ARTICLE

Adaptability and stability of papaya hybrids affected by production seasonality

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Abstract: *The present work aimed to estimate the adaptability and stability of new papaya hybrids. The experiments were carried out at the company Caliman Agrícola S/A, in the municipalities of Linhares-ES and Pureza-RN, with seven hybrids from inbred parents of the groups 'Solo' and 'Formosa' and three controls ('Golden', 'Calimosa', and 'Tainung 01'). The experiment consisted of a randomized block design with four replications and ten plants per plot. The variables mean fruit weight (MFW), number of commercial fruits (NCF), and production (PROD) were measured at 270, 360, 450, and 540 days after planting. Afterward, the adaptability and stability of the hybrids were estimated using the Lin and Binns, Eberhart and Russell, and Mixed Models. MFW was less affected by the evaluation periods and showed high behavior predictability. The hybrids UC10, UC12, UC14, UC15, and UC16 were the most adapted and predictable and can be recommended for the regions where the experiment took place.*

Key words: *Carica papaya L., solo hybrids, formosa hybrids.*

INTRODUCTION

Papaya has been mostly cultivated between the Southern Bahia and Northern Espírito Santo, with a production of 723.582 and 361.270 ton, respectively, corresponding to 74.11% of the national production (IBGE 2016). However, the increased demand for the product has required new cultivation areas to supply the domestic and international markets. In a country with continental dimensions such as Brazil, the expansion of cultivation areas is only possible by the development and dissemination of new cultivars, hybrids, and/or varieties adapted to different Brazilian regions.

As a tropical fruit tree, papaya can be sown in all seasons of the year. Its production, which starts at 270 days after planting, remains uninterrupted until the end of the specific cultivation cycle for the crop, which takes three years, on average. In practice, it is known that papaya production, although continuous, is not uniform and may be more intense in summer and less intense in winter. Few studies on this issue are available in the literature; however, some conclusions can be drawn based on studies on papaya floral behavior, since blooming is a determining factor in its production (Silva et al. 2007a, Damasceno Júnior et al. 2008).

The appearance of imperfect flowers in hermaphrodite papaya plants is

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associated with genetic effects, which are affected by environmental factors, such as high humidity and high levels of nitrogen and water in the soil (Almeida et al. 2003). Silva et al. (2007a) and Damasceno Júnior et al. (2008) evaluated floral behavior in hybrids and elite genotypes and reported that variation in the number of perfect hermaphrodite flowers, which bear commercial standard fruits, is higher in the summer, when the number of sterile flowers increases and fewer fruits are produced. This phenomenon, known as summer sterility (Storey 1958), is one of the main causes of decreased production in some periods of the year, since it concentrates production in certain seasons.

Martelleto et al. (2011) carried out an experiment to compare fruiting in a variety of papaya in different seasons of the year, under greenhouse and field conditions, and estimated the number of carpelloid, pentandric, and normal (commercial) fruits. The data obtained by these authors corroborate the reports of Silva et al. (2007a) and Damasceno Júnior et al. (2008) on increased sterility and increased number of deformed fruits in different seasons of the year. This indicates that production can significantly fluctuate when measured in different seasons, depending on the environmental conditions.

The recommendation of superior genotypes, hybrids, or varieties for cultivation in different regions must meet the minimum criteria that enable inferring about the genotype potential in the cultivation environment. Adaptability and stability, which are the responsiveness of genotype to an improved environment and the predictability of genotype behavior (Cruz et al. 2013), respectively, are the main parameters of reliability in genotype behavior prediction. Several methods can be used to estimate these parameters, including those based on the analysis of variance (Plaisted and Peterson 1959), regression (Finlay and Wilkinson 1963, Eberhart and Russell 1966), mixed models (Resende and Duarte 2007), and more modern methods that combine multivariate analysis techniques, such as AMMI - Additive main effects and multiplicative interaction analysis (Annicchiarico 1997), the Bayesian method proposed by Nascimento et al. (2011), and the artificial neural networks for adaptability and stability evaluation in alfalfa genotypes, proposed by Nascimento et al. (2013).

In annual species, genotype behavior prediction in growing environments is commonly estimated for different cultures using different methodologies. However, the assessment of perennial or semiperennial plants, including papaya, is more difficult. In the case of papaya, fruit production occurs throughout the cycle, being concentrated in specific periods of the year. Under such conditions, coefficients of adaptability and stability can be incorrectly estimated since production fluctuation is common in some periods. Therefore, in papaya, genotypes behavior should be estimated per evaluation season, which refers to an estimated behavior per periods of production or harvest.

In this study, the coefficients of adaptability and stability coefficients for the traits (number of commercial fruits, mean fruit weight, and production) were estimated and compared in production cycles in new hybrids of papaya as they were released. This comparison was carried out by different methods of analysis, aiming at a better interpretation of the results for production fluctuation between production seasons in papaya cultivation.

MATERIAL AND METHODS

Experiments were carried out in two regions of papaya production. The first was located in Linhares-ES, in Santa Terezinha Farm, which belongs to the company Caliman Agrícola S/A (lat 19º 23’ S, long 40º 04’ W, alt 33 m asl), with average annual temperature of 23.4 °C and average rainfall of 1193 mm year^{-1}. The second environment is located in Pureza-RN, in the sub-office of the company Caliman Agrícola S/A (lat 05° 28’ S, long 35° 33’ W, alt 40 m asl).

Seven papaya hybrids from the UENF/Caliman joint breeding program were evaluated. The hybrids were developed in the seed production sector of the company Caliman Agrícola S/A, in Santa Terezinha Farm, in Linhares-ES, from inbred parents preserved in the UENF/Caliman germplasm bank. Hybrid combinations were defined in previous diallel trials carried out by Marin et al. (2006a, b), Ide et al. (2009), and Cardoso et al. (2015).

Hybrids were obtained from parents belonging to the heterotic groups ‘Solo’ and ‘Formosa’. Thus, the hybrids UC13, UC14, UC15, and UC16 were obtained from Solo x Solo hybridizations; the hybrids UC03 and UC10 were obtained from hybridization within the Formosa group; and the triple hybrid UC12 was obtained from the cross between a simple Formosa x Solo hybrid and a Formosa parent, and therefore, it fits in the hybrid category of the Formosa group. The variety ‘Golden’ and the hybrids ‘Calimosa’ and ‘Tainung 01’ were used as controls.

Hybrid seeds were placed in plastic tubes for germination, in a greenhouse in Santa Terezinha Farm. After germination, the seedlings remained in the greenhouse for 20 days. Then, they were acclimatized outside the greenhouse. The same procedure was carried out in Caliman Agrícola sub-office, in Pureza-RN, where the experiments were implanted.

At 30 days after germination, seedlings were planted in the field. The experiment was arranged in a randomized block design with four replications, spaced at 1.5 x 3.6 m (5.4 m^2 $plant^{-1}$) between plants, in single rows, with ten plants per plot.

Field data were collected from harvests carried out at 270, 360, 450, and 540 days after planting in each study environment. The following variables were measured: mean fruit weight - MFW (kg), measured by the mean of five fruits in the plot; Number of commercial fruits - NCF obtained by the counting of the number of fruits per plant in each evaluation period, excluding the fruits that did not meet the commercial standard; and Production - PROD (kg $plant^{-1}$), calculated by the product between the number of commercial fruits per plant and the mean fruit weight.

Data were subjected to the Shapiro-Wilk normality test for quality evaluation. For the homogeneity test, residual variance of each environment was evaluated by the ratio between the largest residual mean square and the lowest residual mean square. According to Pimentel-Gomes (1990), variances are considered as homogeneous if this ratio is lower than seven; in this case, joint analysis of variance can be performed to evaluate seasons and cultivation environments.

Analysis of variance was performed according to the model: $Y_{ijk} = \mu + G_i + B/A_{jk} + A_j + GA_{ij} + \varepsilon_{ijk}$, where Y_{ijk} is the observed value of genotype i in block k (k = 1, 2, ..., r) and within environment j; μ is the overall mean of the trials; G_i is the fixed effect of genotype i, with i = 1, 2, 3, ..., p; B/A_{jk} is the effect of block k within environment j; A_j is the random effect of environment j, with j = 1, 2, 3, ..., q; $(GA)_{ij}$ is the fixed effect of genotype i x environment j interaction; ε_{ijk} is the experimental error. Afterward, the joint analysis of variance and mean comparison were performed using the SAS Studio software system (SAS Institute, Cary, NC, USA). Based on the data of the eight harvests of this study (four seasons in each environment), adaptability and stability of the hybrids were evaluated for the traits, using three different methods: Lin and Binns (1988), Eberhart and Russel (1966), and Mixed Models (Resende 2007, Gonçalves and Fritsche-Neto 2012, Cruz et al. 2013).

The non-parametric analysis of adaptability and stability, according to the method proposed by Linn and Binns (1988), is based on the index $Pi = \Sigma(Yij - Mi)^2/2n$, where P_i is the estimate of the stability index of genotype i; Y_{ij} is the behavior of genotype i in environment j; M_j is the maximal response observed among all genotypes in environment j; and n is the number of environments. The P_i index indicates the stability of a genotype, and the lower the value of P_i index, the more stable is the material.

The Eberhart and Russell (1966) method is based on the linear regression obtained by $Y_{ij} = \mu + \beta_i I_j + \delta_{ij} + \varepsilon_{ij}$, where Y_{ij} is the behavior of genotype i in environment j; μ is the general mean; β_i is the coefficient of linear regression; I_j is the environmental index; δ_{ij} is the deviation of the regression of genotype i in environment j; and δ_{ij} is the error associated with the mean. According to this model, the adaptability of a genotype is estimated by its regression coefficient (β_i) in relation to the environmental index (I_j) in each environment, and the stability is estimated by the variance of the deviations of σ^2_{di} regression. Therefore, genotypes with βi equal to 1 are considered as adapted; and genotypes with σ^2_{di} and not significantly different from zero by the Tukey test are considered as stable.

In the mixed models methodology, the components of variance were estimated by the REML/BLUP procedure, according to the model $Y = X_r + Z_g + W_i + e$, where y is the data vector; r is the vector of replication effects (assumed as fixed) added to the overall mean; g is the vector of genotypic effects (assumed as random); i is the vector of the effects of the genotype × environment interaction (random); e is the vector of errors or residues (random); and the capital letters are the incidence matrices for these effects. Analyses of adaptability and stability were performed considering the model 54 (Complete block design in several environments and one observation per plot - MHPRVG Method) (Resende 2016).

RESULTS AND DISCUSSION

Significant interaction was observed between genotypes for all traits evaluated, as well as for period × harvest environment, except for the genotype × environment interaction for the trait mean fruit weight (Table 1). These significant interactions show that fruit production is strongly affected by the season of the year and planting environment and that

Table 1. Analysis of variance for three traits in papaya hybrids evaluated in two environments, Pureza-RN and Linhares-ES, in eight seasons

Sources of variation	df	Mean Squares		
		NCF	MFW	PROD
Blocks/PE	24	256.131**	0.057*	236.465**
Environment (E)	1	1604.288**	0.104*	1943.751**
Periods (P)	3	6409.909**	0.342**	7701.139**
E*P	3	1704.787**	1.076**	1254.298**
Genotypes (G)	9	1368.776**	6.777**	1095.412**
G*E	9	74.803*	0.024	111.345*
G*P	27	113.163**	0.064**	142.248**
E*G*P	27	165.199**	0.070**	246.476**
Error	216	28.490	0.024	31.574
Mean	-	24.29	1.11	25.15
CV (%)		21.79	13.91	22.34

NCF: number of commercial fruits; MFW: mean fruit weight in kg and PROD: production per period in kg plant^{-1}.

this effect, which can be defined as production seasonality, must be well understood when comparing production rates in different environments and seasons.

Moreover, Table 1 shows that the genetic component, highlighted in the mean square of the genotype, overlaps the residue, which indicates that variation is mainly due to genetics. The experiment precision measured by the coefficient of variation is consistent with that expected from a field experiment (Costa et al. 2002). Furthermore, all the traits presented in Table 1 showed normality and demonstrated that the joint analysis of the experiments was obtained after confirming the error variances homogeneity.

Table 2 shows an estimate of the mean production of the period for the hybrids evaluated. The number of NCF per plant varied widely among hybrids and controls. UC14 was the best in the production rank, and the hybrid 'Tainung 01' was the worst. Differently, for production or yield, hybrid UC10 was superior to the others on average, and the variety 'Golden' showed the worst performance. However, it presented superior performance for the number of commercial fruits. This is because the mean fruit weight of the variety 'Golden' is only 0.466 kg. In terms of production, considering the mean of the seasons, the hybrids of the 'Solo' group, especially UC14, UC15, and UC16, are as productive as the control 'Calimosa', which is a hybrid originated from the Solo × Formosa group, superior to the control 'Golden' and to the control 'Tainung 01' (in the case of UC14).

Despite the contribution of the knowledge of the mean for the mentioned traits, they should not be taken as properties that completely describe the set of hybrids since they depend on the experiment, that is, they represent the mean of the evaluation periods, rather than the mean of each individual period, in which the positions would certainly be changed.

Table 3 shows the values of general stability coefficients (Pi) calculated by the nonparametric method of Lin and Binns (1988). For NCF, a tendency for greater production stability (lowest Pi values) was observed in the seasons for the genotypes from the 'Solo' group (from the largest to the smallest: UC14, 'Golden', UC15, UC16, and UC13). This means, for instance, that during the production cycle, UC14, the best-ranked genotype, produces fruits regularly at any season, depending, of course, on growth conditions. UC14 is also considered as the most stable genotype in both favorable (P+) and unfavorable (P-) environments, which

Table 2. Means for the traits evaluated in the set of environments and seasons

Genotypes	Means		
	NCF	MFW	PROD
UC03	16.82 c	1.390 c	23.40 cb
UC10	17.70 c	1.930 a	35.11 a
UC12	23.18 b	1.340 c	31.65 a
UC13	24.09 b	0.832 fe	19.89 c
UC14	34.68 a	0.777 f	26.93 b
UC15	26.75 b	0.913 e	24.35 cb
UC16	25.71 b	0.929 e	24.61 b
'Golden'	34.06 a	0.390 g	13.78 d
'Calimosa'	24.17 b	1.090 d	26.70 b
'Tainung 01'	15.75 c	1.550 b	25.09 b

Means followed by the same letter in the column were not significantly different ($p < 0.05$) by the Tukey's test. NCF: number of commercial fruits; MFW: mean fruit weight in kg; and PROD: Total production in kg plant^{-1}.

reflects the plasticity of this hybrid in the production seasons.

Conversely, concerning the relationship observed between the genotypes from the 'Formosa' group as a whole, UC03, UC12, UC10, and 'Tainung 01' were the least stable for fruit production over the seasons. This fact confirms, to some extent, the phenomenon observed in the field, in which the genotypes of the 'Formosa' group presented great fruit load in the first months of production and a sharp decline in the last harvests. This was observed for all genotypes of the 'Formosa' group, in both environments. Among the hybrids of the 'Formosa' group, the least sharp production decline occurred exactly with the hybrid UC12, the best Formosa group genotype for stability (Table 3). However, the opposite was reported for MFW, since the hybrids from the 'Formosa' group were the most stable, not only in general but also in favorable and unfavorable environments.

The variable PROD is obtained by multiplying the mean fruit weight and the number of commercial fruits produced by the plant in the period. Table 3 shows that the hybrids UC10, UC12, and 'Calimosa' were more stable for production. The Lin and Binns (1988) method is very practical for allowing the direct evaluation of the results, although it only quantifies stability and gives no measure for adaptability. The method is widely used in several works, and often presents a high

Table 3. Stability by the Lin and Binns model (1988)

Genotypes	Lin and Binns (1988)				
	NCF (mean)	General P_i	Pi+	Pi-	%DG
UC03	18.29	260.49^{8}	420.45^{9}	100.54^{8}	66.35
UC10	18.07	262.21^{9}	404.08^{8}	120.34^{1}	67.48
UC12	22.39	160.55^{7}	238.93^{7}	82.82^{7}	65.47
UC13	24.15	114.20^{5}	174.31^{4}	54.08^{5}	70.99
UC14	33.75	13.34^{1}	18.78^{1}	7.90^{1}	36.95
UC15	26.51	93.17^{3}	153.36^{3}	32.98^{3}	57.76
UC16	26.85	107.81^{4}	194.97^{5}	20.65^{2}	46.66
'Golden'	32.07	34.63^{2}	22.94^{2}	46.32^{4}	33.43
'Calimosa'	24.35	148.41^{6}	236.10^{6}	60.73^{6}	52.92
'Tainung 01'	15.66	280.45^{1}	452.77^{1}	108.13^{9}	80.31
Genotypes	**MFW (mean)**	**General P_i**	**Pi+**	**Pi-**	**%DG**
UC03	1.356	0.148^{3}	0.194^{4}	0.102^{3}	90.31
UC10	1.874	0.000^{1}	0.000^{1}	0.000^{1}	90.32
UC12	1.330	0.177^{4}	0.164^{3}	0.191^{4}	82.99
UC13	0.840	0.576^{8}	0.726^{8}	0.726^{8}	92.7
UC14	0.764	0.658^{9}	0.809^{9}	0.809^{9}	93.57
UC15	0.899	0.497^{6}	0.623^{6}	0.623^{6}	95.47
UC16	0.934	0.490^{7}	0.680^{7}	0.680^{7}	90.02
'Golden'	0.466	1.101^{1}	1.442^{1}	0.761^{1}	89.95
'Calimosa'	1.086	0.335^{5}	0.439^{5}	0.230^{5}	92.5
'Tainung 01'	1.509	0.097^{2}	0.133^{2}	0.061^{2}	68.51
Genotypes	**PROD (mean)**	**General P_i**	**Pi+**	**Pi-**	**%DG**
UC03	24.09	159.90^{7}	223.52^{7}	53.87^{8}	72.21
UC10	34.50	24.92^{1}	16.28^{1}	39.32^{4}	45.91
UC12	30.22	71.37^{2}	93.09^{2}	36.14^{2}	57.24
UC13	19.99	256.24^{9}	378.93^{9}	51.76^{7}	72.60
UC14	25.85	146.54^{5}	212.08^{5}	37.30^{3}	61.58
UC15	23.87	151.87^{6}	215.35^{6}	46.08^{5}	78.20
UC16	25.68	134.31^{4}	206.68^{4}	13.70^{1}	68.91
'Golden'	12.80	448.57^{1}	617.28^{1}	167.37^{1}	78.16
'Calimosa'	26.62	97.56^{3}	123.98^{3}	54.71^{9}	82.11
'Tainung 01'	24.11	231.72^{8}	340.01^{8}	51.25^{6}	49.68

Pi: general stability mean; Pi+: stability at favorable environments; Pi: stability at unfavorable environments; %DG: contribution of the genetic deviation for interaction; NCF: number of commercial fruits; MFW: mean fruit weight in kg; and PROD: production per period in kg $plant^{-1}$.

correlation with more robust methods, such as that of Eberhart and Russel (1966), among others (Elias et al. 2006, Silva and Duarte 2006, Pereira et al. 2009, Scapim et al. 2010).

The adaptability and stability coefficients were also estimated by the Eberhart and Russell method (1966), which is very robust and often used in various crops, such as in papaya (Yang et al. 2011, Oliveira et al. 2014), peanuts (Oliveira and Godoy 2006, Gomes et al. 2007), and popcorn (Scapim et al. 2010). The method has shown its effectiveness in relation to other methods (Elias et al. 2006, Pereira et al. 2009, Silva and Duarte 2006).

The results obtained by the Eberhart and Russell (1966) method, shown in Table 4, for the trait NCF, revealed that all genotypes had broad adaptability, except for UC14, 'Golden', and 'Tainnung 01'). This means that they had broad adaptability to all harvest seasons, being UC13 and UC15 adapted to favorable environments. Regarding the behavior predictability, only UC15 was stable. For the MFL, only UC10 and 'Golden' were not adapted, which in fact is rather consistent. These genotypes showed the highest and the lowest mean for MFW and NCF, respectively, due to the strong negative correlation between weight and number of fruits in papaya (Silva et al. 2007b, Oliveira et al. 2014) and may lead to variation over the harvest seasons.

Regarding the trait production, only UC10 and 'Golden' were not adapted. On the other hand, only UC15 and 'Calimosa' presented stability in the evaluation periods, besides adaptation. Table 4 also shows that despite presenting wide adaptation, UC03, UC12, UC13, UC14, and UC16 are considered as unstable. This might be due to the different

Table 4. Adaptability and stability by the Eberhart and Russell regression model (1966)

Genotypes	Eberhart and Russel (1966)											
	NFC				MFW				PROD			
	Mean	β_i	δ_{ij}	R^2%	Mean	β_i	δ_{ij}	R^2 %	Mean	β_i	δ_{ij}	R^2%
UC03	18.29	0.763	34.63**	61.38	1.356	1.179	0.013*	54.02	24.09	1.019	26.23**	79.74
UC10	18.07	0.782	26.86**	67.46	1.874	2.274**	0.020*	77.29	34.50	1.660**	107.61**	75.08
UC12	22.39	0.911	7.591*	87.55	1.330	1.633	0.005	76.61	30.22	1.293	16.93**	89.80
UC13	24.15	1.056	7.116*	90.75	0.840	0.648	-0.004	54.30	19.99	0.736	10.81*	79.35
UC14	33.75	1.419**	32.32**	85.36	0.764	0.716	-0.002	55.56	25.85	0.991	25.41**	79.22
UC15	26.51	1.219	4.944	94.00	0.899	1.117	-0.005	82.46	23.87	1.007	-4.192	97.96
UC16	26.85	0.836	27.23**	70.06	0.934	0.830	-0.007	33.47	25.68	0.813	28.60**	70.02
'Golden'	32.07	1.462**	134.45**	62.45	0.466	-0.472**	0.033**	9.56	12.80	0.580*	32.57**	51.71
'Calimosa'	24.35	0.961	19.82**	80.02	1.086	0.843	-0.002	63.53	26.62	1.190	7.427	92.56
'Tainung'	15.66	0.593**	11.70**	69.31	1.509	1.729	0.033**	58.32	24.11	0.707	87.10**	40.02

β_i * and ** differs from one, at 5 and 1% probability by the Tukey's test, respectively. δ_{ij} * and ** differs from zero, at 5 and 1% probability by the F test, respectively. NCF: number of commercial fruits; MFW: mean fruit weight in kg; and PROD: production per period in kg plant^{-1}.

Table 5. Adaptability and stability based on individual genotypic values for three production traits in papaya

Genotype	NCF			MFW			PROD		
	MHV	PRV	MHPRVG	MHV	PRV	MHPRVG	MHV	PRV	MHPRVG
UC03	10.08	16.04	15.21	1.21	4.63	4.63	15.69	22.78	22.31
UC10	10.49	16.61	15.68	1.10	4.82	4.82	24.56	35.07	32.83
UC12	17.87	23.42	23.03	1.20	4.62	4.62	23.78	31.89	31.38
UC13	19.00	24.30	24.01	1.16	4.48	4.48	14.90	20.23	19.84
UC14	27.69	35.33	34.74	1.16	4.47	4.47	19.77	27.35	26.63
UC15	18.85	26.21	25.94	1.17	4.51	4.51	14.64	23.61	22.99
UC16	20.50	26.30	25.99	1.17	4.51	4.51	18.13	24.84	24.59
'Golden'	26.96	34.66	33.69	1.13	4.37	4.36	8.68	13.70	12.97
'Calimosa'	18.03	24.16	23.66	2.14	8.06	8.03	18.97	26.32	25.94
'Tainung'	9.52	15.41	14.50	1.22	4.68	4.68	16.77	25.45	23.75

MHVG: harmonic mean of the genetic values; PRVG: relative performance of the genetic values; MHPRVG: harmonic mean of the performance relative to the genetic values; NCF: number of commercial fruits; MFW: mean fruit weight in kg; and PROD: production per season in kg plant^{-1}.

fruiting rate in the seasons, that is, the gap in the periods of maximum plant load. Conversely, UC03, UC10, UC12, and UC15 showed adaptability to favorable environments, that is, environments whose β1 magnitude is superior to the unity, although UC13, UC14, and UC16, which are hybrids from the 'Solo' group, showed adaptation to unfavorable environments, with β1 lower than the unity. Thus, it is inferred that in environments where the standard required for cultivation are more difficult to be maintained, hybrids from the 'Formosa' group tend to accumulate more production losses than hybrids from the 'Solo' group. This actually occurs, and these hybrids are more affected by summer sterility than those of the 'Solo' group.

Table 5 describes the harmonic mean of the genetic values (MHVG), the stability measurement, the relative performance of the genetic values (PRVG), the stability measurement, and the combination with the harmonic mean of the performance related to the genetic values (MHPRVG), which includes adaptability and stability. For NCF, the result of Table 5 highlights the genotypes UC13, UC14, UC16, and 'Golden', that is, hybrids from the 'Solo' group. This is consistent with the results obtained by the Lin and Binns (1988) method, discussed in Table 3. UC03, UC12, UC16, and 'Calimosa' stand out for MFW, which corroborates the results in Table 3.

In general, for the trait production, hybrids UC10 and UC12 from the 'Formosa' group, and hybrids UC14 and UC16, from the 'Solo' group, presented the best MHPRVG estimates. In other words, they showed wide adaptability and predictable behavior over the harvests. Regarding the hybrids from the 'Formosa' group, these results are similar to those obtained the by Lin and Binns (1988) method, and generally different from those provided by the Eberhart and Russell (1966) method.

Mean fruit weight is the least affected trait by the evaluation periods, with high behavior predictability. Hybrids UC10, UC12, UC14, UC15, and UC16 are among the most adapted and predictable in the set of hybrids evaluated in this study. This behavior regarding the evaluation seasons indicates that these genotypes can be recommended for several regions, including the semi-arid area and the region of Linhares-ES, where the hybrids were evaluated. The non-exact agreement between the methods and the occurrence of high adaptability in the hybrids, with low predictability in some cases, should be understood as a result of the specificity of each method employed and the seasonal crop production, resulting from the behavior of each hybrid and environmental conditions.

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