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GENETIC PARAMETER ESTIMATES AND EFFICIENCY OF THREE SELECTION PROCEDURES IN CARROT BREEDING, VARIETY CAMPINAS*

Walter José Siqueira[1], Rolf Dieter Illg[2], João Baptista Fornasier[1+], Newton Prado Granja[1], Rogério Sales Lisbão[1+] and Rui Ribeiro dos Santos[1]

ABSTRACT

The potential for genetic breeding of the carrot variety "Campinas" was assessed through estimates of the genetic-statistical parameters of 16 traits of agronomic importance. The parameters were obtained from 102 half-sib progenies, harvested in a seed production field. Two experiments were carried out in Randomized Complete Blocks in the fall-winter and spring-summer planting periods. To compare the three selection methods, usually employed in population breeding genetics the expected genetic gains were estimated considering each block or plot as strata, and mass selection between and within the half-sib progenies. Samples of 15 marketable roots per plot were evaluated at the individual level for the characters root length (RL) and root shape index (SI). A joint analysis of variance, weighted for the differences in number of replications between the experiments was performed for the six common traits. The results of the genetic parameter estimates of the single variance analysis indicated that the variety Campinas was best adapted to the fall-winter planting period. Heritabilities greater than 60% were observed for the majority of traits assessed at the plot level. The selecction against the trait premature flowering (PF) may result in satisfactory genetic gain in the two environmental conditions because of the high genetic variability coefficients obtained. The percentage of marketable cylindrical roots (MCR) demonstrated an expected genetic gain per cycle of only 4.82% in the fall-winter period, probably because it had already been selected, for various cycles, under these environmental conditions. On the other hand, in the spring-summer planting period, the genetic gain was estimated to be 14.44%. Total and marketable yields were high in the fall-winter period and low in the spring-summer period. For the traits RL and SI, assessed at the individual level, the stratified mass selection, considering each plot as strata, was less efficient in relation to the other proposed selection methods. Therefore it is concluded that breeding of the variety Campinas, based on the performance of the half-sib progenies for root quality and yield is fairly promising within each planting period, but simultaneous selection for both periods is difficult.

INTRODUCTION

The carrot *Daucus carota* is a cross pollinated and polymorphic species, with high genetic variability for several root and plant traits such as coloring, diameter, shape, length, soluble solids (root), disease resistance, earliness, vigor, flowering (plant), etc. It is best adapted for cultivation in temperate and subtropical areas and is sensitive to frosts. It is generally speaking a biennial crop with flowering induced by low temperatures. Some populations of Asian origin, however, behave like annuals and flowering is induced by a long and increasing photoperiod (Casali *et al.*, 1984). Traditional carrot cultivation in São Paulo State, as in the southeastern and central western regions of the country, is carried out in the fall-winter, a period of predominantly low temperatures, using the French cultivar Nantes which has commercially acceptable cylindrical roots. Varieties developed for high temperature cultivation are also available. However, this summer germplasm still presents some disadvantages, especially in the variation of root shape (selections "Kuroda", "Kuronan", "Brasilia", "Tropical", and "Campinas") and premature flowering in the long photoperiod at subtropical latitudes (12.5 hours of light) in the spring-summer period ("Tropical", "Brasilia" and

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[1] Instituto Agronômico, Caixa Postal 28, 13001-970 Campinas, SP, Brasil. Send correspondence to W.J.S.

[2] Departamento de Genética e Evolução, UNICAMP, Caixa Postal 6109, Campinas, SP, Brasil.

[+] Deceased.

''Campinas''). These last three varieties are, on the other hand, suitable for all year planting in latitudes near the Equator or under conditions of shorter days (winter) at greater latitudes (Costa, 1974; Vieira *et al.*, 1983 and Camargo, 1984). For example, recurrent selection based on families for half-sibs was used for the development of the varieties Brasília and Kuronan (Vieira *et al.*, 1983). Also, simple mass selection within populations *per se* or within cross derived populations has been successful in the genetic improvement of this species (Banga, 1976).

Ikuta and Vencovsky (1971) carried out recurrent selection on the oriental variety Kuroda Gossum for the root characteristics, shape, shoulder diameter and length. McCollum (1971), using half-sib and S1 progenies from three carrot populations, they obtained heritability values slightly smaller than 25% for green shoulder, between 38 and 56% for root formation and very low for root weight, length and diameter.

Vieira *et al.* (1979), using 92 half-sib progenies of the commercial variety Kuroda, which is adapted for summer planting, found a narrow sense haritability of only 2.2% for resistance to leaf blight (Reifschneider, 1980, 1983). In spite of its resistance to leaf blight and heat, this variety has reduced commercial value, even in times of product shortage, due to the pronounced conical shape of the roots (Filgueira, 1982).

Intrapopulational selection in carrots can lead to substantial genetic gain for several traits of agronomic interest. Commercial varieties, mainly those resistant to leaf blight and, therefore, tolerant to cultivation under high temperature conditions, still have a reasonable genetic variability available for selection. This variability can be used to improve many commercial traits of the carrot (Vieira and Casali, 1984). In this aspect, the variety Campinas (introduced by the IAC in 1965), in spite of having a high resistance to leafburn (Camargo, 1984), has shown wide phenotypic variation in root shape and a tendency to early flowering after a low temperature (fall-winter planting) and/or long photoperiod (spring-summer planting) stimuli. Sensitivity to cold and the photoperiod, which caused premature flowering and undefined rot shape, has hampered its success with farmers.

The objective of this work was to assess the breeding potential of the variety Campinas, in the two traditional planting periods.

MATERIAL AND METHODS

A total of 102 half-sib progenies of the carrot variety Campinas were obtained by randomly harvesting seeds from individual plants in a seed production field, located on the Experimental Station of Monte Alegre do Sul, SP, belonging to the Agronomic Institute of Campinas. In the Experimental Station two experiments, the first sown on April 20 and the second on October 15, 1987 corresponding, respectively, to the fall-winter and spring-summer cultivation, were carried out. The sowing density was approximately 1.0 g of seeds per linear meter in drills across the plot at 25 cm spacing. A Randomized Complete Block design with four and three replications was used for the first and second planting periods, respectively. Each progeny was made up of four lines (1 m^2) with approximately 60 plants per plot. Cultural practices included weed control, irrigation, fertilizing, etc. according to the technical recommendations for carrot cultivation (Instruções Agrícolas para o Estado de São Paulo, 1987).

The progenies (plot level) and individual (within plots) were assessed in the fall-winter experiment. The percentage data were always calculated in relation to the total number of roots harvested in the plot. The traits assessed at the plot level are listed in Table I.

The observations of the traits MCRL, MCRM, MCRS and MCRSP were obtained from the second, third and fourth replications; the remaining were obtained from all four replications. In the spring-summer cultivation period, the data were collected only at the plot level.

The traits assessed at the level of individuals within plots were obtained from fifteen marketable roots randomly sampled from each plot in the first planting period. The individual measurements corresponding to root length (RL) and two diameters, at the shoulder and near the tip of the root, were taken in centimeters. From the diameter data a shape index was defined (SI) and obtained from the ratio between the diameters of the shoulder and the tip.

The analyses of variance were carried out using the average of the plots (first and second planting periods) and individual scores within plots (first planting period) to obtain the respective components of variance and the genetic parameters, according to Vencovsky (1978).

The estimates of the phenotypic variance within plots (d), supplied by the analysis of variance of individuals (first period), allow a comparison among methods of selection. The comparison uses the genetic gain formula and shows the relation between the genetic variance explored in each method and the respective phenotypic variance.

The phenotypic variance is dependent on the experimental unit where selection is applied. Thus, the number of individuals selected should be the same, whatever the method adopted, so that the expressions of genetic gain result in comparable data. The intensity of selection carried out for the stratified mass selection (block and plot) was 10% with k=1.7550, resulting in 612 selected roots. To obtain the same number of selected roots with the selection between and within progenies the selection intensities of 50% between and 20% within progenies were used, with values of k=0.7979 and 1.3998, respectively. The tabulated values of K were found for samples greater than 50 selected individuals, according to Vencovsky (1978). Therefore, the estimates of genetic gain expected for the root length (RL) and shape index (SI) traits at the individual level for the three selection methods were calculated as follows:

Selection between and within half-sib progenies (Gs_p%)

$$GS_p = \frac{1/4\ VA}{\sqrt{Vd/nr + Ve/r + Vp}} \cdot K_{50\%} + \frac{3/4\ VA}{\sqrt{Vd}} \cdot K_{20\%}$$

and

$$GS_p\% = (GS_p/\overline{X}) \cdot 100$$

Stratified mass selection in both sexes, where each block is a strata (GS_b%)

$$GS_b = \frac{VA}{\sqrt{V_d + V_e + V_p}} \cdot K_{10\%}$$

and

$$GS_b\% = (GS_b/\overline{X}) \cdot 100$$

Stratified mass selection in both sexes, where each plot is a strata (GS_d%)

$$GS_d = \frac{3/4\ VA}{\sqrt{V_d}} \cdot K_{10\%}$$

and

$$GS_d\% = (GS_d/\overline{X}) \cdot 100$$

Joint analysis of variance

Joint analyses of variance were carried out for the phenotypic characteristics common to both planting periods. The different number of replications in the two experiments were considered in the analysis (weighted).

All the effects of the models were considered random, except the average, because the two planting periods cover a wide range of temperature and photoperiod. This allowed a correct assessment of the progenies for future selection for a variety which can be recommended for all year planting. The sums of the squares of the source of the variation of the weighted joint analysis of variance were developed from the expressions of degrees of freedom as suggested by Silva (1980).

The structure of the joint analysis of variance and the E(M.S.), considering the random model, are as follows:

S.V.	M.S.	E(M.S.)
Blocks/Period	-	-
Periods (EP)	MS_{EP}	$Ve + q_4Vpa\ q_5Va$
Progenies (P)	MS_P	$Ve + q_2Vpa + q_3Vp$
EP x P	MS_{EPxP}	$Ve + q_1Vpa$
Pooled error	MS_R	Ve

As this is a model for analysis of variance of cross classification for unweighted data and because of the distinct number of replications in each experiment, L.H. Waddell's simplified algorithm quoted by Silva (1980) was applied, to obtain the coefficients q_1, q_2, q_3 and q_4 of the expected mean square components. For the progenies F test, it was necessary to obtain the mean square for the offspring x periods interaction (M.S. EP x P) as suggested by Sokal and Rohlf (1969). The degrees of freedom of this interaction was also determined using a general formula indicated by Sokal and Rohlf (1969). The estimates of the genetic parameters of the joint analysis of variance, which involve the use of the coefficients q_1, q_2, q_3 and q_4 are as follows:

Coefficient of genetic variation (Cvg%)

$$CVg\% = (\sqrt{(MS_P - MS_{EPxP})}\ /\overline{X}$$

where q_3 = coefficient of the Vp component.

Narrow sense heritability (h_n%)

$$h_n\% = \frac{Vp}{1/q_3\,(V_e + q_2\ Vpa) + Vp} \cdot 100$$

where

$$Vp = \frac{MS_P - MS_{EPxP}}{q_3}$$

Expected genetic gain (Gs%)

$$Gs = \frac{Vp}{\sqrt{1/q_3\,(V_e + q_2\ Vpa) + Vp}} \cdot K_{10\%}$$

Gs% = (Gs'%/$\overline{X}$') where Gs' and $\overline{X}$' are Gs and $\overline{X}$ scaled back from arcsin $\sqrt{\%}$ to the original percentage unit.

RESULTS AND DISCUSSION

Genetic parameters in two planting periods

The results of the estimates of the genetic parameters are shown in Tables I and II for the first and second planting periods, respectively. The heritability coefficients for the premature flowering trait at the plot level were high in both experiments. Genetic control of the early flowering or early panicle trait has been little studied by plant breeders (Vieira and Casali, 1984). Della Vecchia and Pessoa (1984), using early flowering means from half-sib progenies of the varieties Brasília and Kuronan, estimated heritability values of 94.6% and 77.9%, respectively. According to these authors, all the other traits studied relative to marketable root production have enough additive genetic variability for significant genetic gain with selection among progenies means. The values found for the genetic variation coefficient were high, 32.47% and 24.63%, respectively, for the first and second experiments. When the relation CVg/Cve is close to or larger than one, conditions are favorable for selection according to experiments made with maize (Vencovsky, 1978). The respective values of this ratio, called b, found for PF in the first and second periods, showed high genetic variability (Tables I and II). The expected estimates of genetic gain, in percentages based on selection among half-sib families were high for PF. The estimated value for the fall-winter period was higher than that obtained for the spring-summer period of (Tables I and II). The higher values in the fall-winter may be due to the greater genetic variation observed in this period, since the heritability coefficients are almost the same.

Table I - Genetic parameter estimates for the selection between half-sib progenies with traits assessed at the plot level in the fall-winter planting.

Traits	Average (%, g)	h^2 (%)	Cvg(%)	CVe(%)	b	Gs(%)
	- % -					
PF	16.54	90.76	32.47	20.72	1.57	30.73
MKR	23.92	77.09	18.58	20.26	0.92	8.89
MCR	51.55	80.84	12.60	12.27	1.03	4.89
MCRR	22.78	74.93	16.76	19.39	0.86	7.01
MCRP	27.24	74.41	14.18	16.63	0.85	5.08
MCRL	6.10	48.04	19.17	34.55	0.55	5.55
MCRM	23.78	64.03	12.40	13.10	0.77	3.30
MCRS	18.32	67.52	15.84	19.03	0.83	5.55
MCRSP	9.05	68.61	22.27	26.08	0.85	10.78
DEF	4.06	70.16	31.33	40.85	0.77	21.42
	- g -					
AWMCR	115.41	48.10	7.50	15.58	0.48	9.13
AWMCL	112.24	68.47	7.27	9.87	0.74	10.56
MP	5,431.54	85.08	15.63	13.09	1.19	25.30
TP	7,228.69	66.74	6.10	8.62	0.71	8.75

In percentage (%): PF = Plants with premature flowering during the vegetative stage; MKR = marketable conical roots, without defects and minimum length of 7 cm; MCR = marketable cylindrical roots with the same characteristics as above; MCRR = marketable cylindrical roots with rounded point; MCRP = marketable cylindrical roots with pointed end; MCRL = marketable long cylindrical roots (> 17 cm); MCRM = marketable medium length cylindrical roots (> 12 to 17 cm); MCRS = marketable short cylindrical roots (7 to 12 cm); MCRSP = marketable special cylindrical roots, typically cylindrical obtained from the long and medium classes; DEF = defective roots (splits, green shoulder, dividing, secondary roots and others.

In grams (g): AWMCR = Average weight of marketable conical roots obtained from the respective ratio weight/number of marketable conical roots; AWMCL = average weight of marketable cylindrical roots, defined by the ratio between weight/number of marketable cylindrical roots; MP = marketable production, obtained from the sum of the weight of marketable conical and cylindrical roots; TP = total production which includes the weight of roots from flowered plants and those with defects. h^2: Heritability coefficient; CVg: Coefficient of genetic variation; CVe: Coefficient of environmental variation; b: CVg/CVe; Gs: Expected genetic gain.

Table II - Genetic parameters estimates for the selection between half-sib progenies with traits assessed at plot level in the spring-summer planting.

Traits	Average (%, g)	h^2 (%)	CVg (%)	CVe (%)	b	Gs (%)
	- % -					
PF	43.94	91.48	24.63	13.02	1.89	19.83
MKR	31.97	91.93	19.15	15.58	1.23	10.34
MCR	12.04	73.39	24.82	25.89	0.96	14.44
DEF	7.87	54.56	19.37	24.89	0.78	6.47
	- g -					
AWMCR	79.06	59.25	9.77	14.04	0.70	13.20
AWMCL	89.42	37.62	6.80	15.17	0.45	7.32
MP	2,349.29	87.76	35.50	22.97	1.54	58.37
TP	4,432.68	81.97	15.15	12.31	1.23	24.08

See Table I for abbreviations.

The preliminary results obtained for the PF trait indicate the possibility of success of applying divergent selection to the Campinas variety, obtaining two subpopulations. One subpopulation would be selected for insensitivity to premature flowering in plants under low temperature conditions, present in the fall-winter period, while the other sub-population would be selected for insensitivity to high temperature conditions and a long and increasing photoperiod, present mainly in spring sowings in the months of October, November and December. Another possibility is the obtaining of a commercial variety for the traditional fall-winter carrot planting period which could have its crop cycle complete from seed to seed without using refrigeration or root vernalization techniques, which are necessary for the varieties from the Nantes group (Filgueira, 1982). After the normal vegetative cycle for the variety, the more specialized farmers can choose to keep a separate plot of plants for seed production or even harvest all the crop and select roots, according to their own criteria and plant them in the second semester to induce flowering. It is true, however, that several selection cycles for several planting dates and locations in the period in question, are necessary for the production of material sufficiently stable to assure adequate balance in the vegetative and reproductive phase without damage to the commercial product during successive plantings. Also, Sonnenberg *et al.* (1979) comparing the behaviour of the variety Tropical with the varieties Nantes and Kuroda, discuss the prospect of using annual varieties for seed production in countries where the temperatures are not low enough to cause flowering of biennial varieties under field conditions.

The heritability coefficients for the rate of production of MCR was similar in the two seasons. The genetic variation coefficient obtained for the spring-summer cycle was almost double the value found for the fall-winter, resulting in a much higher estimate of relative genetic gain (Tables I and II).

Quicker responses are therefore expected with selection for the MCR trait in the spring-summer planting even though the general average of this experiment has been small, 12.04% because the material has not suffered selection pressure under the environmental conditions of this planting period. it was observed that the variety Campinas still has a reasonable amount of genetic variability to be explored for genetic improvement in this alternative carrot planting period. Greater genetic gains for the fall-winter period will be more difficult to obtain to judge by the high average of 51.55% for the MCR trait and the consequent gradual reduction of the genetic variability with successive selection cycles. The potential of the variety Campinas evaluated through the estimates of the genetic parameters obtained for selection for cyclindrical formation and absence of premature flowering in both planting periods is evident. Della Vecchia and Pessoa (1984) also found high heritability values, although inferior to those of the present study, for the percentage of marketable roots in the varieties Brasília and Kuronan in the hot period of the year (December 1983 to March 1984).

The two planting periods, which showed marked climate contrasts, did not present accentuated proportions of defective roots, even with the grouping of all the defect types in a single trait. Further, the higher genetic gains values are expected for the highly desirable traits of round-pointed cylindrical root production in comparison with the complementary trait of fine point and of special cylindrical roots.

The heritability coefficient was high for AWMCL in the first experiment, but decreased noticeably when the half-sib progenies were subjected to the spring-summer experimental conditions, where a lower heritability was observed in all the assessed traits, showing limited additive genetic variability available for selection (Table I). Therefore, the spring-summer genetic gain estimate obtained for AWMCR was higher than for AWMCL due to differences, between the two traits, in the existing additive genetic variability. The estimates of the additive genetic variability obtained in the present study, indicate that the average weights of the marketable cylindrical roots can be increased through breeding in the fall-winter and, with greater difficulties, in the spring-summer period, where the climatic conditions are limiting for root development. The MP trait in the second experiment, in spite of the mean of only 2.4 kg/m^2 showed ample additive genetic variability for selection, thus resulting in a higher genetic gain estimate comparated to those obtained for the other traits assessed (Table II).

Comparison of the three selection methods in the fall-winter period

Table III shows the heritability coefficients at the individual within progenies level for plots and blocks and between the means of half-sib progenies. Table III also shows the general progenies mean, the genetic and experimental coefficients of variation and the predicted genetic gains from the three proposed selection methods in the two assessed traits (stratified mass selection taking each plot and block as strata and selection between and within the half-sib progenies of both sexes). Within the present experimental conditions, low genetic gains were observed in the calculation for the RL trait in the three selection methods because of the reduced additive genetic variability available in the population. The selection between and within the half-sib progenies for RL was shown to be as efficient as stratified mass selection with blocks. The estimated genetic gains for SI were reasonable for the three proposed selection methods to judge by the low genetic variation coefficient obtained (Table III). The estimate of the expected genetic gain based on selection among and within the half-sib off progenies was greater than for the two alternate methods of stratified mass selection, although it was nearer to the value obtained for the genetic gain of blocks as strata. Based on estimates of the genetic parameters for the RL and SI traits, the least efficient selection method was the stratified mass selection taking each plot as a strata. On the other hand, as the results of the methods based on selection among blocks were practically the same as the expected genetic gains (Table III), the latter is recommended because of its greater functionality. The stratified mass selection generally allows high selection intensities without harming the genetic variability necessary for the next cycles (Paterniani and Miranda Filho, 1978). Similar results about the superiority of the method of stratified mass selection within blocks in relation to other methods are found in the literature for some species of vegetables such as ''broccoli'' *Brassica oleraceae* var. italica (Dias *et al.*, 1971); onion *Allium cepa* (Buso, 1978); cauliflower *Brassica oleraceae* var. *botrytis* (Buso *et al.*, 1980 and Baldini and Silva, 1985). Vieira *et al.*, 1979, compared two selection methods, stratified mass selection and selection among and between half-sib progenies for resistance to *Alternaria dauci* in the Kuroda variety, and found low heritability and genetic gain coefficients in both methods. The authors justified the low estimate levels because the variety already had a good resistance level to the disease.

Table III - Genetic parameter estimates for selection between and withing in half-sib progenies ($h^2b\%$, $Gs_p\%$) mass selection in each block ($h^2b\%$, Gs_b) and in each plot ($h^2d\%$, $Gs_d\%$) as strata, for 102 half-sib progenies in the fall-winter planting.

Traits	Unit	Average	$h^2p\%$	$h_2d\%$	$h^2b\%$
RL	cm	14.08	48.92	18.12	19.39
SI	--	0.62	68.62	16.82	20.53

Traits	Unit	$Gs_p\%$	$Gs_d\%$	$Gs_b\%$	Cve%	Cvg%	b
RL	cm	4.37	3.56	4.25	5.62	2.75	0.50
SI	--	9.44	7.11	9.07	7.71	5.70	0.74

RL = Root length.
SI = Shape index.

Joint analysis of variance

Within the perspective of future development of a variety suitable for all year planting in the state of São Paulo, the genetic parameters were estimated from the joint analysis of the two experiments. The genetic variation coefficients were low for the traits TP, MCR and DEF, average for MP and MKR and high for PF (Table IV). The narrow sense heritability coefficients were high for the traits PF (66.01%), MP (61.51%) and MCR (50.19), moderate for TP (46.27%) and low for DEF (28.0%) (Table IV). Among the traits assessed in percentages the selection against PF showed the greatest gain estimate. The traits MKR and MCR showed reduced expected genetic gains (Table IV). The low additive genetic variability available for simultaneous selection in the two environmental conditions where the experiments were carried out shows the need to improve the experimental techniques to reduce the environmental effects and allow greater genetic gains. For the traits assessed in grams per plot, a considerable estimate for genetic gain for the trait MP of 20.24% was obtained from the joint analysis of variance (Table IV). Considering the average obtained for the joint analysis of roughly 4.10 kg/m2, and the loss of 35% of usable area in a hectare due to the spacing between beds, an increase of about 5.0 ton/ha of marketable roots is expected in a single selection cycle. The expected genetic gain of 6.94% for TP was considered reasonable to judge by the low genetic variation coefficient of observed for this trait (Table IV).

Table IV - Genetic parameter estimates taking the selection between half-sib progenies from the joint analysis of variance for common traits assessed at plot level.

Traits	Average (%, g)	h^2 (%)	Cvg (%)	Cve (%)	b	Gs (%)
	- % -					
PF	27.32	66.01	20.89	16.34	1.28	9.74
MKR	27.28	65.13	14.80	18.14	0.82	4.84
MCR	32.77	50.19	10.33	15.71	0.66	1.86
DEF	5.54	28.00	12.84	35.58	0.36	1.45
	- g -					
MP	4,110.58	61.51	14.78	15.76	0.94	20.34
TP	6,030.40	46.27	5.80	9.84	0.59	6.92

See Table I for abbreviations.

CONCLUSIONS

It can be concluded from the assessments of two planting periods of half-sib progenies of the variety Campinas under experimental conditions that:

The Campinas variety has been shown to be comparatively more adapted to plating under fall-winter climatic conditions rather than spring-summer, showing in the first period, a greater percentage of marketable cylindrical roots, higher total yield and a lower rate of premature flowering.

There is high additive genetic variability for the majority of the traits assessed at plot level. On the other hand, in the traits assessed at the individual level, the genetic variation coefficients were low, showing uniformity of the progenies for root length and shape index for the fall-winter planting period.

The best selection method used was the stratified mass selection taking the blocks as strata, using the estimated genetic gains and the ease of application criteria.

The joint analysis of variance indicated that it would be more difficult to obtain a variety adapted to simultaneous planting in the two planting periods in spite of the additive genetic variability present in all the assessed traits.

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RESUMO

Avaliou-se o potencial da variedade de cenoura ''Campinas'' para o melhoramento genético, através das estimativas de parâmetros genético-estatísticos de 16 caracteres de importância agronômica. Os parâmetros foram obtidos tendo por base 102 progênies de irmãos, coletadas num campo de produção de sementes da referida variedade. Foram feitos dois experimentos em blocos ao acaso com quatro e três repetições, respectivamente, nas épocas de cultivo de outono-inverno e primavera-verão. Para comparar três esquemas seletivos, usualmente empregados no melhoramento genético de populações, estimaram-se os progressos genéticos esperados com a seleção massal estratificada, considerando-se cada bloco ou parcela como estrato e seleção massal entre e dentro de progênies de meios irmãos. Neste caso, avaliaram-se, ao nível individual, através de amostras de 15 raízes comerciáveis por parcela, os caracteres comprimento (COMP) e índice de formato (IF). Realizou-se também a análise de variância conjunta ponderada entre os dois experimentos para seis caracteres comuns. Os resultados das estimativas de parâmetros genéticos das análises de variância simples, indicaram maior adaptação da variedade Campinas para a época de plantio de outono-inverno. Observou-se herdabilidade maior que 60% para a maioria dos caracteres avaliados ao nível de parcelas. A seleção contra o caráter florescimento prematuro poderá resultar em progressos genéticos satisfatórios nas duas condições de ambiente em razão dos elevados coeficientes de variação genética obtidos. A porcentagem de raízes cilíndricas comerciáveis (CILC) apresentou o progresso genético estimado, por ciclo, de 4,82% na época de outono-inverno, provavelmente por já ter sido selecionada nestas condições de ambiente, como indicado pelo coeficiente de variação genética de 12,06% e média geral de 51,55%. Por outro lado, na época de plantio de primavera-verão, apesar da média de CILC ter sido baixa (12,04%), estimou-se o progresso genético de 14,44%. As produções, total e comerciável, foram altas no período de outono-inverno e baixas no período de primavera-verão. Entretanto, existe variabilidade genética aditiva suficiente entre progênies de meios irmãos de modo a permitir progressos genéticos substanciais em ambas as épocas de plantio. Para os caracteres COMP e IF, avaliados ao nível de indivíduos, a seleção massal estratificada, considerando-se cada parcela como estrato, foi o menos eficiente em relação aos demais métodos de seleção propostos. Conclui-se, portanto, que o melhoramento de cenoura, variedade Campinas, baseado no desempenho de progênies de meios irmãos visando a qualidade de raízes e rendimento é bastante promissor dentro de cada época de plantio, mas apresenta maiores dificuldades quanto à seleção simultânea para ambas as épocas.

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