicated also that the increase in root phenols content in pepper plants upon inoculation or infection with root knot nematode was not the only defense mechanism against this nematode. This conclusion agreed with what has been reported by Giebel (1974) who pointed out the possibility of the presence of other defense mechanisms against root knot nematode in plants.

The results presented in Table 9, indicated significant differences between the different parents, F<sub>1</sub> hybrids, and parents versus F<sub>1</sub> hybrids, concerning the defense mechanism of increasing root phenols content upon inoculation or infection with root knot nematode. The parent No.4791 had the highest increase percentage of root phenols after inoculation (50.51%) while the F<sub>1</sub> hybrids which exceeded the highest parent in this

decrease, due to inoculation with root knot nematode for the plants of the different parental genotypes Table (9): Mean squares of percentage of root phenols increase, leaf chlorophyll decrease and total plant yield and its F1 hybrids in field experiment.

Source of variance         df         Root Phenols Increase (%)         Leaf Chlorophyll Decrease (%)           Genotypes         27         1008.883"         51.254"           Parents         6         546.757"         84.054"           Parents         20         1159.338"         33.757"           Parents vs. Hybrids         1         772.555"         204.757"           Error         54         84.592         4.570           General combining ability (GCA)         6         357.991"         29.263"           Specific combining ability (SCA)         21         330.096"         13.605"           Error         54         28.197         1.523           Error         1.084         2.150					
s vs. Hybrids	Some of variance	Jp	Root Phenols Increase(%)	Leaf Chlorophyll Decrease (%)	Total Plant Yield Decrease(%)
s vs. Hybrids   27   1008.883   18   15   15   18   18   18   18   18	Source of variance			s1.254**	009.209
6 546.757"  8 xs. Hybrids  ombining ability (GCA)  ombining ability (SCA)  21 330.096"  54 28.197  54 28.197	Senotroes	27	1008.883	107.10	***************************************
20 1159.338" 1 772.555" 54 84.592 6 357.991" 51 330.096" 54 28.197 1.084		9	546.757**	84.054**	559.941
20 1139.538 1 772.555** 54 84.592 6 357.991** 21 330.096** 54 28.197 1.084	Parents		***************************************	33 757**	592.259**
1 772.555** 54 84.592 6 357.991** 51 330.096** 54 28.197 1.084	Hybrids	20	1159.558		***
54 84.592 6 357.991** 21 330.096** 54 28.197 1.084	TI-builde	-	772.555**	204.757**	1200.385
54 84.592 6 357.991" 21 330.096" 54 28.197 1.084	Parents vs. Hybrius			4 570	163.535
6 357.991" 21 330.096" 54 28.197 1.084		54	84.592		**
21 330.096** 54 28.197 1.084	Error		257 091**	29.263**	448.283
21 330.096** 54 28.197 1.084	General combining ability (GCA)	0	1777166	# # # # # # # # # # # # # # # # # # #	127 310**
54 28.197	(A)39	21	330.096**	13.605	115.251
54 28.197	Specific combining abunty (SCA)			1 573	54.512
1.084		54	28.197	0.70.1	
1.084	Error			2 150	3.387
SOC ACTOR	478/ 470		1.084		
	GCA / SCA				

\*\* Significant at 1% level of significance

respect were, in decreasing order, Yellow Wax X No.4791 (76.46 %), California Wonder X Murch (61.14%), California Wonder X Domalik Buber (60.95 %), Aswany X Murch (59.76%) and Aswany X Mirch (51.62%). One resistant parent was involved in all of the previously mentioned F<sub>1</sub> hybrids. On the other hand, the F<sub>1</sub> hybrids which showed very low increase percentage of root phenols content after inoculation involved two susceptible plants, i.e., Yellow Wax X Aswany (2.41%) and Yellow Wax X California Wonder (10.58 %) (Table 8). These results indicated the possibility of forming pepper hybrids which have high expression of this defense mechanism.

The results presented in Table 9 show significant general (GCA) and specific (SCA) combining abilities and the GCA/SCA ratio was relatively 1.10 which indicates that the additive type of gene action was more important than the non- additive type in the inheritance of this defense mechanism. These results give an indication for the possibility of improving this character through selection in the segregating generations of pepper crosses made in the present study. The results presented in Table 10 show that the parents which had the highest desirable general combining ability effects were, in descending order, No.4791 (9.14), Murch (5.06), and Mirch (1.27). These parents were classified as highly resistant to root knot nematode (Table 1). These results indicated that the parents which possess the defense mechanism of increasing the root phenols content upon infection with root knot nematode and classified as highly resistant can be considered as good combiners to form pepper hybrids which are resistant to the root knot nematode

Table (10): General combining ability effects (gi) for percentages of root phenols content increase, leaf chlorophyll content (SPAD Reading) decrease and total plant yield decrease, due to inoculation with the root knot nematode for the different parental genotypes in field experiment.

		Character	
Genotypes	Root Phenols Increase(%)	Leaf Chlorophyll Decrease(%)	Plant Yield Decrease(%)
Yellow Wax	-10.606	3.013	11.927
Aswany	-3.854	0.232	2.826
California Wonder	- 0.605	1.911	5.686
Murch	5.060	- 1.076	-6.820
Domalik Buber	- 0.409	-1.414	-5.399
Mirch	1.273	- 1.260	-5.958
No.4791	9.141	-1.406	-2.262
L.S.D 5%	3.291	0.765	3.828
L.S.D 1%	4.408	1.025	5.468

The F<sub>1</sub> hybrid which showed the highest desirable specific combining ability effect (42.19) was Yellow Wax X No.4791 (Table, 11). This pepper hybrid will perform well in areas infested with root knot nematode. Several F<sub>1</sub> hybrids expressed better parent heterosis concerning carrying the defense mechanism of increasing root phenols content upon infection with the root knot nematode (Table 12). The F<sub>1</sub> hybrids which had the highest percentage of root phenols content increase following artificial inoculation with the root knot nematode, measured by better parent heterosis were Yellow Wax X No. 4791 (51.39%), Aswany X Murch (70.95%), Aswany X Mirch (69.16%), California Wonder X Murch (74.88%), and California Wonder X Domalik Buber (54.90%). Such F<sub>1</sub> hybrids will Perform well in areas where infection with root knot nematode is likely to occur.

The results presented in Table 13 indicated the uniformity of Wr-Vr. In addition, the regression coefficient (b) for Wr and Vr was 0.5331801 and proved to be not significantly different from 1 (Table 13) which indicated the validity of the assumptions required for Jinks-Hayman analysis

Concerning the statistics needed for the genetic interpretation using the Jinks-Hayman's diallel analysis, the ratio  $H_2/4H_1$  is the estimate of uv where u refer to the frequency of alleles which increase the mean expression of character and are situated at loci which exhibited dominance, while v refer to the frequency of alleles at loci that decrease the expression of the character. When u = v = 0.5, then  $H_1 = H_2$  and the value of uv, i.e.,  $H_2/4H_1$  will reach its maximum value 0.25. Since the

Table (11): Specific combining ability effects (Sij) of the different F1 hybrids for percentages of root phenols content increase, leaf chlorophyll content (SPAD Reading) decrease and total plant yield increase, due to inoculation with the root nematode in field experiment.

TOTAL			
		Character	plott Viold
Genotypes	Root Phenols Content	Leaf Chlorophyll Content Decrease(%)	Decrease(%)
	Increase(70)	C1.E.O.	26.741
- 8	-18.87	-0.512	16,694
Yellow Wax X Aswany	-1415	6.169	CVE 21
Yellow Wax X California Bonder	35 7.1	-2.76	-10.743
Yellow Wax X Murch	0000	-1.76	-12.663
Vollow Wax X Domalik Buber	19.08	-7616	-17.988
Tenow was X Mirch	1.16	008 6	-7.134
ellow way with 4701	42.19	000:7-	-2.542
Yellow Wax X No.4/91	12.34	-2.553	-2 202
Aswany X California Wonder	22.82	0.538	2027
Aswany X Murch	513	- 0.728	0.000
Aswany X Domalik Buber		- 0.661	757.5-
Acrony X Mirch	19.47	- 0 442	- 4.327
N No. 4701	-12.91	300 1	-8.753
Aswany A 100.4/21	20.94	4.223	-7.253
- 3	26.23	- 5.320	109.7-
California Wonder X Domain Duoci	4.93	- 0.717	19301
California Wonder X Mirch	3 80	-5.311	105.01-
California Wonder X No.4791	2000	1.223	000.9
Murch X Domalik Buber	-10.10	1 397	4.499
Murch X Mirch	96.9	1 583	-2.321
Viaita V No 4791	-1.29	880 -	8.312
Murch A No. 7/2	-15.72	000.1	3.065
Domaiik Buber A Milicii	-26.21	2.497	0.873
Domalik Buber A No.4/71	1.36	1.800	13 075
Mirch X No.4791	11.24	2.612	017.00
L.S.D 5% (Sij-Sij)	90 51	3.499	8.0/8
L.S.D 1% (Sij-Sij)	20.51	3.305	16,538
L.S.D 5% (Sij-Sik)	77:+1	4.427	23.626
T C D 10% (Sii-Sik)	19:09		

Table (12): Percentage of better parent-heterosis in the  $F_1$  generation over better parents for percentage of root phenols content increase, leaf chlorophyll content (SPAD Reading) decrease, and total plant yield decrease, due to inoculation with the root knot nematode for the different  $F_1$ hybrids.

	Better	r Parent Hetero	sis %
Genotypes	Root Phenols Increase %	Leaf Chlorophyll Decrease %	Total Plant Yield Decrease %
Yellow Wax X Aswany	- 92.09	63.38	32.24
Yellow Wax X California Wonder	- 47.52	4.37	13.08
Yellow Wax X Murch	- 63.85	- 94.58	- 109.39
Yellow Wax X Domalik Buber	11.32	- 89.09	- 94.73
Yellow Wax X Mirch	- 7.16	- 136.42	- 110.41
Yellow Wax X No.4791	51.39	- 97.65	- 71.63
Aswany X California Wonder	- 37.94	- 90.54	- 52.09
Aswany X Murch	70.95	- 70.90	- 82.57
Aswany X Domalik Buber	- 25.43	- 110.78	- 112.13
Aswany X Mirch	69.16	- 105.31	- 102.13
Aswany X No.4791	- 44.33	- 103.48	- 68.23
California Wonder X Murch	74.88	- 116.97	- 106.03
California Wonder X Domalik Buber	54.90	- 129.68	- 96.10
California Wonder X Mirch	39.20	- 87.50	- 99.18
California Wonder X No.4791	- 4.63	- 129.50	- 96.00
Murch X Domalik Buber	-23.04	- 52.98	- 55.28
Murch X Mirch	40.34	- 59.03	- 103.49
Murch X No.4791	- 3.67	29.10	- 124.03
Domalik Buber X Mirch	- 46.92	- 108.40	6.07
Domalik Buber X No.4791	- 63.84	6.69	- 74.31
Mirch X No.4791	-5.93	- 53.44	- 94.40
S.D 5%	13.06	3.04	15.19
L.S.D 1%	17.49	4.07	21.70

Table(13): Manual plotting for parabola limits and regression line, calculated statistics, and tested hypothesis in the diallel pepper crosses for root phenol contents according to Jinks-Hayman analysis.

Parents	VR	Wr-Parabola	Wr- Regression
Yellow Wax	691.19330	354.92297	278.78027
Aswany	370.76855	259.94751	75.89369
California Wonder	438.46597	282.68454	118.75836
Murch	303.98306	235.37427	33.60645
Domalik Buber	217.14031	198.93189	- 21.38065
Mirch	146.63493	163.47560	- 66.02325
No.4791	341.43930	249.45430	57.32300
Calculated Statistics		Value	
Regression Coefficient (b)		0.6331801	
Intercept (a)		- 158.8696	
Parental Mean		30.48809	
Mean of N ^ 2 Progeny		36.49055	
Mean of N ^ 2 Progeny - Parental Mean		6.002453	
Variance of Parents ( VoLo )		182.2504	
Variance of the Means of Arrays VoL1		42.56709	
Mean Covariance of Arrays With Non- Recurring Parents (VoLo1)		68.13682	
Mean Variance of Arrays (V1L1)		358.5179	
Tested Hypothesis		Calculated t. 05	Significance k
Ho: Wr-Vr is homogenious		0.3096354	ns
Ho: b = 0 ( not significantly different from zero )		2.185534	ns
Ho: b = 1 (not significantly different from unity)		1.266144	ns

 $<sup>^{</sup>k}$  ns = not significant

value of the ratio  $H_2/4H_1$  did not reach the maximum value, i.e., 0.238 Table 14, it can be indicated that the positive and negative alleles at these loci are not in equal proportion in the parents. The estimate of the ratio  $((4DH_1)^{1/2}+F)/((4DH_1)^{1/2}-F)$ , was 1.127 which measure the total numbers of dominant to recessive alleles in all parents indicating that the parents used for this study carried more dominant than recessive alleles. This conclusion was supported by the positive value of F, i.e., 52.930, Table 14, which indicated that there were more dominant than recessive alleles in the used parents. Furthermore, the positive value of h (+ 130.738) indicated that dominance acted in the direction of the parents with the higher expression of root phenols content increase percentage, after inoculation with root knot nematode.

The estimate of  $(H_1/D)^{1/2}$ , which measures the degree of dominance, was more than one (i.e., 2.863) indicating over dominance for the higher expression of this defense mechanism, i.e., the high increase in percentage of root phenols content after inoculation or infection with root knot nematode. This result is supported by the regression analysis of Wr and Vr whereas the regression line intersected the Wr axis below the origin, i.e., a = -158.8696 Table 13 which indicate overdominance for this character. In addition, the values of (mean of N^2 progeny parental mean)was 6.002453, which indicated the direction of over dominance toward high level of root phenol content after inoculation with root knot nematode.

Table (14): Estimates of genetic components of variation and heritability values for percentages of root phenols content increase and leaf chlorophyll content (SPAD Reading) decrease, due to inoculation with root knot nematode, according to Jinks-Hayman analysis.

Component	Root Phenols Content Increase(%)	Leaf Chlorophyll Content Decrease(%)
D	154.933	26.516
$\mathbf{H}_1$	1269.63	47.906
$H_2$	1209.17	43.352
F	52.930	21.532
h	130.738	37.401
$(H_1/D)^{1/2}$	2.863	1.344
H <sub>2</sub> /4H <sub>1</sub>	0.238	0.226
$((4DH_1)^{1/2} + F)/((4DH_1)1/2 - F)$	1.127	1.866
h <sub>ns</sub>	19.8%	27.9%
h <sub>bs</sub>	93.4%	91.2%

The parent Yellow Wax had the highest relative value of Vr and Wr while the parent Mirch had the lowest value (Table 13). These results indicated that the parental cultivar Yellow Wax had the most dominant genes while the parental cultivars Mirch had the most recessive genes.

The broad (h<sub>bs</sub>) and narrow (h<sub>ns</sub>) sense heritability estimates were 93.4 % and 19.8 %, receptively, (Table 14). The relatively low value of the narrow sense heritability estimate indicated the involvement of the non-additive and environmental effects on the expression of this character. According to these results, selection for lines or hybrids carrying the defense mechanism of plant ability to increase root phenols content upon infection with root knot nematode, should be performed in replicated experiments to eliminate as much as possible the environmental effects on the expression of this character. No reports have been found on the genetics and inheritance of root phenols content in pepper.

# 2.2. Leaf Chlorophyll Content (SPAD R reading):

The results presented in Table 8 indicate significant differences among the pepper germplasm concerning leaf chlorophyll content (SPAD Reading) under the condition of artificial inoculation with root knot nematode. In addition, the parental germplasm which have been previously categorized as susceptible, i.e., Aswany, or as highly susceptible, i.e., Yellow Wax and California Wonder Table 1, had higher chlorophyll leaf content (SPAD Reading) under nematode free conditions

than that recorded for the same genotypes under the condition of artificial inoculation with root knot nematode (Table 8). On the other hand, in the case of parental germplasm which have been previously categorized in Table 1 as resistant, i.e., Domalik Buber, or as highly resistant, i.e., Murch, Mirch, and No.4791, the chlorophyll leaf content (SPAD Reading) of the nematode free plants and nematode infected plants were very close to each other (Table 8). These results indicated that chlorophyll leaf content (SPAD Reading), which is essential for photosynthesis had been affected by infection with root knot nematode and can be used as a criterion to evaluate resistance or susceptibility to root knot nematode in pepper. These results were supported by the value of chlorophyll leaf content (SPAD Reading) decrease percentages calculated for the different parental germplasm and its F<sub>1</sub> hybrids (Table 8). The percentage of chlorophyll leaf content (SPAD Reading) decrease, due to artificial inoculation with root knot nematode, associated with the susceptible or highly susceptible parents were 12.04 %, 4.02 % and 11.28 % for Yellow Wax (highly susceptible), Aswany (susceptible) and California Wonder (highly susceptible), respectively (Table 1). On the other hand the parental germplasm Murch (highly resistant), Domalik Buber (resistant), Mirch (highly resistant) and NO.4791 (highly resistant) had very low leaf chlorophyll decrease percentages, i.e., 0.45 %, 0.15 %, 1.31 % and 0.00 %, respectively (Table 8). In addition, the F<sub>1</sub> hybrids Yellow Wax X Aswany (susceptible) and Yellow Wax X California Wonder (highly susceptible) had percentages of 4.41% and 12.57% decrease in leaf chlorophyll content (SPAD Reading) due to inoculation with the root knot nematode, respectively. However,

the F<sub>1</sub> hybrid Aswany X California Wonder (susceptible) showed relatively low percentage chlorophyll leaf content (SPAD Reading) decrease (1.07 %), (Table 8). This could be due to the involvement of the parental cultivar Aswany which showed relatively lesser degree of susceptibility (i.e., susceptible) comparing to the reaction showed by other susceptible parental germplasm (i.e., highly susceptible). On the other hand, the other F<sub>1</sub> hybrids showed different degrees of resistance had low percentages of chlorophyll leaf content (SPAD Reading) which ranged from 0.00 % to 1.41 %, (Table 8). These results supported the previously mentioned conclusion, since it indicated that decrease percentage of chlorophyll leaf content (SPAD Reading), due to infection with root knot nematode, can be used as a criterion to evaluate resistance or susceptibility of pepper germplasm to the root knot nematode.

Using percentage of chlorophyll leaf content (SPAD Reading) reduction due to artificial inoculation with root knot nematode as a criterion for evaluating degree of resistance or susceptibility expressed by the different parental pepper germplasm and its F<sub>1</sub> hybrids, significant general and specific combining ability effects were detected (Table 9). These results indicate the presence of both the additive and non-additive type of gene action in the inheritance of this character. However, the additive type of gene action was more important since GCA/SCA ratio was 2.15.

The results presented in Table 10 show that the parental pepper germplasm Murch, Domalik Buber, Mirch, and

No.4791 had significant desirable general combining ability effects, i.e.,—1.08, -1.41, -1.26 and -1.41, respectively, which indicate that these parental germplasm can be used to form  $F_1$  hybrids which express resistance to the deterioration which occurs in leaf chlorophyll content (SPAD Reading) of pepper plant after infection with the root knot nematode.

The highest specific combining ability effects were expressed by the F<sub>1</sub> hybrids Yellow Wax X Mirch (-7.62), California Wonder X Domalik Buber (-5.32), and California Wonder X Murch (-4.23), (Table 11). Chlorophyll leaf content (SPAD Reading) of the plants of such F<sub>1</sub> hybrids will not deteriorate under nematode infection which will keep the photosynthesis rate almost normal, which may be help the plants to tolerate the infection. The F<sub>1</sub> hybrids which expressed resistance to leaf chlorophyll content (SPAD Reading) deterioration upon infection with root knot nematode, measured by percentage of better parent heterosis, were Yellow Wax X Mirch (-136.42%), Aswany X Domalik Beber (-110.78%), Aswany X Mirch (-105.31%), Aswany X No.4791(-116.97%), California Wonder X Domalik Beber (-129.68%), California Wonder X Mirch(-129.53%), and Domalik Beber X Mirch (-108.40%), (Table 12). Such F<sub>1</sub> hybrids will keep enough level of biological efficiency under the condition of infection with root knot nematode.

The decrease percentages of chlorophyll leaf content (SPAD Reading) due to infection with root knot nematode which have been calculated for the different parental pepper germplasm and its  $F_1$  hybrids were analyzed using Jinks-

Hayman's method. Since the value of  $H_2/4H_1$  was less than 0.250 (i.e. 0.226), Table 14, it can be concluded that the positive and the negative alleles at the loci exhibiting dominance in the involved parents were not in equal proportions. Moreover, since the value of  $((4DH_1)^{1/2} + F) / ((4DH_1)^{1/2} - F)$  was 1.886 Table 14, it can be assumed that the seven parental pepper germplasm used in the present study carried more dominant than recessive alleles. In addition, the positive value of F (+21.532) is a further proof that there were more dominant than recessive alleles in the involved parents. Moreover, the sign and value of h (i.e.,+37.401), Table14, indicated the involvement of dominance effects in the inheritance of this character.

The value of  $(H_1/D)^{1/2}$  was 1.344 (Table 14). In addition, the regression line of Vr and Wr intersected the Wr below the origin since the value of the intercept (a) was -4.281174 (Table 15). Furthermore, the value of (mean of N^2 progeny-parental mean) was -3.087755 (Table 15). These results indicated overdominance of resisting the chlorophyll leaf content (SPAD Reading) deterioration after exposing pepper plants to nematode infection.

The parental cultivar California Wonder had the highest relative value of Wr-Vr while the parental cultivar Murch had the lowest value (Table 15), which, indicated that parental cultivar California Wonder had the most recessive genes and the parental cultivar Murch, had the most dominant genes. In addition the proximity of parents Yellow Wax and California Wonder in the manual plotting of Wr-Vr Table 15 indicated that these parents belong to the same genotype concerning this

Table(15): Manual plotting for parabola limits and regression line, calculated statistics, and tested hypothesis in the diallel pepper crosses for leaf chlorophyll content (SPAD Reading) according to Jinks-Hayman analysis.

Parents	VR	Wr-Parabola	Wr- Regression
Yellow Wax	40.11655	33.52592	30.96263
Aswany	4.07052	10.67933	- 0.70507
California Wonder	44.88659	35.46314	35.15328
Murch	0.98626	5.25671	- 3.41471
Domalik Buber	2.39336	8.18885	- 2.17852
Mirch	3.92719	10.48963	- 0.83099
No.4791	2.18687	7.82762	- 2.35994
Calculated Statistics		Value	
Regression Coefficient (b)		0.8785353	
Intercept (a)		- 4.281174	
Parental Mean		4.178095	
Mean of N ^ 2 Progeny		1.09034	
Mean of N ^ 2 Progeny - Parental Mean		- 3.087755	
Variance of Parents (VoLo)		28.01804	
Variance of the Means of Arrays VoL1		2.491792	
Mean Covariance of Arrays With Non-Recurring		8.089523	
Parents (VoLo1)		14.08105	
Mean Variance of Arrays (V1L1)			
Tested Hypothesis		Calculated t. 05	Significance k
Ho: Wr-Vr is homogenious		1.109886	ns
Ho: b = 0 ( not significantly different from zero )		10.20415	**
Ho: b = 1 (not significantly different from unity)		1.410807	ns

k ns = not significant

<sup>\*\* =</sup> significant at 1% level of significance

character. On the other hand, the parent Aswany had relatively distant point on the manual plotting of Wr-Vr from those of the previously mentioned parents, i.e., Yellow Wax and California Wonder Table 15, which indicated that parent Aswany had a unique genotype comparing to genotypes of Yellow Wax and California Wonder. These results are supported by the results recorded in Table 1, whereas parents Yellow Wax and California Wonder, were classified as "highly susceptible" to the root knot nematode while Aswany was classified as "susceptible".

The broad and narrow sense heritability estimates for resistance to chlorophyll leaf content (SPAD Reading) deterioration after infection with root knot nematode were 91.2 % and 27.9 %, respectively (Table 14). These results indicated that selection for this character in the segregating generations of the crosses made in the present study should be preformed in replicated experiments to avoid as much as possible the effects of environmental conditions on the expression of this character.

#### 2.3. Total Plant Yield:

The results presented in (Table 8), indicated that total plant yield of the different parents and F<sub>1</sub> hybrids under the condition of artificial inoculation was less than total plant yield recorded for the same genotypes under nematode free condition. In addition, the different parents and F<sub>1</sub> hybrids showed significant differences concerning plant yield loss due to inoculation with root knot nematode (Table 9). Plant yield loss percentage of parents which had been previously evaluated as

highly susceptible Table, 1, i.e., Yellow Wax and California Wonder were higher (i.e., 37.51% and 29.39%, receptively) than percentages recorded for plants of parents which had been classified as resistant, i.e., Domalik Buber (2.02 %), or as highly resistant, i.e., Murch (4.22%), Mirch (4.78%) and No.4791 (13.69%), (Table 8). The low percentage of yield loss indicate the resistance or tolerance of the pepper germplasm associated with these low percentages. However, no significant difference between percentage of yield loss of parent Aswany (11.00%) which had been previously classified as susceptible Table 1 and percentages recorded for resistance or highly resistant parents. It is worth mentioning here that parent Aswany was classified as susceptible based on the appearance of symptoms caused by root knot nematode 45 days after inoculation using R-factor and gall index (see material and methods), a criterion used by plant pathologists. Eventhough this criterion is accurate, it dose not consider plant yield or plant yield loss under the condition of infection with the root knot nematode. Thus, based on the results of the present study, plant reaction to inoculation with root knot nematode using the R-factor and gall index (GI) should be considered as well as plant performance, i.e., yield loss percentage due to infection with root knot nematode, to avoid ignoring the tolerance of the evaluated pepper germplasm. It is suggested that the best method to evaluate the practical resistance or tolerance of germplasm to the root knot nematode is to use percentage of yield loss after inoculation with root knot nematode. These results agreed with that of Thomas and Cardenas (1985), Di-Vito et al. (1983), and Thies et al. (1997and 1998) who used yield loss of pepper plants as a criterion for measuring susceptibility or resistance of pepper plants to root knot nematode. Using percentage of yield loss instead of total plant yield under the condition of inoculation with root knot nematode is better because the former method ignore the difference in yielding capacity of the evaluated germplasm (Aggour et al. 1998). Thus, the parents Aswany can be classified as tolerant using the previously suggested realistic criterion, i.e., percentage of total plant yield loss due to inoculation with root knot nematode.

Several F<sub>1</sub> hybrids gave negative value when calculating percentage of yield loss due to inoculation with root knot nematode (Table 8). These negative values were considered as zero, meaning that these F<sub>1</sub> hybrids, i.e., Yellow Wax X Murch, Yellow Wax X Mirch, Aswany X Domalik Buber, Aswany X Mirch, California Wonder X Murch, Murch X Mirch, and Murch NO.4791, showed the highest degree of tolerance or yield stability under the condition of artificial inoculation with the root knot nematode. In addition, some other F<sub>1</sub> hybrids had very small percentage of yield loss., i.e., Yellow wax X Domalik Buber (1.98%), Aswany X Murch (1.92%), California Wonder X Domalik Buber (1.15 %), California Wonder X Mirch (0.24 %), California Wonder X No.4791 (1.18 %), Murch X Domalik Buber (1.89%), and Mirch X No.4791 (0.77%), (Table 8), which indicated that these F<sub>1</sub> hybrids carried high degree of tolerance to root knot nematode.

The results presented in Table 9 indicated the significance of general and specific combining ability effects indicating the presence of both the additive and non- additive

type of gene action in the inheritance of this character. However, the additive type of gene action was more important since the GCA/SCA exceeded the unit (3.39), (Table 9).

The results presented in Table 10 indicated that the parental genotypes which had the highest desirable general combining ability effects were, in descending order Murch (-6.82), Mirch (-5.96), Domalik Buber (-5.40), and No. 4791 (-2.26). These parents can be considered as good combiners to form pepper hybrids with high degree of tolerance to root knot nematode.

The F<sub>1</sub> hybrids which showed the highest desirable specific combining ability were, in descending order, Yellow Wax X Mirch (-17.98), Yellow Wax X Murch (-16.74), California Wonder X Murch (-8.75), California Wonder X Mirch (-7.60), California Wonder X Domalik Buber (-7.25) and Yellow Wax X No.4791 (-7.13), (Table 11). These F1 hybrids will perform well in areas where infection with root knot nematode is likely to occur, since these hybrids will then tolerate that infection and give reasonable yield under such condition. The F<sub>1</sub> hybrids which had the highest values of better parent heterosis respecting percentage of total plant yield decrease, due to inoculation with root knot nematode, were Yellow Wax X Murch (-109.39%), Yellow Wax X Mirch (-110.41%), Aswany X Domalik Buber (-112.13%), Aswany X Mirch (-102.13%), California Wonder X Murch (-106.03%), Murch X Mirch (-103.49%) and Murch X No.4791(-124.03%), (Table 12). Such F<sub>1</sub> hybrids will perform well in areas where infection with root knot nematode is likely to occur.

The results presented in Table 16 showed that Wr-Vr was not uniform which indicated absence of one or more of the assumptions required for validity of Jinks-Hayman analysis for percentage of plant yield loss.

Since the Jinks–Hayman analysis was not valid, the broad and narrow sense heritability estimates were calculated using genetic components obtained from Griffing analysis. The broad and narrow sense heritability values were 54.27% and 25.73%, respectively (Table 17). These results indicated that percentage of plant yield decrease due to infection with root knot nematode was influenced greatly by environmental and non-additive gene action. Based on these findings, selection for resistance to root knot nematode in pepper, using low percentage of plant yield loss under the condition of artificial inoculation with the root knot nematode as a criterion, should be performed in replicated experiments on family mean basis.

# 2.4. Detached Leaves Fresh Weight / plant:

The results presented in Table 18 indicate that leaves fresh weight of the parental genotypes or hybrids which showed high susceptibility, i.e., Yellow Wax, California Wonder, Yellow Wax X Aswany, Yellow Wax X California Wonder, or Aswany X California Wonder expressed obvious differences between the inoculated and the uninoculated plants whereas leaves fresh weights were higher in case of the uninoculated plants comparing to those of the inoculated plants. On the other hand, in case of the parental genotypes or hybrids which showed less degree of susceptibility, i.e., Aswany or different

Table (16): Tested hypothesis in the diallel pepper crosses concerining percentage of total plant yield decrease for validity of Jinks-Hayman analysis.

Tested Hypothesis	Calculated t.05	Significance k
Ho: Wr-Vr is homogenious	3.741188	**
Ho: b = 0 ( not significantly different from zero)	7.812023	**
Ho: b = 1 (not significantly different from unity)	4.874788	**

<sup>\*\* =</sup> significant at 1% level of significance

Table (17): Broad and narrow sense heritability estimates calculated using Grifing analysis for persentage of plant yield decrease and detched leaf fresh weight/plant under the condition of inoculation with the root knot nematode.

Character	Herita	bility %
	Broad sense (h <sup>2</sup> <sub>bs</sub> )	Narrow sense (h <sup>2</sup> <sub>ns</sub> )
Total Plant Yield Decrease %	54.27	25.73
Detached Leaves Fresh Weight / Plant	66.34	32.80

Table (18): Mean of detached leaves fresh weight/plant and root fresh weight/plant for the inoculated and uninoculated plants of the different parental genotypes and its F1hybrids evaluated in the field experiment.

	Detached Leav	Detached Leaves Fresh Weight/Plant(g)	Root Fr	Root Fresh Weight/Plant(g)
Genotypes	Dota care	Potolingerini	Inoculated	Uninoculated
	Inoculated	Ollinoculated	11.11	31.67
11. 11.	143.33	220.00	65.67	00 001
· I	375.00	475.00	105.00	100.00
Yellow Wax X Aswany	50.575	408 33	30.00	66.67
Vellow Wax X California Wonder	308.33	25.557	71.67	70.00
Vollow Wax X Murch	266.67	7000.07	71.67	70.00
Chon Was V Damelit Buhar	283.33	303.33	10:17	00 59
Yellow wax A Domain Duber	333.33	325.00	/0.00	20.00
Yellow Wax A Mirch	433.33	450.00	73.33	00.67
Yellow Wax X No.4791	533 33	550.00	00.06	90.00
Aswany	400.33	471.67	00.00	00.00
Aswany X California Wonder	400.33	496 67	75.00	71.67
Aswany X Murch	488.33	166.67	65.00	65.00
Aswany X Domalik Buber	450.00	10:00+	76.67	78.33
Aswany X Mirch	441.67	400.07	03.33	91.67
V No.4701	566.67	585.33	20.00	57.33
ASWany A 100-4731	308.33	468.33	55.55	00 00
	950.00	958.33	81.6/	00.00
Murch	491 67	491.67	88.33	83.00
California Wonder X Domalik Buber	508 33	500.00	115.00	/9/111
California Wonder X Mirch	200.33	491 67	115.00	98.33
California Wonder X No.4791	200.00	433.33	78.33	81.67
Murch	441.67	55.50	08.33	98.33
Murch X Domalik Buber	508.33	483.33	20.07	20 00
	508.33	491.67	05.00	80.00
Mulci A Martin	666.67	716.67	00.00	19 99
Murch A 190.4791	541.67	550.00	/0.00	10:00
Domalik Buber	650.00	633.33	108.33	/9.111
Domalik Buber X Mirch	23355	650.00	116.67	115.00
Domalik Buber X No.4791	000.07	591 67	93.33	91.67
Mirch	296.67	575.00	86.67	95.00
Mirch X No.4791	558.55	800.00	91.67	109.00
No.4791	816.6/	20,000	11.95	16.11
L.S.D 5%	54.01	78.63	15.90	21.59
* C.D. 10/	72.01	(0.03)		

degree of resistance, i.e., Murch, Domalik Buber, Mirch, No. 4791, Yellow Wax X Murch, Yellow Wax X Domalik Buber, Yellow Wax X Mirch, Yellow Wax X No.4791, Aswany X Murch, AswanyX Domalik Buber, Aswany X Mirch, Aswany X No.4791, California Wonder X Murch, California Wonder X Domalik Buber, California Wonder X Mirch, California Wonder X No.4791, Domalik Buber X Mirch, Domalik Buber X No.4791, or Mirch X No.4791, the differences between detached leaves fresh weight of inoculated and uninoculated plants were close to each other (Table 18). In addition, in case of the hybrids Murch X Domalik Buber, Murch X Mirch, and Murch X No.4791, which showed high resistance, the inoculated plant had relatively higher leaves fresh weights than that of the uninoculated plant (Table 18). However, these unexpected results can be explained, since the inoculated plants of such genotypes (highly resistant) showed no symptoms which indicates that such difference can be attributed to factors other than infection with root knot nematode. The previously mentioned results indicated that infection of susceptible or highly susceptible genotypes with root knot nematode affects the biological efficiency of the plants, measured by detached leaves fresh weight. In other words, under the conditions of infection with root knot nematode, the high detached leaves fresh weight/plant will be a desirable trait.

The results presented in Table 19 show significant general and specific combining ability effects which indicate the presence of both the additive and non-additive gene action in the inheritance of high plant leaves fresh weight under the

Table (19): Mean square values of detached leaves fresh weight and root fresh weigh for the plants of the different parental germplasm and its F<sub>1</sub> hybrids under the condition of artificial inoculation with root knot nematode.

Source	df	C	haracter
Source		Leaves Fresh Weight	Root Fresh Weight
Genotypes	27	85176.84**	1660.01**
Parents	6	138909.52**	2495.63**
Hybrids	20	73230.75**	1273.57**
Parents vs. Hybrids	1	1702.48	4375.00**
Error	54	1082.99	52.78
General combining ability (GCA)	6	77152.34**	1016.40**
Specific combining ability (SCA)		14460.84**	421.03**
Error	54	361.00	17.59
GCA/SCA		5.34	2.41

<sup>\*\*</sup> significant at 1% level of significance

condition of infection with root knot nematode. However, the additive type of gene action was more important since the ratio of GCA / SCA was > 1.0, i.e., 5.34 (Table 19).

The results presented in Table 20 indicate that the parental cultivars which have desirable general combining ability effects were Murch (38.28), Domalik Buber (22.91), Mirch (29.58). and No.4791 (121.98), which indicate that these parental genotypes can be considered as good combiners for forming pepper hybrids which can keep reasonable level of biological efficiency due to high leaves fresh weight, under the condition of infection with root knot nematode. This conclusion was supported by the results presented in Table 21 which show that the hybrids California Wonder X Murch and Domalik Buber X Mirch had the highest specific combining ability effects which indicate the suitability of these hybrids to be planted in soils which infection with root knot nematode is likely to occur.

The results presented in the Table 22 showed no prove for uniformity of Wr-Vr. This result indicated absence of one or more of the assumptions required for the validity of Jinks-Hayman analysis to be applied on the data of detached leaves fresh weight/plant under the conditions of artificial inoculation with root knot nematode.

The broad and narrow sense heritability values estimated by the general and specific combining ability analysis of Griffing method were 66.34% and 32.80%, respectively (Table 17). The low value of the narrow sense heritability value indicate the influence of the environmental factors and non-additive type of

Table (20): General combining ability effects (gi) for detached leaves fresh weight/plant and root fresh weigh/plant for the different parental genotypes under the condition of artificial inoculation with root knot nematode in the field experiment.

	Cha	nracters
Genotypes	Leaves Fresh Weight	Root Fresh Weigh
Yellow Wax	- 182.28	- 20.03
Aswany	- 14.50	4.05
California Wonder	- 16.00	- 6.88
Murch	38.28	- 0.77
Domalik Buber	22.91	4.42
Mirch	29.58	7.57
No.4791	121.98	11.64
L.S.D 5%	11.73	2.59
L.S.D 1%	15.71	3.47

Table (21): Specific combining ability effects (Sij) for detached leaves fresh weight/plant and root fresh weigh/plant of the different F<sub>1</sub> hybrids, under the condition of artificial inoculation with root knot nematode in the field experiment.

Genotypes	Cha	racters
3-2-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-2-1-	Leaves Fresh Weight	Root Fresh Weight
Yellow Wax X Aswany	80.88	39.91
Yellow Wax X California Wonder	15.69	- 24.17
Yellow Wax X Murch	- 80.23	11.39
Yellow Wax X Domalik Buber	- 48.19	6.20
Yellow Wax X Mirch	- 4.86	1.39
Yellow Wax X No.4791	2.73	0.65
Aswany X California Wonder	- 52.08	11.76
Aswany X Murch	- 26.34	- 9.35
Aswany X Domalik Buber	- 49.30	- 24.54
Aswany X Mirch	- 64.31	- 16.02
Aswany X No.4791	- 31.71	- 3.43
California Wonder X Murch	436.81	8.24
California Wonder X Domalik Buber	- 6.16	9.72
California Wonder X Mirch	3.84	33.24
California Wonder X No.4791	- 96.90	29.17
Murch X Domalik Buber	- 43.75	13.61
Murch X Mirch	- 50.42	-14.54
Murch X No.4791	15.51	- 6.94
Domalik Buber X Mirch	106.62	15.28
Domalik Buber X No.4791	30.88	19.54
Mirch X No.4791	- 84.12	- 13.61
L.S.D 5% (Sij – Sij)	40.06	8.84
L.S.D 1% (Sij – Sij)	53.67	11.85
L.S.D 5% (Sij – Sik)	50.67	11.19
L.S.D 1% (Sij – Sik)	67.89	14.99

Table (22): Tested hypothesis in the diallel pepper crosses concerning detached leaves fresh weight/plant, for validity of Jinks-Hayman analysis.

Tested Hypothesis	Calculated t.05	Significance k
Ho: Wr-Vr is homogenious	3.458091	**
Ho: b = 0 (not significantly different from zero)	- 1.071193	ns
Ho: b = 1 (not significantly different from unity)	8.784381	**

k ns = not significant

<sup>\*\* =</sup> significant at 1% level of significance

gene action on the expression and inheritance of this character. Based on these results selection in the segregating generations of pepper crosses for relatively high leaves fresh weight under the condition of artificial inoculation with the root knot nematode should be made on family mean basis in replicated experiments.

### 2.5. Root Fresh Weight/Plant:

The results presented in Table 18 show that the differences between the root fresh weight of the inoculated and uninoculated plants of resistant or susceptible parental genotypes or F<sub>1</sub> hybrids, had no specific pattern. However, root fresh weight of the susceptible parents which have been previously categorized as very susceptible, i.e., Yellow Wax and California Wonder Table 1, had significantly less root fresh weight than that of the parent which showed less degree of susceptibility, i.e., Aswany "susceptible", or that of the parents which showed different degrees of resistance, i.e., Murch, Domalik Buber, Mirch, and No 4791 whether under the condition of artificial inoculation or nematode free conditions. These results indicate that the vigor of root system, measured by root fresh weight, may be have a role in the pepper plant reaction to root knot nematode.

The results presented in Table 19 show significant general and specific combining ability which indicates the presence of both the additive and non-additive gene action in the inheritance of root fresh weight/plant under the condition of infection with root knot nematode. In addition, the GCA/SCA ratio (2.41) indicate that the additive type of gene action was

more important than the non-additive type in the inheritance of this character.

The parental genotypes which had the highest desirable general combining ability effect were No.4791 (11.64) and Mirch (7.57), Table 20, which indicates the suitability of these parental genotypes to form pepper hybrids with relatively vigour root system, measured by root fresh weight/plant, under the condition of infection with root knot nematode.

The F<sub>1</sub> hybrids California Wonder X Mirch and California Wonder X No.4791 which have been previously classified as resistant and highly resistant, respectively, Table 1, had the highest specific combining ability effect, i.e., 33.42 and 29.17, respectively (Table 21). On the other hand, the specific combining ability effect of the F<sub>1</sub> hybrid which has been previously classified as susceptible i.e., Yellow Wax X Aswany, (Table 1), was relatively high, i.e., 39.91, (Table 21). This result can be explained by the involvement of the parental genotype Aswany which has been found to have less degree of susceptibility, and less number of galls or eggs comparing to other susceptible parental genotypes, i.e., Yellow Wax and California Wonder which have been previously classified as highly susceptible, (Table 1).

The analysis of homogeneity of Wr-Vr over arrays indicated the presence of the assumptions required for the validity of Jinks-Hayman analysis for root fresh weight/plant under the condition of artificial inoculation of root knot nematode (Table 23). Absence of epistatic effect, which is one of the important assumptions required for the validity of Jinks-

Table (23): Manual plotting for parabola limits and regression line, calculated statistics, and tested hypothesis in the diallel pepper crosses for root fresh weight according to Jinks-Hayman analysis.

			Wr-	
Parents	VR	Wr-Parabola	Regression	
Yellow Wax	788.36066	809.82727	583.79504	
Aswany	181.48177	388.54974	- 50.57822	
California Wonder	1215.60876	1005.60388	1030.39941	
Murch	83.99349	264.33395	- 152.48315	
Domalik Buber	410.18555	584.14459	188.48686	
Mirch	305.42447	504.05957	78.97966	
No.4791	253.44141	459.16498	24.64153	
Calculated S	tatistics	Val	ue	
Regression Coefficient (b)	_	1.045	305	
Intercept (a)		- 240.	2819	
Parental Mean		68.57	143	
Mean of N ^ 2 Progeny		82.85	5713	
Mean of N ^ 2 Progeny - Pa	rental Mean	14.28	571	
Variance of Parents (VoLo	)	831.8	789	
Variance of the Means of Arrays VoL1		100.1	881	
Mean Covariance of Arrays With Non-				
Recurring Parents (VoLo1)		243.3202		
Mean Variance of Arrays (V1L1)		462.6423		
Tested Hypo	othesis	Calculated t.05   Significance		
Ho: Wr-Vr is homogenious		0.6819583	ns	
Ho: b = 0 ( not Significantly	different from Zero)	7.22	**	
Ho: b = 1 (not Significantly		- 0.312922	ns	

 $<sup>^{</sup>k}$  ns = not significant

<sup>\*\* =</sup> significant at 1% level of significance

Hayman analysis, was indicated by the value of the regression coefficient (b) calculated for the Wr-Vr which found to be significantly different from zero and not significantly different from one (Table 23). Concerning the results of Jinks-Hayman diallel analysis Table 24, the ratio of H<sub>2</sub>/4H<sub>1</sub> was 0.195, which indicated that the alleles which increase the mean expression of character and are situated at loci which exhibit dominance, and the alleles at loci that decrease the expression of the character, were not in equal proportion in the parents. The ratio, which measured the total numbers of dominant to recessive alleles in all parents, i.e.,  $((4 \text{ DH}_1)^{1/2} + \text{F})/((4 \text{ DH}_1)^{1/2} - \text{F})$ , was 1.802 which indicated that there were more dominant that recessive alleles in the parents involved in the present study. The positive value of F, i.e., + 666.23 Table 24 supported the previously mentioned conclusion, since it indicated that there were more dominant than recessive alleles in the parents used in the present study. Furthermore, the positive sign of h, i.e., +808.01, indicated that the dominance acted in the direction of the parent with the higher expression of root fresh weight/plant under the condition of infection with root knot nematode. Moreover, the degree of dominance, averaged over all loci, i.e.,  $(H_1/D)^{1/2}$ , was 1.429 which indicated over-dominance for this character. This conclusion was supported by the regression line of the Vr-Wr manual plotting which intersected the Wr axis below the origin (a = -240.2819). This also indicated the presence of overdomince (Table 23). Moreever, the value of (mean of N^2 progenyparental mean) was 14.28571 Table 23 which indicated overdomince for high root fresh weight/plant under the artificial inoculation with root knot nematode.

The relative values of Vr-Wr Table 23 showed that the parent California Wonder had the highest value, while the parent Murch had the lowest value (Table 23). These results indicated that the parental cultivar California Wonder had the most recessive genes, while the parental cultivar Murch had the most dominant genes. In addition, both the parental cultivars California Wonder and Yellow Wax had high and relatively close values of Vr-Wr (Table 23). These results indicate that these two cultivars have similar genotypes concerning the studied character. On the other hand the parent Aswany, had a value of Vr-Wr which was relatively distant from those of California Wonder and Yellow Wax (Table 23). These results indicated that parent Aswany has a distinguished genotype which is different from genotypes of California Wonder and Yellow Wax. Considering that root fresh weight of pepper plant under the condition of artificial inculation could be an indication for or component of resistance to root knot nematode, it can be mentioned that these results support the results presented in Table 1 which categorized parents California Wonder and Yellow Wax as "highly susceptible" while parent Aswany was categorized as "susceptible".

The results presented in Table 24 indicated that the broad  $(h_{bs})$  and narrow  $(h_{ns})$  since heritability estimates were 97.0% and 34.8%, respectively, (Table 24). These values indicated that progress in improving root fresh weight/plant under the condition of infection with root knot nematode, can be achieved.

Table (24): Estimate of genetic components and heritability values in diallel pepper crosses for root fresh weight/plant, under the condition of artificial inoculation with the root knot nematode in the field experiment.

Components	Root Fresh Wight
D	814.91
$H_1$	1663.1
$H_2$	1415.87
F	666.23
h	808.01
$(H_1/D)^{1/2}$	1.429
H <sub>2</sub> /4H <sub>1</sub>	0.213
$((4DH_1)^{1/2} + F) / ((4DH_1)^{1/2} - F)$	1.802
h <sub>ns</sub>	34.8%
h <sub>bs</sub>	97.0%

## **Correlation Study**

The results presented in Table 25 show highly significant positive correlation (r=0.98) between number of galls and number of nematode eggs counted inside the examined galls in the greenhouse experiment. This indicates that number of galls counted on roots of pepper plants after the artificial inoculation with root knot nematode, can be used alone to evaluate pepper plant's reaction to infection with root knot nematode, which will save time and efforts of pepper breeder.

Furthermore, number of galls counted on the roots of pepper plants of the different genotypes in the greenhouse after the artificial inoculation was found to be negatively correlated with some measurements recorded in the field i.e. plant yield (r = -0.57), number of fruits / plant (r = -0.44), root weight (r = -0.75), leaf weight (r = -0.55), plant height (r = -0.82), root phenols content (r = -0.66), and leaf chlorophyll content (SPAD Reading) (r = -0.57). These results indicate that the high susceptibility of pepper genotypes expressed by large number of galls counted on plant root after the artificial inoculation with root knot nematode was associated with decreasing in fruit weight, plant yield, root weight, plant height, root phenol content and leaf chlorophyll content (SPAD Reading). To explain part of this relationships, it can be suggested that the decrease in leaf chlorophyll content (SPAD Reading) due to high susceptibility expressed by large number of galls, may have affected the biological efficiency of infected pepper plants resulting in reducing root weight, leaf weight, plant height and number of fruits per plant, which consequently reduced total

Table (25): Simple correlation coefficients between the different studied characters in half diallel crosses between some pepper germplasm.

3.	e .addad							0	0	10	11	12	13	14	2
"haracters	-	7	3	4	w	9	-	•	1	-					
2	**86.0											1	-	+	
		1.00**											+	-	
4	-0.05	-0.05	-0.05											+	
- 1	-	-0.58***	-0.59**	-0.25										-	
n	*****	** 33 0	0 53.	-0.22	0.11										
9	0.52		****	000	-0.10	-0.83									
7	-0.44	-0.43	-0.43	0.02	24.0	***************************************	0 50					1	1	+	
	000	0.06	90.0	-0.08	0.30	0.58		- 1							
×	0.0	_	****	0.17	0.14	0.78	99.0-	0.1/	1	+					
6	0.41	0.47	1.44	- 1	* 15.0	-0.43*	0.37	-0.12	-0.30				-		
10	-0.75**	-0.72	-0.73	-0.04	1.0		900	-0.20	0.01	0.57**			1		
3	***	-0.52**	-0.53**	0.31	0.34	-0.2/			*5.	10.	0.52**				
	***************************************	**000	-0.81**	0.07	0.34	-0.55	0.39	-0.12	-0.42	_	7.00	0.38	_		
12	-0.82	10.0-	*****		0 35	-0.19	0.27	90.0	-0.33	0.33		:00	0.43		
13	-0.66	89.0-	89.0-	-0.0-	*	0.00	0.03	0.41	-0.15	0.50	0.31	0.50	0.0	000	
:   :	0.57	-0.56**	-0.56**	-0.03	0.40	-0.0					0.04	0.20	-0.02	-0.03	
41	10.0	0.73*		0.20	-0.21	-0.69	69.0		70.0-	.,,750	0.44**	-0.56"	-0.17	-0.28	-0.04
15	-0.23		*	100	-0.44	0.16	-0.21	0.12	0.41	-0.50					
16	0.54	0.48	10.0												

Significant at 5% level of Significance. W1- Number of galls

5- Plant total yield 6- Fruit weight 7- Fruit number 2- Number of eggs 3- Reproduction factor 4- Root fresh weight (greenhouse)

8- fruit length

13- Root phenols content 10- Root fresh weight (field exp.) 11- Leaves fresh weight 9 - Fruit diameter 12- Plant height

14- Leaves chlorophyll content15- Shoot dry weight16- Leaves dry weight

yield per plant. Furthermore, the negative correlation (r = -0.66) between number of galls counted on plant root after the artificial inoculation with root knot nematode and root phenol content Table 25, indicates the role of root phenols content as a defense mechanism against root knot nematode in pepper. In addition, according to the results presented in Table 25, significant positive correlation was detected between number of galls and each of fruit diameter (r = +0.41) and fruit weight (r = +0.52) which indicates that high susceptibility expressed by large number of galls counted on plant root after inoculation with root knot nematode was associated with large fruits, i.e., high fruit weight and diameter. These results were supported by the results found in the present study and presented in Table 26, where California Wonder and Yellow Wax had the largest fruit size and, in the same time, these parental genotypes expressed the highest degree of susceptibility to the root knot nematode (Table 1).

Number of eggs counted inside the galls on plant roots of the different genotypes, as a measure for plant reaction to artificial inoculation with root knot nematode, had same trend of results concerning its correlation with other studied characters (Table 25). Significant negative correlations were observed between number of eggs and each of plant yield (r = -0.58), fruit number per plant (r = -0.43), plant root weight (r = -0.72), leaf weight (r = -0.52), plant height (r = -0.80), root phenols content (r = -0.68), and leaf chlorophyll content (SPAD Reading) (r = -0.56). On the other hand, significant positive correlations were detected between number of eggs and each of fruit weight

Table (26): means for Number of fruits. Fruit weight (gm ), Fruit diameter (cm), Fruit length (cm), Root fresh weight greenhouse (gm), Shoot dry weight (g/100gm f.w), Leaves dry weight (g/100gm f.w) for the inoculated and uninoculated plants of different parental genotypes and its F<sub>1</sub> hybrids evaluated in field:

THE REAL PROPERTY AND PERSONS ASSESSMENT OF THE PERSONS ASSESSMENT OF										A	200	TO DE COMMENT	-			
				1 ha (mm)	Fruit diameter	meter	Fruit length	ength	ne -	nt (cm)		1 ninoculated	Inoculated	Uninoculated	Inoculated Uninoculated	ninoculated
Genotypes	Number of	Number of fruits/plant	Fruit w	Fruit weight (gm )	- Industrial	t n inoculated	Inoculated	Un inoculated	Inoculated	Uninoculated	Inoculated	Chinoculation		20.00	05 FC	22.83
	Inoculated	Un inoculated	Inoculated	Un inoculated			25.57	9.33	50.00	29.67	7.19	7.00	24.33	66.77		20.03
	18 67	67.67	18.67	29.79	2.10	55.7	100	5	17 57	115 11	7.17	6.97	27.17	28.73	23.00	70.83
Yellow wax		23 623	150.33	672.67	1.37	1.47	6.03	6.50	113.07	00000	151	6.80	19.33	18.60	25.00	18317
Yellow Wax X Aswany	150.33	0	.,	00 99	3.03	3.57	5.60	08.9	47.67	75.00	2001		25.13	24.87	19.93	21.10
Yellow Wax X California Wonder	44.67	00'99	14.0/	00000	0, 0	2.33	7.13	7.53	84.33	81.00	2.67	5.50	61.63	23.37	77.77	22.00
Yellow Wax X Murch	236.67	231.00	236.67	231.00		1 80	9.10	8.87	83.33	86.00	6.18	5.47	23.70	77.67	21.50	09 00
y Suppose	113.67	107.33	113.67	107.33	1.03	001		1.07	80.33	80.67	5.13	4.70	22.93	22.87	00.12	20.00
Yellow was A Dollians Door	73.757	228.00	237.67	228.00	2.17	223	4.17	5.7	17 001	00 11	7.20	5.67	25.40	25.03	22.57	21.50
Yellow Wax X Mirch		11.11	223.33	224.33	1.87	1.73	8.40	7.97	100.07	2000	0.0	8.17	28.40	27.17	22.00	20.73
Yellow Wax X No.4791	223.33	20,432	270.00	586.33	0.93	06.00	2.63	2.77	92.00	101.67	7.50	11.7	26.93	24.47	24.37	22.67
Aswany	220.00	586.33	20000	353.00	1.43	1.60	4.83	5.50	95.00	107.00	8.00	50.0	25.17	75.67	77.22	21.53
Aswany X California Wonder	185.33	253.00	185.33	20000	20.0	1.23	4.83	4.63	97.33	101.33	4.77	3.83	15.62	02.00	20.70	20.77
Aswany X Murch	580.33	581.33	580.33	581.55	0.03	76.0	6.07	6.30	102.67	105.33	7.10	29.9	26.10	00.04	07.00	20.73
Aswany X Domalik Buber	365.67	344.33	365.67	344.33	200	1	3.13	2.27	108.67	105.67	6.30	7.33	26.53	07.72	200	0,00
Aswany X Mirch	332.67	332.33	332.67	332.33	1.37	1	1.70	4.43	105.00	111.33	6.67	6.07	22.63	21.73	20.03	70.47
1027 N. V	321.67	316.00	321.67	316.00	1.37	1.33		5.03	19.00	60.33	7.00	7.00	21.77	21.60	20.90	70.50
Aswany A NO-177	20.67	22.33	20.67	22.33	4.33	3.33	0.7	2 5	79 00	19.66	7.97	7.17	20.73	20.33	21.80	20.20
California worker		140	145.33	671	3.77	3.93	4.77	6/.4	1000	2710	517	4.67	19.93	18.77	21.57	21.67
California Wonder X Murch			00 20	87.33	3.43	3.43	6.53	9.50	82.33	91.0/		00.	10.01	20.00	20.03	19.93
California Wonder X Domalik Buber	sr 85.00	87.33	00.00		217	2.13	6.27	6.57	125.67	124.00	6.57	4.90	-	11.00	18.67	19.33
California Wonder X Mirch	146.33	150.33	146.33	55.051	00.0	2.13	7.33	7.50	120.33	116.00	4.30	3.87	19.77	0000	17 14	21.60
California Wonder X No.4791	116.33	119,33	116.33	119.33	07.7	:	090	2.83	105.33	103.00	13.13	12.83	21.87	27.13	1	
Camorina	224.00	221.33	224.00	221.33	2.13	2.17	207	11.1	116.67	118.33	5.80	6.17	22.33	21.93	18.53	18.57
Murch	11111	221.33	233.33	221.33	2.50	2.20	7.33	(2)		57.50	6.23	5.93	26.40	21.53	21.53	21.67
Murch X Domalik Buber	00.00	00100	287.33	293.00	2.63	1.57	3.33	3.47	66.33	1000	10.87	9.00	24.87	19.30	19.30	19,40
Murch X Mirch	287.33	0071	240.33	234.00	1.47	1.50	5.97	2:30	107.67	107.07	14.10	12.60	23.00	22.13	22.13	22.20
Murch X No.4791	CC-0+7	27.02	80.33	79.67	2.17	2.07	10.60	11.00	104.6	102:01	1 50	7.80	27.20	28.53	19.53	19.50
Domalik Buber	80.33	+	-	131 00	2.13	2.17	4.13	157	118.67	120.33	S:	00.1	1995	35.53	20.77	20.83
Domalik Buber X Mirch	326.00		326.00	217.00	2.13	1.93	6.97	7.40	104.67	105.00	6.10	5.67	00.00	29.20	18.50	19.27
Domalik Buber X No.4791	219.33	217.00	50.617		90.	2.17	2.70	2.90	98.67	28.67	10.33	9.10	22.00		30.10	20.30
Mirch	525.67	539.67	525.67	539.67	00.7	1.70	8.00	7.73	105.00	104.00	6.67	10.07	27.43	27.90	20.02	19.53
Mirch X No.4791	224.33	221.67	224.33	221.67	100.1	1.70	5.10	2.40	92.00	90.00	13.03		24.47	74.8/	1.01	1 39
192,4791	373.67	374.33	373.67	374.33	CCI	5 4	0.78	0.82	7.88	10.96	1.88	1.47	1.62	1.33	101	! ! !
1 S D 3%	19.85	28.82	19.85	28.82	0.41	C+-ii	1.03	1.09	10.50	14.68	1.95	1.97	2.17	1.78	1.75	1.50
L.S.D.3.10				19 61	*** 0	0.58	1.03									

(r = +0.55), and fruit diameter (r = +0.47), (Table 25). Since number of eggs had same trend of results as number of galls, and since high significant correlation was observed between these two measurements (r = 0.98), it can be suggested that depending on number of galls alone as a measure for severity of plant reaction to infection with root knot nematode will be easier faster and more practical for the breeder.

Significant positive correlations were observed between plant yield and each of plant roots weight (r = 0.41) and leaf chlorophyll content (SPAD Reading) (r = 0.40), under the condition of artificial inoculation with root knot nematode in field (Table 25). These results indicate that selection for pepper plants with high yield under the condition of artificial inoculations with root knot nematode will be accompanied by less damage to root system and leaf chlorophyll. Such relationship seems logical, since under the condition of infection with root knot nematode, the less damage to the root system and leaf chlorophyll content (SPAD Reading), the more plant yield can be obtained. From the practical paint of view, leaf chlorophyll content (SPAD Reading) of pepper plants under the condition of infection with root knot nematode will be relatively efficient as a selection criteria for plants with high yield and less damaged roots.

The results presented in Table 25 show that under the condition of infection with root knot nematode, significant positive correlations between plant root weight and each of plant yield (r = 0.41), number of fruits per plant (r = 0.37), leaf fresh weight (r = 0.57), plant weight (r = 0.86), and leaf

chlorophyll content (SPAD Reading) (r = 0.50). The high weight of plant roots under the condition of infection with root knot nematode could be an indication for the resistance of root system of this plant. In addition, the previously mentioned significant positive correlation observed between plant root weight and each of leaf fresh weight, plant yield, number of fruits per plant, leaf fresh weight, plant height and leaf chlorophyll content (SPAD Reading), will ease the process of selecting strong root system of pepper plants under the condition of infection with root knot nematode.

# 3. Bioassay Experiment

The results presented in Table 27, show that root exudates of parental cultivars Mirch, Murch which have been previously categorized as highly resistant Table 1, and Yellow Wax, which has been categorized as highly susceptible Table 1, had no effect on the motility (activity) of the second stage juveniles of root knot nematode. Also, no effects were observed in this respect for root exudates of the F<sub>1</sub> hybrids Yellow Wax X Mirch (resistant) and Yellow Wax X Murch (highly resistant), (Table 27). Furthermore, root exudates of the different parental cultivars, whether they are highly resistant, i.e., Murch and Mirch or highly susceptible, i.e., Yellow Wax, as well as that of its F<sub>1</sub> hybrids, whether they are resistant, i.e., Yellow Wax X Murch or highly resistant, i.e., Yellow Wax X Mirch, (Table 27), had no significant inhibiting effects on hatching of eggs of root knot nematode. These results indicate that factors of the chemical basis of root resistance to the root knot nematode only exist inside the cells of root tissue.

Table (27): Influence of root exudates of some pepper genotypes and their F<sub>1</sub>hybrids on second stage juveniles (J<sub>2</sub>)

motility and egg hatching of Meloidgyne incognita.

Inhibition of hatching × 1 ¥ × 4 hatched J2 after 4 Number of days 810 810 810 820 800 us Inhibition of motility 4 × Y. 4 × \* different exposure days Number of active 100 86 10066 100 Juveniles after 86 us 100 100 100 100 100 100 us 100 100 100 100 100 100 us Pepper genotype x Mirch Yellow Wax x Murch Water (control) Yellow Wax Yellow Wax LS.S(5%) Murch Mirch

ns: not significant a 5% level of significance.

k : has not been observed.

#### 4. Acid phosphatase Isozyme Analysis Experiment:

The acid phosphatase patterns for the susceptible parent California Wonder and resistant parents, i.e., Mirch, Domalik Buber and Murch as well as F<sub>1</sub> hybrid California Wonder X Domalik Buber are presented in (Table 28) and illustrated in Figure 1. A total of six bands with different densities and R<sub>f</sub> were observed and scanned. All detected bands were present in all examined genotypes, except for band number 3 which was present in the resistant parents, i.e., Mirch, Domalik Buber and Murch and the resistance F<sub>1</sub> hybrid California Wonder x Domalik Buber, while this band was absent in the susceptible parent California Wonder (Table 28). These results indicated that band number 3 can be used in distinguishing between pepper genotypes concerning resistance to root knot nematode. Based on the obtained results it can be mentioned that acid phosphatase isozyme analysis can be successfully used by pepper breeders to select for resistance to root knot nematode without any need to make artificial inoculation with nematode, which will save time and effort as well as avoiding hazards caused to soil and environment from artificial inoculation. Boerma and Hussey (1992) reported the importance of finding efficient screening procedure in developing new cultivars which are resistant to plant parasitic nematode.

Table (28): Electrophoretic Patterns of some pepper parents and  $F_1$  California Wonder X Domalik Buber for acid phosphates isozyme.

		COLUMN TO SERVE		Company of the Sales of the Company	
Genotype Groups of Isozymes (band No.) k	California Wonder	Murch	Domalik Buber	Mirch	California Wonder X Domalik uber
#1 A. phos. 1	D	D	VD	D	VD
RF	0.06	0.06	0.06	0.06	0.06
#2 A. phos. 2	F	F	F	F	F
RF	0.15	0.15	0.15	0.13	0.15
#3 A. phos. 3		VD	VD	F	VD
RF		0.27	0.27	0.35	0.27
#4 A. phos. 4	VD	D	VF	D	VF
RF	0.47	0.40	0.42	0.45	0.40
Density #5 A. phos. 5	D	D	VD	D	VD
RF	0.58	0.55	0.60	0.55	0.55
Density #6 A. phos. 6	F	VF	VD	D	VF
RF	0.75	0.71	0.67	0.67	0.67

K

F = Faint

VF = very faint

D = Dark

VD = Very Dark

RF = Relevant from the Front