Brazilian Journal of Agriculture **v.95, n.3, p. 191 – 201, 2020**
DOI: 10.37856/bja.v95i3.3710

RESPONSE TO DIRECT AND CORRELATED SELECTION ON YIELD AND LEAF BLIGHT IN CARROTS

Agnaldo Donizete Ferreira de Carvalho[1], Giovani Olegário da Silva[2]

[1] EMBRAPA - Brazilian Agricultural Research Corporation, Brazil. E-mail: agnaldo.carvalho@embrapa.br, giovani.olegario@embrapa.br

ABSTRACT

This work aimed to estimate genetic parameters and to verify response to direct and correlated selection on yield components and leaf blight in carrot populations. The experiment was carried out in the experimental field of Embrapa Vegetables, from November 2010 to April 2011. Half-sib progenies of three carrot populations were sown with a randomized block design with three replications and plots of 1.1 m^2. The area under the disease progress curve as well as the marketable and total root mass were assessed. Results indicated that population CNPH-561 presented the highest level of resistance to leaf blight, but lower genetic variability to obtain greater gains with the selection for this character. For all populations evaluated, selection for marketable root mass and total root mass would allow for direct and indirect gains on these traits. Selection for leaf blight, whether direct or indirect, would be efficient only for the CNPH-587 population.

Keywords: *Daucus carota* L., breeding, heritability, *Alternaria dauci*, *Cercospora carotae*

RESPOSTA À SELEÇÃO DIRETA E CORRELACIONADA SOBRE PRODUTIVIDADE E QUEIMA-DAS-FOLHAS EM CENOURAS

RESUMO

Este trabalho teve como objetivos estimar parâmetros genéticos e verificar a resposta à seleção direta e correlacionada em componentes de produção e queima das folhas em populações de cenoura. O experimento foi realizado no campo experimental da Embrapa Hortaliças, no período de novembro de 2010 a abril de 2011. Progênies de meias irmãs de três populações de cenoura foram semeadas em delineamento de blocos ao acaso, com três repetições e parcelas de 1,1 m^2. Foi avaliada a área sob a curva de progresso da doença e a massa total e comercializável da raiz. Verificou-se que a população CNPH-561 apresentou o maior nível de resistência à queima das folhas, mas menor variabilidade genética para obter maiores ganhos com a seleção para esse caráter. Para todas as populações avaliadas, a seleção para massa de raízes comercializável e massa total de raízes permitiria ganhos diretos e indiretos para essas características. A seleção para a queima das folhas, direta ou indireta, seria eficiente apenas para a população CNPH-587.

Palavras-chave: *Daucus carota* L., melhoramento, herdabilidade, *Alternaria dauci*, *Cercospora carotae*

INTRODUCTION

Carrot is one of the main cultivated vegetables worldwide. In Brazil approximately 725 thousand tons of carrots produced each year (IBGE, 2017). Its importance goes beyond supplying carbohydrates and minerals, because it is also rich in α-carotene and ß-carotene, vitamin A precursors (SIMON et al., 2019).

An increase in the efficiency of the breeding process largely depends on obtaining reliable estimates of genetic parameters related to the characteristics of interest. In breeding, understanding the variance components and heritability consequently associated with traits of interest is of fundamental importance, since it helps in the choice of the methodology to be adopted (HALLAUER & MIRANDA FILHO, 1981).

Heritability is one of the most important parameters for the genetic breeding of plants. In the selection progenies that will form the next generation, the degree of change in the desired trait can be predicted with the ratio between genetic and phenotypic variance. For high heritability of characters, simple methods such as mass selection may provide satisfactory results, since few are influenced by the environment (FALCONER, 1989).

In tropical carrot germplasm there are few studies to estimate heritability and selection gains, especially for leaf blight. Breeding strategies often emphasize selection of just a few characteristics at each stage of selection. However, it is important to determine the effects that selection for a specific character can have on others (PEREIRA et al., 1994).

The existence of genetic associations between different characters determines whether selection may cause changes in other characters, whose direction may or may not be of interest for breeding. Thus, knowledge of correlated gains between characters is very important. Such information may allow efficient strategies of selection to be adopted for a complex phenotypic

DOI: 10.37856/bja.v95i3.3710

characteristic that presents a relationship with others that are more easily measured and identified and/or have greater heritability (SILVA et al., 2006 ; CRUZ et al., 2012).

Response to selection, according to Hallauer & Miranda Filho (1981), is one of the greatest contributions of quantitative genetics, because it allows selection gains to be estimated in advance. Selection gains reflect the changes in the observable characteristics of interest after a cycle of recombination and multiplication of selected progenies.

In carrot breeding programs in Brazil, major efforts are made to increase tolerance levels to leaf blight. This disease damages the carrot crop mainly during summer and is reported worldwide (PRYOR et al., 2002, CARVALHO et al., 2015, KOIKE et al. 2017). It is caused by a complex of two fungi, *Alternaria dauci* (Kuhn) Groves & Skolko and *Cercospora carotae* (Pass.) Solheim, and a bacteria *Xanthomonas hortorum* pv. *carotae* (Kendr.) Dows. These three pathogens may be present in isolation or simultaneously in a crop, plant or injury (TÖFOLI & DOMINGUES, 2010).

A major problem in the evaluation for resistance to these pathogens is the fact that all induce very similar symptoms in carrots. The disease causes severe loss of leaf area, with negative effects on production and quality of roots. The most efficient method for leaf blight control has been the combined use of resistant varieties and fungicides (LOPES & REIS, 2016; MARCUZZO & TEIXEIRA, 2019).

This study thus aimed to estimate genetic parameters and response to direct and correlated selection for (total and marketable) root mass and tolerance to leaf blight in three carrot populations with different proportions of tropical and temperate germplasm.

MATERIAL AND METHODS

An experiment was carried out in experimental fields located at Embrapa Vegetables (15º 55 '43.87 S; 48º 08' 35.32 W; Alt. 1000 m). Soil analysis (0-20 cm) revealed the following results: sum of bases = 5.9 $cmol_c$ dm^{-3}, CTC= 10,7 $cmol_c$ dm^{-3}, base saturation= 55%, pH = 5.6, organic matter = 36.7 g dc^{-3}, P = 0.814 g dm^{-3}, K = 0.090 g dm^{-3}; Na = 0.008 g dm^{-3}, Ca = 3.9 $cmol_c$ dm^{-3}, Mg = 1.7 $cmol_c$ dm^{-3}, Al = 0.0 $cmol_c$ dm^{-3} and H + Al = 8 $cmol_c$ dm^{-3}.

From November 2010 to April 2011, precipitation and average temperature for each month are described in order: Nov10 254.5 mm, 21.2 ºC; Dec10 318.0mm, 21.9 ºC; Jan11 126.8 mm, 21.9 ºC; Feb11 172.4 mm, 21.7 ºC; Mar11 243.2 mm, 21.6 ºC and Apr11 69.5 mm, 21.6 ºC (INMET; 2019). The region's climate is Aw, Tropical Climate with winter dry season, according to Köppen-

Geiger. Soils in the experimental area were characterized as dystrophic Red Latosol with clay texture. The experimental area was under fallow with palisade glass (*Urochloa brizantha*). It was chalked three months before planting, and prepared with a deep plowing, a harrowing and seed beds with 30 cm high and 100 cm wide.

On November 17, 2010, 26 half-sib progenies of population CNPH-561 (obtained by crossing a male-sterile commercial hybrid 'Juliana' F1 and BRS Planalto, followed by a backcross with BRS Planalto), 10 half-sib progenies of population CNPH-586 (obtained by crossing a temperate male-sterile lineage '101/1A' and BRS Planalto, followed by a backcross with BRS Planalto), and 15 half-sib progenies of population CNPH-587 (obtained by crossing a temperate male-sterile lineage and population CNPH-554 followed by a backcross with CNPH-554 population) were sown. The experimental design was a randomized complete block with three replications. The experimental plot consisted of three double rows spaced 20 cm apart, with 10 cm between rows for a total area of 1.1 m^2. After thinning, performed at 35 days after sowing (DAS), carrot plants were spaced 5 cm apart. Planting fertilization was carried out with the commercial formula 04-14-08 (NPK) at a dosage of 1.5 t ha^{-1}. Topdressing was performed after thinning 30 DAS with ammonium sulfate at a dose of 400 kg ha^{-1}. Weed control was performed by spraying 1.5 L ha^{-1} (commercial product) of the herbicide Linuron at four DAS. In the development phase, weed control was carried out manually. Irrigation, when necessary, was performed by sprinkling with sufficient water depths to maintain soil at field capacity. No product was applied aiming at the control of fungal or bacterial diseases; so that the different genotypes evaluated expressed their maximum resistance to leaf blight the other cultural treatments followed the recommendations for the summer carrot crop in the Brazilian savannah conditions, according to Filgueira (2008).

The infection with leaf blight occurred naturally in the field, without inoculation. The natural levels of inoculum were considered appropriate for the severity of the infection and uniformity observed in the plots. There was no fungicide or other chemical agent during the experiment for control of pathogens.

At 72, 79, 84, 89 and 94 DAS, the incidence of leaf blight was evaluated by applying a note scale, adapted from Gaube et al. (2004), from 0 to 9 for the plots, 0 = no visible disease damaged; 1 = few scatted lesions, < 5% leaf area damaged; 3= few scatted lesions on petioles, lesions around 30% of foliage, 5-20% leaf area damaged; 5= lesions about 60% of foliage, 20-40% leaf area damaged; 7=lesions about 90% of foliage, 40-60% leaf area damaged; 9= severe defoliation, only

DOI: 10.37856/bja.v95i3.3710

new leaves remaining. At the end of the evaluations area under the disease progress curve (ADPC) of each treatment were calculated according to Shaner and Finney (1977), by the following formula $ADPC = \sum_{i=1}^{n}[(Y_{i+n1} + Y_i)/2][X_{i+1} - X_i]$

In which Y_i= leaf blight severity (per unit) at the ith observation, X_i= time (days) at the ith observation, and n=total number of observation.

At 100 DAS, carrots were harvested and commercial as well as total production of roots quantified. Data were then converted to t ha^{-1}. Analysis of variance and estimated genetic parameters was done using the application in computational and statistical genetics Genes (v. 2006.4.1) (CRUZ, 2013). The direct responses with 20% selection of progenies of each population, and correlated gain, were also estimated according to Falconer (1989), using the standard deviation of genotypic population.

RESULTS AND DISCUSSION

In the analyses of variance for each population, a significant difference was observed for the marketable roots mass (MRM) and total root mass (TRM). However, a significant difference was found only for the population CNPH-587 concerning the area under the disease progress curve (ADPC) (Table 1).

The lack of significant differences between the progeny of populations CNPH-561 and CNPH- 586 may be related to the crop year being unfavorable to disease or a high degree of tropical germplasm in these populations. These facts made all the progenies of these populations exhibit a high level of tolerance to leaf blight, which could not be detected by testing differences by F test. Assessing populations of the same genealogy, Carvalho et al. (2005) found significant differences for both MRM and ADPC, demonstrating the interference of the year in the selection of more tolerant progenies.

The coefficients of environmental variation showed values from 6.43 to 10.63% for MRM and TRM, indicating good experimental precision, and ADPC ranged from 16.79 to 25.99%. However, these values can also be considered to represent good accuracy, because this is a character that is more influenced by the environment.

The values of broad-sense heritability ranged from 0.57 to 0.79 for ADPC and TRM, respectively. These values can be considered moderate to high. Similar values for heritability of carrot yield components, ranging between 0.29 and 0.58, have been reported by Alves et al. (2006), who studied progenies obtained from cv. Brasília and Priya & Santhi (2015) reported value of 0.35 for TRM on the heritability estimate among 60 carrot cultivars grown in India. On the other hand Singh et al. (2019) and Meghashree et al. (2018) reported values above 0.90 in winter carrot, probably due to the high genetic variability in the genotypes evaluated by these authors.

Table 1. Summary of analysis of variance, and estimates of genetic parameters, heritability (h^2), genetic variation coefficient (CVg) and the relationship between genetic variation coefficient and experimental (CVg/CVe) among progenies for marketable roots mass (MRM) and total roots mass (TRM) in t ha^{-1} and area under the disease progress curve (ADPC) for leaf blight for populations CNPH-561, CNPH-586 and CNPH-587 evaluated in the Federal District at harvest 2010/11. Brasília, Federal District, Brazil, Embrapa Hortaliças, 2019.

	CNPH-561			CNPH-586			CNPH-587		
	MRM	TRM	ADPC	MRM	TRM	ADPC	TRM	MRM	ADPC
MS	53.51*	49.54*	685.94^{ns}	55.74*	48.56*	1172.57^{ns}	28.47*	25.53*	2,015.26*
CV (%)	10.13	8.65	25.99	10.63	6.47	18.86	6.43	7.94	16.78
Means	43.00	49.91	102.58	41.37	48.81	119.20	46.33	39.77	138.83
$\hat{h}^2$	0.65	0.62	-	0.65	0.79	0.57	0.69	0.61	0.73
CVg (%)	9.66	7.87	-	10.31	9.00	15.32	6.75	15.32	19.55
CVg/CVe	0.95	0.91	-	0.97	1.39	0.81	1.05	0.88	1.17

* Significant at 5% by the F test; ^{ns} not significant at 5% by the F test.

For ADPC, populations CNPH-561 and CNPH-586 showed lower heritability, CVg and CVg/CVe relationship, i.e., a condition that is unfavorable to selection. However, population CNPH-587, with a higher heritability of 0.73, which indicates the possibility of direct ADPC gains for this character, although the average severity of the leaf blight was greater than the other two populations. The population CNPH-561 showed the lowest ADPC, that is, the highest tolerance level, a fact possibly due to the higher percentage of tropical genotype in the population (87.5%).

However, genotypic variability was lower than the phenotypic, thus not allowing the estimates of genetic parameters needed for the selection process.

A higher proportion of tropical-origin germplasm in relation to temperate population at CNPH-561 led to a higher level of tolerance to the disease, but lower genetic variability. This can be explained by its origin, which was the hybridization between Juliana hybrid (summer-season cultivars) and BRS Planalto. As mentioned by Vieira et al. (1991), Le Clerc et al. (2015) and Du Toit and Le Clerc (2019), resistance to leaf blight has polygenic inheritance, and as crossing did not provide sufficient variability for selection gains by the evaluation methodology adopted, it should focus only on selecting characters and yield components (MRM and TRM).

Heritability values similar to that observed for the population CNPH-587 were mentioned by Vieira et al. (1991); these ranged from 0.46 to 0.76, depending on the population studied. Similar values were also observed by Silva et al. (2009), ranging from 0.33 to 0.79 for five populations in the Brasília groups. However, Boiteux et al. (1993) found values from 0.40±0.16 to progenies from the same group (Brasília). These variations can be explained by several reasons, because they relate to different populations and thereby to different degrees of genetic variability. In addition, there are differences in methodology and in different environmental conditions.

The CVg had values between 6.75 and 19.55%, being generally lower than those for CVe. According to Cruz et al. (2012), the CVg/CVe ratio is of the utmost importance for breeding. According to these authors, values greater than one are favorable to selection. The values of this ratio were values greater than one only for TRM of the CNPH-586 population and ADPC of the CNPH-587 population, i.e., for these characters in the aforementioned populations larger gains with selection are expected.

According to the estimates of direct and correlated responses for the CNPH-561 population (Table 2), the selections for MRM and TRM provide similar gains, and selection in TRM and response in MRM and TRM or vice versa. The direct gains for the characters MRM and TRM were 9.61% and 6.09%, respectively. In this population the estimated correlated response was 6.41% for TRM with a selection index of 20% on the character MRM. Note that the response correlated to MRM was 9.15%, when the best progenies were selected as the TRM. The correlated response to the characters MRM and TRM proved an important strategy because they were similar or even higher than the direct gains.

Table 2. Estimates of responses to direct and correlated selection (index = 20%) for the characters marketable roots mass (MRM, t ha^{-1}), total root mass (TRM, t ha^{-1}) and area under the disease progress curve (ADPC) for leaf blight for populations CNPH-561, CNPH-586 and CNPH-587 evaluated in the Federal District at harvest 2010/11. Brasília, Federal District , Brazil, Embrapa Hortaliças, 2019.

CNPH-561										
		Selection in MRM			Selection in TRM			Selection in ADPC		
Response	Xo	Xs	Gs	Gs%	Xs	Gs	Gs%	Xs	Gs	Gs%
MRM	43.01	49.41	4.13	9.61	49.11	3.94	9.15	43.81	0.52	1.21
TRM	49.91	55.04	3.2	6.41	55.43	3.45	6.9	50.84	0.59	1.17
ADPC	102.58	102.58	-	-	96.38	-	-	78.63	-	-
Total gain			7.33	16.02		7.38	16.05		1.11	2.38
CNPH-586										
		Selection in MRM			Selection in TRM			Selection in ADPC		
Response	Xo	Xs	Gs	Gs%	Xs	Gs	Gs%	Xs	Gs	Gs%
MRM	41.37	48.35	4.56	11.01	48.35	4.56	11.01	40.11	-0.82	-1.98
TRM	48.81	54.55	4.56	9.35	54.55	4.56	9.35	48.69	-0.1	-0.2
ADPC	119.2	122.46	1.85	1.55	122.46	1.85	1.55	95.42	-13.52	-11.35
Total gain			10.97	21.91		10.97	21.91		-14.44	-13.53
CNPH-587										
		Selection in MRM			Selection in TRM			Selection in ADPC		
Response	Xo	Xs	Gs	Gs%	Xs	Gs	Gs%	Xs	Gs	Gs%
MRM	39.77	44.46	2.85	7.17	43.65	2.36	5.95	39.69	-0.05	-0.13
TRM	46.33	51.21	3.36	7.25	51.42	3.5	7.56	45.46	-0.6	-1.3
ADPC	138.83	124.02	-10.83	-7.8	146.52	5.62	4.05	93.7	-32.98	-23.76
Total gain			-4.61	6.62		11.49	17.56		-33.63	-25.19

Xo: initial population mean; Xs: selected population mean; Gs: selection gain and Gs (%): selection gain in percentage.

Obtaining responses correlated to lower ADPC was feasible only for the population CNPH-587, by the selection of MRM, which had a direct response of 7.17% and correlation of 7.25% to TRM and -7.80 % to ADPC. However, direct selection of TRM showed a direct response of 7.56% and correlation of 5.95% to MRM and 4.05% to ADPC; i.e., selection based on TRM provides a

DOI: 10.37856/bja.v95i3.3710

reduced level of tolerance to leaf blight, which is favorable. The high and negative correlation (-0.77) between MRM and tolerance to leaf blight was demonstrated by Brito et al. (1997). These results agree with those presented by Pereira et al. (2012) and Carvalho et al (2016), who found a negative correlation between the MRM (-0.52 and -0.31) and TRM (-0.59 and -0.47) of populations 561 and 586 with the leaf blight severity. The fact that the MRM is correlated with ADPC makes sense, since plants were more tolerant to leaf blight and kept their leaves for longer, thereby enabling conditions for the development of the roots until they reach a marketable standard.

The response to selection based on ADPC presented a direct response to selection of 23.76%. However, little or no gains for yield components were seen. In fact, the effect of this selection would be virtually nil in MRM, and TRM decreased by 1.30%. Thus, the simultaneous selection of characters must be held in MRM.

According to Cruz et al. (2012), most traits of economic importance are correlated. Thus, knowing the strong correlation between MRM and ADPC the selection process adopted can be based on tolerance to leaf blight, while the population shows great variability. When this variability is exhausted, the selection process can be continued with selection based on the MRM until the population can be indicated. The CNPH-561 population has the highest tolerance level to leaf blight, but lower genetic variability to obtain higher gains with selection for this character.

CONCLUSION

Selection for leaf blight, for direct or correlated response, proved to be efficient only for the CNPH-587 population, and direct response was more efficient. The direct selection of MRM, in populations with high genetic variability, is more promising than selection in TRM and ADPC, since it provides gains in desired directions for all traits under selection.

REFERENCES

ALVES, J.C.S; PEIXOTO, J.R.; VIEIRA, J.V.; BOITEUX, L.S. 2006. Herdabilidade e correlações genotípicas entre caracteres de folhagem e sistema radicular em famílias de cenoura, cultivar Brasília. **Horticultura Brasileira**, Brasília, v. 24, n. 3, p. 363-367.

BOITEUX, L.S.; DELLA VECCHIA, P.T.; REIFSCHNEIDER, F.J.B. 1993. Heritability estimate for resistance to *Alternaria dauci* in carrot. **Plant Breeding**, Berlin, v. 110, n. 2, p. 165–167.

BRITO, C.H.; POZZA, E.A.; JULIATTI, F.C.; LUZ, J.M.Q.; PAES, J.M.V. 1997. Resistência de cultivares de cenoura (*Daucus carota* L.) a queima das folhas durante o verão. **Revista Ceres,** Viçosa, v. 44, n. 253, p. 371-379.

CARVALHO, A.D.F.; SILVA, G.O.; PEREIRA, R.B.; PINHEIRO, J.B. 2015. Productivity and tolerance to the leaf blight disease of hybrid and open-pollinated carrot cultivars. **Horticultura Brasileira**, Brasília, v. 33, n. 3, p. 299–304.

CARVALHO, A.M.; JUNQUEIRA, A.M.R.; VIEIRA, J.V.; REIS, A.; SILVA, J.B.C. 2005. Produtividade, florescimento prematuro e queima-das-folhas em cenoura cultivada em sistema orgânico e convencional. **Horticultura Brasileira**, Brasília, v. 23, n. 2, p. 250-254.

CARVALHO, A. D. F.; SILVA, G. O.; PEREIRA, R. B. 2016. Capacidade de combinação de genitores de cenoura para caracteres de produtividade de raízes e tolerância à queima-das-folhas. **Revista Ceres**, Viçosa, v. 63, n. 2, p. 183-190.

CRUZ C.D. 2013. Genes– a software package for analysis in experimental statistics and quantitative genetics. **Acta Scientiarum**, Maringá, v. 35, n. 3, p. 271-276.

CRUZ, C.D.; REGAZZI, A.J.; CARNEIRO, P.C.S. 2012. **Modelos biométricos aplicados ao melhoramento genético**. Viçosa: UFV. 4th ed. 514p.

DU TOIT, L.J.; LE CLERC, V.; BRIARD, M. 2019. **Genetics and Genomics of Carrot Biotic Stress**. In: SIMON, P. W.; IORIZZO, M.; GRZEBELUS, D.; BARANSKI, R. (eds) The Carrot Genome. Compendium of Plant Genomes. New York: Springer, 1st ed. 372 p.

FALCONER, D.S. 1989. **Introduction to quantitative genetics**. New York: Longman Group. 3rd ed., 438p.

FILGUEIRA, F.A.R. 2008. **Novo manual de olericultura***:* agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa: UFV. 3rd ed., 412 p.

GAUBE, C.; DUBOUR, C.; PAWELEC, A.; CHAMONT, S.; BLANCARD, D.; BRIAND, M. 2004. Brûlures foliaires parasitaires de la carotte: *Alternaria dauci* sous surveillance. **PHM Revue Horticole**, Paris, v. 445, n. 1, p. 15-18.

HALLAUER A.R.; MIRANDA FILHO, J.R. 1981. **Quantitative genetics in maize**. Ames: Iowa State University. 1st ed. 468p.

INMET - Instituto Nacional de Meteorologia. 2019. Available at < http://www.inmet.gov.br/portal/index.php?r=estacoes/estacoesConvencionais>. Accessed on: Oct. 28, 2019.

IBGE - Instituto Brasileiro de Geografia e Estatística, 2017. **Horticultura: número de estabelecimentos agropecuários e quantidade produzida por produtos da horticultura.** Available at: <https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/21814-2017-censo-agropecuario.html?edicao=21858&t=resultados > Accessed on: Oct. 23, 2019.

KOIKE, S.T.; SMITH, R.F.; CAHN, M.D.; PRYOR, B.M. 2017. Association of the carrot pathogen *Alternaria dauci* with new diseases, Alternaria leaf speck of lettuce and celery in California. **Plant Health Progress**, Saint Paul, v. 18, n. 2, 136-143.

LE CLERC, V.; MARQUES, S.; SUEL, A.; HUET, S.; HAMAMA, L.; VOISINE, L.; AUPERPIN, E.; JOURDAN, M.; BARROT, L.; PRIEUR, R.; BRIARD, M. 2015. QTL mapping of carrot resistance to leaf blight with connected populations: stability across years and consequences for breeding. **Theoretical and Applied Genetics**, Berlin, 2015, v. 128, n. 11, p. 2177-2187.

LOPES, C. A.; REIS, A. 2016. **Doenças da cenoura**. Brasília: Embrapa Hortaliças, 67p.

MARCUZZO; L.L.; TEIXEIRA, V.R. 2019. Caracterização do progresso da queima das folhas em diferentes genótipos de cenoura. **Summa phytopathologica**, Botucatu, v. 45, n. 2, p. 219-222.

MEGHASHREE, J.R.; HANCHINAMANI, C.N; HADIMANI. H.P.; NISHANI, S.; RAMANAGOUDA, S.H.; KAMBLE, C. 2018. Genetic Variability Studies for Different Attributes in Carrot Genotypes (*Daucus carota* L.) under Kharif Season. **International**

Journal of Current Microbiology and Applied Sciences, Tamilnadu, v. 7, n. 12, p. 3419-3426.

PEREIRA, A.S.; TAI, G.C.C.; YADA, R.Y.; TARN, T.R.; SOUZA-MACHADO, V.; COFIN, R.H. 1994. Effect of selection for chip color on some economic traits of potatoes. **Plant Breeding**, Berlin, v. 113, n. 4, p. 312–317.

PEREIRA, R.B.; CARVALHO, A.D.F.; PINHEIRO, J, B.; SILVA, G.O.; VIEIRA, J.V. 2012. Resistência de populações de cenoura à queima-das-folhas com diferentes níveis de germoplasma tropical. **Horticultura Brasileira**, Brasília, v. 30, n. 3, p. 489-493.

PRIYA, P.A.; SANTHI, V.P. 2015, Variability, character association and path analysis for yield and yield attributes in carrot (*Daucus carota* L.). **Electronic Journal of Plant Breeding**, Tamil Nadu, v. 6, n. 3, p. 861-865.

PRYOR, B.M.; STRANDBERG, J.O.; DAVIS, R.M.; NUNEZ, J.J.; GILBERTSON, R.L. 2002. Survival and persistence of *Alternaria dauci* in carrot cropping systems. **Plant Disease**. Saint Paul, v. 86, n. 10, p. 1115-1122.

SHANER, G.; FINNEY, R. E. 1977. The effect of nitrogen fertilization on the expression of slow mildewing resistance in knox wheat. **Phytopathology**. Saint Paul, v. 67, n. 8, p. 1051-1056.

SILVA, G.O.; SOUZA, V.Q.; PEREIRA, A. S.; CARVALHO, F.I.F.; FRITSCHE NETO, R. 2006. Early generation selection for tuber appearance affects potato yield components. **Crop Breeding and Applied Biotechnology,** Viçosa, v. 6, n. 1, p. 73-78.

SILVA, G.O.; VIEIRA, J.V.; VILELA, M.S.; REIS, A.; BOITEUX, L.S. 2009. Parâmetros genéticos da resistência ao complexo da queima-das-folhas em populações de cenoura. **Horticultura Brasileira**, Brasília, v. 27, n. 3, p. 354-356.

SIMON, P.W.; GEOFFRIAU, E.; ELLISON, S.; IORIZZO, M. 2019. Carrot Carotenoid Genetics and Genomics. In: SIMON, P.W.; IORIZZO, M.; GRZEBELUS D.; BARANSKI, R. (eds). **The Carrot Genome. Compendium of Plant Genomes**. New York: Springer, p. 247-260.

SINGH, S.R.; AHMED, N.; RANJAN, J.K.; SRIVATAVA, K.K.; DINESH K.; YOUSUF, S. 2019. Assessment of genetic variability, character association, heritability and path analysis in European carrot (*Daucus carota* var. sativa) **Indian Journal of Agricultural Sciences**, New Delhi, v. 89, n. 7, n. 1140–1144.

TÖFOLI, J.G.; DOMINGUES, R.J. 2010. Sintoma, etiologia e manejo da queima das folhas (*Alternaria dauci*; *Cercospora carotae*) na cultura da cenoura. **Biológico**, São Paulo, v.72, n. 1, p. 47-50.

VIEIRA, J.V.; CASALI, V.W.D.; MILAGRES, J.C.; CARDOSO, A.A.; REGAZZI, A.J. 1991. Heritability and genetic gain for resistance to leaf blight in carrot (*Daucus carota* L.) populations evaluated at different times after sowing. **Revista Brasileira de Genética**, Ribeirão Preto, v. 14, n. 2, p. 501-508.

Received in: September, 3, 2020
Accepted in: November, 11, 2020