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Assessment of table grape progenies and correlation between seedlessness and other agronomic traits

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Abstract: The aim of the present study was to identify grape parent varieties that lead to greater frequency of seedless genotypes in the progenies and to understand the relationships between the seedless trait and other fruit traits. A group of 200 hybrids (F1) originating from 38 crosses among cultivars of *Vitis vinifera* L. and interspecific hybrids were evaluated in Juazeiro, Bahia, Brazil, over six consecutive crop seasons (2018 to 2021). The progenies were placed in three classes based on seedlessness: completely seedless (class 1), seed traces or soft seeds (class 2), and with seeds (class 3). The mean dry matter of the seeds in each class was 0 mg, 2.3 mg, and 25.7 mg respectively, which corresponded to 40 genotypes (20%) in class 1, 52 genotypes (26%) in class 2, and 108 (54%) in class 3. The interspecific cross 'BRS Isis' and 'Marroo Seedless' stood out through favoring high frequency of seedless individuals in the progeny (47.5%). The traits associated with berry size (length, diameter, and weight) had high positive correlations with each other. The results obtained make an important contribution for table grape breeding aiming at the development of new table grape cultivars.

Index Terms: grapevine; plant breeding; seedless grapes.

Avaliação de progênies de uvas de mesa e correlações entre apirenia e outras características agronômicas

Resumo: O objetivo do presente trabalho foi identificar genitores que proporcionem maior frequência de genótipos apirenos nas progênies, bem como compreender as relações entre a característica apirenia e outras características do fruto. Foram avaliados 200 híbridos (F1) originados de 38 cruzamentos entre cultivares de *Vitis vinífera* L., e híbridos interespecíficos, em Juazeiro, Bahia, durante seis safras consecutivas (2018 a 2021). As progênies foram classificadas em três classes quanto à apirenia: completamente sem sementes (classe 1), presença de traço ou semen-

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tes macias (classe 2) e com sementes (classe 3). A massa fresca média das sementes, em cada classe, foi de 0mg, 2,3mg e 25,7mg, respectivamente, o que correspondeu a 40 genótipos (20%) na classe 1, 52 genótipos (26%) na classe 2 e 108 (54%) na classe 3. O cruzamento interespecífico 'BRS Isis' e 'Marroo Seedless' destacou-se por favorecer elevada frequência de indivíduos sem sementes na progênie (47,5%). As características associadas ao tamanho de baga (comprimento, diâmetro e massa) apresentaram correlações positivas e elevadas entre si. Os resultados obtidos fornecem subsídios importantes para o planejamento de cruzamentos, avaliação das progênies e seleção de híbridos visando ao desenvolvimento de novas cultivares de uvas de mesa.

Termos para Indexação: Videira; melhoramento genético; uvas sem sementes.

Introduction

The renewal of vineyards and adoption of new cultivars developed by Embrapa and private plant breeding companies has been the main technological innovation responsible for the increase in yield and competitiveness of viticulture in the *Vale do Submédio São Francisco* in Brazil in the past decade. In 2021, the Northeast region achieved a mean yield of 30.19 t/ha, an increase of 14.74% in relation to the previous year, showing prominence among all the production regions in Brazil, with values 31.77% higher than the Brazilian mean value (IBGE, 2022).

In this scenario, strengthening public programs of grape plant breeding that lead to a supply of new grape cultivars with agronomic traits and high and competitive quality in the domestic market and abroad is a strong demand of the production sector (Leão, 2020).

Seedlessness, the absence of seeds, is considered one of the most important traits for table grapes and for raisins (EBADI et al., 2009; MALABARBA et al., 2017). Nevertheless, the ideotype of the table grape cultivar should combine other traits, such as high yield, physical traits of the bunch and of the berry, and properties that express quality, such as soluble solids content (SS), titratable acidity (TA), SS/TA ratio, color, flavor, berry texture, and others (LEÃO, BORGES, 2009).

Seedless grapes may arise from two different biological processes, parthenocarpy and stenospermocarpy (PRATT, 1971). In parthenocarpy, the fruit forms as a result of development of the ovary, though without fertilization, that is, there is total absence of seeds, as is the case of the cultivar Black Corinth (MEJÍA et al., 2011; JAIN; PRIYADARSHAN, 2009). In contrast, in stenospermocarpy, fertilization occurs and the seed begins to develop. However, there is abortion of the still immature embryo and/or absence or poor formation of the endosperm, giving rise to rudimentary seeds, as in the cultivar Sultanina (LEDBETTER; SHONNARD, 1991; JAIN and PRIYADARSHAN, 2009; MEJÍA et al., 2011). The rudimentary size of the seed furthermore depends on seasonal climate variations and seems to be affected by the age of the grapevine and rootstock (CHRISTENSEN et al. 1983).

The perception of the seed by the consumer is influenced by berry traits, such as size and consistency, and also by traits of the seed itself, such as size, degree of development, sclerification of the seed coat, and development of the endosperm (LEDBETTER; RAMMING, 1989). Thus, classification of a grapevine cultivar regarding the presence or absence of seeds is a sensory evaluation characterized by a certain degree of subjectivity.

Different methods have been used for classification of genotypes regarding the presence/absence of seeds, such as sensory analysis (SPIEGEL-ROY et al., 1990), chemical methods (EBADI et al., 2009; MERIN et al., 1983; PERL et al., 1989), and physical methods (LEDBETTER; SHONNARD, 1991).). However, the grapevine descriptor method (IPGRI 1997) considers classes of separation of seeds based on the dry matter of 100 seeds: I – very low weight (≤ 10 mg.seed^{-1}), II – low weight (21 to 29 mg.seed^{-1}), III – medium weight (36 to 44 mg.seed^{-1}), IV – high weight (51 to 59 mg.seed^{-1}), and V – very high weight (> 65 mg.seed^{-1}). Classes I and II, that is, those of less than 29 mg, are considered seedless according to regulatory standard 243 of the OIV (1983).

Studies were also conducted to determine the frequency of seedlessness in the progenies, heritability, and correlations between seedlessness and different quality traits as tools to increase efficiency in table grape breeding programs (WEI et al., 2002; EBADI, et al., 2009; VERMA et al., 2014).

The objective of the present study was to identify parent varieties that lead to greater frequency of seedless genotypes in the progenies, and to understand the relationships between the seedless trait and other traits of the fruit, with the aim of making a contribution for planning and advancing seedless table grape breeding projects.

Materials and Methods

Characterization of the experiment

The study was conducted over six consecutive crop seasons in the period from 2018 to 2021 in the Mandacaru Experimental Field belonging to Embrapa Semiárido in Juazeiro, Bahia, Brazil (9°24' S, 40°26' W, and 365.5 m altitude). Climate in the region is classified as Bswh according to Koeppen, which corresponds to hot semiarid, with mean annual rainfall of 505 mm, mean annual relative humidity of 60.7%, and annual mean, maximum, and minimum temperatures of 26.7 °C, 32.0 °C, and 20.8 °C, respectively (*www.cpatsa.embrapa.br/servicos/dadosmet/cem-anual.html*). The experimental vineyard consisted of a field of progenies where each genotype was represented by a single individual, therefore, an experimental design and replications were not used. The grapevines were grafted onto the rootstock IAC 572, using the espalier trellis vine-training system at a plant spacing of 3 m × 1 m, with drip irrigation. Only minimal crop treatments were performed, which included pruning, application of hydrogen cyanamide for breaking bud dormancy (5%), thinning, tying the shoots and branches, phytosanitary control, and application of nutrients through fertigation, as well as weed control.

Plant Material

A total of 38 progenies and 200 F1 individuals were evaluated, obtained from crosses made among 30 cultivars of *Vitis vinifera* L. (53%) and interspecific hybrids (47%). Most (67%) of the parental lines used were seedless grape cultivars and/or hybrids. The progenies ranged from one to sixty individuals.

Variables evaluated

The variables used were selected from descriptors proposed by the International Plant Genetic Resources Institute (IPGRI, 1997): yield – Y (kg.plant^{-1}), number of bunches – NB (bunches.plant^{-1}), bunch length – BL and bunch width – BW (cm), bunch weight – BWt (g), berry length – BrL and berry diameter – BD (mm), berry weight – BrWt (g), seed dry matter – DM (mg.seed^{-1}), total soluble solids content – SS (°Brix), titratable acidity – TA (g tartaric acid.100 mL^{-1}), and SS/TA ratio (non-dimensional). Five bunches per plant composed the samples for the bunch traits, while the berry weight and size variables were determined in a sample composed of ten berries randomly removed from the five bunches evaluated in the previous step, or a total of fifty berries per plant. This same sample was used for extraction of the juice in which determinations were made of soluble solids content in a digital refractometer and titratable acidity by titration of a 5 mL sample of juice with 0.1 N NaOH (AOAC, 2010). One hundred seeds or seed traces were separated per plant and then dried in a laboratory oven, obtaining the seed dry matter.

The genotypes were placed in three classes regarding seedlessness: class 1 – imperceptible seed traces; class 2 – miniscule seed traces and/or small soft seeds; and class 3 – presence of seeds with sclerified seed coats.

Statistical analyses

The results were presented through mean descriptive statistics and standard deviation of all the quantitative variables evaluated according to the class of genotypes regarding seedlessness. Pearson correlation coefficients were estimated using the GENES statistical software (CRUZ, 2016).

Results and Discussion

The progenies were distributed in three classes regarding seedlessness, observing the predominance of 54% of the genotypes in class 3 (with seeds), while 26% of the genotypes were classified in class 2 (minuscule seed traces and/or soft seeds) and 20% in class 1 (imperceptible seed traces), which is in agreement with the results obtained by Ebadi et al. (2009), who also found 51.2% of the genotypes with seeds in the progenies. This frequency of seedlessness in the progenies resulting from crosses between two seedless parents is in agreement with the polygenic characteristic of seedlessness in the grapevine, expressed by the wide variation in phenotypes, such as number, size, and weight of seeds, observed in the progenies. According to Li et al. (2017), seedlessness in the grapevine depends on the gene expression and interaction of the homeobox composed of 73 genes divided into 11 phylogenetic families. Considering that the stenospermocarpic trait of the seed is determined by the dominant gene SDI, Mejía et al. (2011) reported that VvAGL11 was the main gene for the absence of seeds in the cultivars of *Vitis vinifera*, and the seed abortion caused by a substitution of amino acids in VviAGL11 is the main cause of the absence of seeds in cultivated grapevines (ROYO et al., 2018). In addition, it is important to highlight that the expression of stenospermy is affected by the environment (PONCE et al., 2000)

Three progenies, CPATSA 79, 28, and 49, were composed of 16, 24, and 60 individuals, respectively, and were analyzed regarding the phenotypic distribution of classes of seedlessness (Table 1), highlighting the progeny CPATSA 79 ('BRS Isis' × 'Marroo Seedless'), with 56.25% of the genotypes with imperceptible seed traces or seedlessness.

According to Zhu et al. (2020), the absence of seeds is an inheritable trait and, therefore, stenospermocarpic parents are widely used in classic breeding of elite cultivars because they may transmit this trait to their progeny. Generating seedless grapes is traditionally based on "seedless × seeded" hybridization, which consists of crossing stenospermocarpic females with male parents with desirable traits (LAHOGUE et al., 1998; THIS et al., 2000). Nevertheless, the hybridization of two stenospermocarpic parents is considered more efficient than the seedless × seeded crosses, because it gives rise to a larger number of seedless progenies (RAMMING, 1990).

Therefore, use of the cultivar BRS Ísis, developed by Embrapa (RITSCHEL et al., 2013), is suggested as a female parent to increase the frequency of seedless individuals in the progeny. This cultivar also has long bunches and good adherence of the flower buds to the pedicel, facilitating emasculation and pollination and, consequently, increasing fruit set and efficiency in the crosses.

The mean dry matter observed in the different classes for each one of the progenies is shown in Table 1.

Table 1 – Phenotypic frequencies of classes of seedlessness and mean seed dry matter (DM) in three progenies of crosses between seedless grape parents.

Progeny	Cross	Class 1 (%)	DM (g)	Class 2 (%)	DM (g)	Class 3 (%)	DM (g)
79	BRS Isis × Marroo	56.25	0.0	18.75	6.27	25.0	31.22
49	Jupiter × Marroo	16.3	0.0	41.66	3.68	42.04	29.73
28	A 1581 × Marroo	4.17	3.32	4.17	5.75	91.66	29.16

Based on the grapevine descriptors (IPGRI, 1997) whose method considers the dry matter of 100 seeds, 75% of the individuals of the progeny CPATSA 79 were observed to be seedless (0.0 g) or showed very low weight (≤ 10 mg.seed^{-1}); while 25% were classified with low weight (21 to 29 mg.seed^{-1}) to medium weight (36 to 44 mg.seed^{-1}). In progeny 49, 57.96% of the genotypes were seedless or with seeds of very low weight, while 42.04% had seeds with low and medium weight. CPATSA 28, which had the selection Arkansas 1581 (A1581) as female parent, resulted in low recovery of seedless individuals in the progeny: only 8.34% were seedless or with seeds of very low weight, whereas 91.66% were classified with low to medium weight. Therefore although it has agronomic traits of interest, the use of genotype 'A1581' as a female parent is not recommended because it does not favor an increase in the frequency of seedless grape genotypes in the progeny.

The results obtained by visual observation of the seeds in this study differ from the descriptors of the OIV (1983), which considers seedless grapes as all those with 100-seed dry matter of less than 29 mg. Visual observation along with sensory perception of the presence of the seed in grape berries should be considered by grape breeders for evaluation of seedlessness in grapes, since these are the main forms of classification of grape types adopted by consumers. Therefore, other methods of classification of seedlessness in the grapevine should show good correlation with this visual observation.

The mean values of the yield components and physical and physical-chemical traits of the grapes varied considerably among the three classes of seedlessness (Table 2), with a tendency of higher mean values of the yield components and traits associated with bunch and berry size in class 3 (seeded grapes).

Table 2 – Mean values and standard deviation for components of yield and of quality of table grape progenies in accordance with the class of seedlessness.

Variables	Classes of seedlessness		
	Class 1	Class 2	Class 3
Yield (Kg.plant^{-1})	1.42 ± 1.17	1.36 ± 0.72	2.29 ± 1.28
Number of bunches	11.77 ± 5.98	12.33 ± 5.88	13.01 ± 5.89
Bunch weight (g)	142.57± 60.79	151.01 ± 61.54	219.93 ± 86.27
Bunch length (cm)	12.88 ± 2.69	12.45 ± 2.26	13.82 ± 2.32
Bunch width (cm)	7.43 ± 1.40	7.37 ± 1.46	8.22 ± 1.53
Berry weight (g)	16.31 ± 2.15	2.13 ± 0.56	3.27 ± 0.92
Berry length (mm)	14.19 ± 1.57	16.68 ± 1.78	19.14 ± 2.28
Berry diameter (mm)	1.99 ± 0.61	14.67 ± 1.39	16.74 ± 1.63
Total Soluble Solids (°Brix)	16.28 ± 1.40	16.79 ± 1.81	16.59 ± 1.60
Titratable acidity (g.100mL^{-1})	0.54 ± 0.13	0.49 ± 0.12	0.49 ± 0.11
SS/TA ratio	34.71 ± 10.92	38.06 ± 10.39	38.09 ± 10.82

The results obtained in this study differ from those reported by Verma et al. (2014), who found bunches of greater size (weight and length) in the group of seedless grapes. Berry size (weight, length, and diameter), exhibited growth in accordance with the presence and weight of seeds in the berry, and this is in agreement with other authors (BARBAGALLO et al., 2011; VERMA et al., 2014).

The values for soluble solids content were near each other in the three classes, namely, 16.28 °Brix, 16.79 °Brix, and 16.59 °Brix in classes 1, 2, and 3 respectively, but higher values of titratable acidity were recorded in the seedless grape progenies (class 1). The results obtained for soluble solids content are in agreement with those mentioned by Wei et al. (2002), who did not find differences between two grape progenies seedless and with seeds, but differ from Verma et al. (2014), where higher values for soluble solids were associated with seedless grape genotypes.

The differences found by different authors can be explained by the genotypes used in each study or by the genealogy of the progenies and cultivars studied.

Significant correlations ($p < 0.05$ and $p < 0.01$) were observed between the different traits studied (Table 3). Positive correlations were obtained between yield weight per plant and the other yield components; however, greater correlation was recorded between yield and bunch weight (r = 0.71), bunch length and weight (r = 0.77), and bunch length and width (r = 0.71). The highest values of correlation were found between the variables related to berry size, such as berry weight and berry length (r = 0,89), berry weight and berry diameter (r = 0.92), and berry length and berry diameter (r = 0.87), which is in agreement with results obtained by other authors (WEI et al., 2002; EBADI et al., 2009; VERMA et al., 2014; NIKOLIĆ et al., 2018). The soluble solids content, titratable acidity, and ratio (SS/TA) had negative correlations with most of the variables; however, they were not significant or were of low magnitude, which indicates that the selection of superior individuals in relation to the production components will not have negative impacts in reduction of soluble solids content and acidity of the grapes. Negative and low correlations between components of yield and of quality were also observed in other studies (WEI et al., 2002; EBADI et al., 2009; VERMA et al., 2014; NIKOLIĆ et al., 2018).

Table 3. Pearson linear correlation among the following traits: yield (Y), number of bunches (NB), bunch length (BL), bunch width (BW), bunch weight (BWt), berry length (BrL), berry diameter (BD), berry weight (BrWt), soluble solids content (SS), titratable acidity (TA), ratio (SS/TA), and seed dry matter (DM) from 200 hybrid genotypes of *Vitis* spp.

	Y	NB	BL	BW	BWt	BrL	BD	BrWt	SS	TA	SS/TA	DM
Y	-	0.51**	0.61**	0.51**	0.71**	0.36**	0.35**	0.43**	-0.04^{ns}	-0.05^{ns}	0.06^{ns}	0.33**
NB			0.14**	-0.06^{ns}	0.06^{ns}	0.02^{ns}	-0.04^{ns}	0.03^{ns}	-0.08**	-0.15*	0.15^{ns}	0.04^{ns}
BL				0.71**	0.77**	0.32**	0.33**	0.38**	-0.05^{ns}	0.07^{ns}	-0.09^{ns}	0.21**
BW					0.74**	0.40**	0.44**	0.45**	-0.08^{ns}	0.02^{ns}	-0.03^{ns}	0.24**
BWt						0.50**	0.54**	0.58**	-0.09^{ns}	-0.03^{ns}	-0.02^{ns}	0.36**
BrL							0.87**	0.89**	0.04^{ns}	-0.15*	0.12^{ns}	0.52**
BD								0.92**	-0.009^{ns}	-0.08^{ns}	0.04^{ns}	0.57**
BrWt									-0.03^{ns}	-0.06^{ns}	0.03^{ns}	0.58**
SS										0.26**	0.56**	-0.04^{ns}
TA											-0.85**	0.03^{ns}
SS/TA												0.0001^{ns}
DM												-

^{ns}non-significant; **p < 0.01; *p < 0.05.

Yield per plant and seed dry matter had positive correlation, though of low magnitude (r = 0.33). However, significant positive correlations were found between seed weight and berry weight (r = 0.58), berry length (r = 0.52), and berry diameter (r = 0.57), which explains the result shown in Table 2, where greater weight, length, and diameter of the berry were observed in class 3 (seeded grapes). Verma et al. (2014) and Wei et al. (2002) also found positive correlations between seed dry matter and berry weight, length, and diameter.

Estimates of genetic correlation between traits are important because they allow the breeder to evaluate the selective response and obtain indirect gains in other variables. That way, some polygenic traits strongly affected by the environment can be selected indirectly from other variables that are more easily measured.

Conclusion

Cultivar ‘BRS Isis’ used as a female parent favors a high frequency of seedless grape genotypes in the progeny. On the other hand, 'A1581' is not recommended as a female parent because it results in a low frequency of seedless vines in the progeny. Seedlessness measured by seed dry matter showed high positive correlation with traits associated with berry size (length, diameter, and weight).

References

AOAC -Association of Official Agricultural Chemists. **Official methods of analysis of the Association of the Agricultural Chemists**. 18th ed. Gaithersburg: AOAC, 2010. 1025 p.

BARBAGALLO, M.; GUIDONI, S.; HUNTER, J. J. Berry size and qualitative characteristics of *Vitis vinifera* L. cv. Syrah. S. **South African Journal of Enology and Viticulture**, Stellenbosch, v.32, n.1, p.129-36, 2011.

CHRISTENSEN, P.; RAMMING, D.; ANDRIS, H. Seed trace content of Fiesta grapes. **American Journal of Enology and Viticulture**, Davis, v.34, n.4, p.257-9, 1983.

CRUZ, C. D. Genes Software – extended and integrated with the R, Matlab and Selegen. **Acta Scientiarum Agronomy**, v.38, p.547-552, 2016.

EBADI, A.; MOGHADDAM, J. E.; FATAHI, R. Evaluation of 22 populations achieved from controlled crossing between some seeded × seedless grapevine cultivars. **Scientia Horticulturae**, Wageningem, v.119, n.4, p.371-6, 2009.

IBGE - Instituto Brasileiro de Geografia e Estatística. **Levantamento sistemático da produção agrícola**. Rio de Janeiro: IBGE, 2022. Disponível em: *https://sidra.ibge.gov.br/home/lspa/brasil*. Acesso em: 13 jan. 2022.

IPGRI - International Plant Genetic Resources Institute. **Descriptors for grapevine**: *Vitis* spp. Roma, 1997. 62p.

JAIN, S.M.; PRIYADARSHAN, P.M. **Breeding plantation tree crops**: tropical species. New York: Springer, 2009.

LAHOGUE, F.; THIS, P.; BOUQUET, A. Identification of a codominant scar marker linked to the seedlessness character in grapevine. **Theoretical Applied Genetics**, Berlin, v.97, p.950-9, 1998.

LEAO, P.C. de S. Produção de uvas sem sementes no semiárido brasileiro. *In*: AGUILA, J. S. del; AGUILA, L.S.H. del (org.). **Vitivinicultura**: função exata em cada processo. Ponta Grossa: Atena, 2020. cap. 7, p.70-81.

LEAO, P.C. de S.; BORGES, R.M.E. **Melhoramento genético da videira**. Petrolina: Embrapa Semiárido, 2009. 61 p. il. (Documentos, 224).

LEDBETTER, C.A.; RAMMING, D.W. Seedlessness in grapes. **Horticulture Reviews**, Westport, v.11, p.159-84, 1989.

LEDBETTER, C.A.; SHONNARD, C.B. Berry and seed characteristics associated with stenospermy in vinifera grapes, **Journal of Horticultural Science**, Meshed v.66, n.2, p.247-52, 1991.

LI, Y.; ZHU, X.; YAO, J.; ZHANG, S.; WANG, L.; GUO, C.; NOCKER, S.van; WANG, X. Genome-wide identification and expression analyses of the homeobox transcription factor family during ovule development in seedless and seeded grapes. **Scientific Reports**, London, v.7, p.1-16, 2017.

MALABARBA, J.; BUFFON, V.; MARIATH, J.E.A.; GAETA, M.L.; DORNELAS, M.C.; MARGIS-PINHEIRO, M.; PASQUALI, G.; REVERS, L. The MADS-box gene Agamous-like 11 is essential for seed morphogenesis in grapevine. **Journal of Experimental Botany**, Oxford, v.68, n.7, p.1493-506, 2017.

MEJÍA, N.; SOTO, B.; GUERRERO, M.; CASANUEVA, X.; HOUEL, C.; MICCONO, M.A.; RAMOS, R.; CUNFF, L.; BOURSIQUOT, J.M.; HINRICHSEN, P.; ADAM-BLONDON, A.F. Molecular, genetic and transcriptional evidence for a role of VvAGL11 in stenospermocarpic seedlessness in grapevine. **BMC Plant Biology**, London, v.11, n.57, p.471, 2011.

MERIN, U.; ROSENTHAL, L.; LAVI, U. A chemical method for the assessment of grapes according to their seed content. **Vitis**, Davis, v.22, p.306-10, 1983.

NIKOLIĆ, D.; MILIJKOVI´C, J.; RAKONJAC, V.; RADOJEVIC, I.; ZORICA, R.V. Inheritance and phenotypic correlations of agronomic traits in grapevine offsprings. **Acta Scientiarum Polonorum Hortorum Cultus**, Lublin, v.17, n.5, p.87-99, 2018.

OIV - Organization Internacional de la Vigne et du Vin. **Descriptor list for grapevine varieties and *Vitis* species**. Paris, 1983. 232p.

PERL, M.; LAVI, U.; SPIEGEL-ROY, P. Estimation of seed traces in grape berries by inhibition of Luciferase activity. **HortScience**, Alexandria, v.24, n.5, p.853, 1989.

PONCE, M.T.; AGÜERO, C.B.; GREGORI, M.T.; TIZIO, R. Factors affecting the development of stenospermic grape (*Vitis vinifera*) embryos cultured *in vitro*. **Acta Horticulturae**, The Hague, v.528, p.667-71, 2000.

PRATT, C. Reproductive anatomy in cultivated grapes - a review. **American Journal of Enology and Viticulture**, Davis, v.22, n.2, p.92-109, 1971.

RAMMING, D.W. The use of embryo culture in fruit breeding. **Horticultural Science**, Meshed, v.25, p.393–8, 1990.

RITSCHEL, P.S.; MAIA, J.D.G.; CAMARGO, U.A.; SOUZA, R.T. de; FAJARDO, T.V M.; NAVES, R. de L.; GIRARDI, C.L. **BRS Isis**: nova cultivar de uva de mesa vermelha, sem sementes e tolerante ao míldio. Bento Gonçalves: Embrapa Uva e Vinho, 2013. 20 p. (Comunicado técnico, 143).

ROYO, C.; TORRES-PÉREZ, R.; MAURI, N.; DIESTRO, N.; CABEZAS, J.A.; MARCHAL, C.; LACOMBE, T.; IBÁÑEZ, J.; TORNEL, M.; CARREÑO, R.; MARTÍNEZ-ZAPATER, J.M.: CARBONELL-BEJERANO, P. The major origin of seedless grapes is associated with a missense mutation in the MADS-Box Gene VviAGL111. **Plant Physiology**, Oxford, v.177, p.1234-53, 2018.

SPIEGEL-ROY, P.; BARON, Y.; SAHAR, N. Inheritance of seedlessness in seeded X seedless progeny of Vitis vinifera L. **Vitis**, Davis, v.29, p.79-83, 1990.

THIS, P.; LAHOGUE, F.; ADAM-BLONDON, A.F.; DOLIGEZ, A.L; BOUQUET, A. Towards marker-assisted selection for seedlessness in grapevine. **Acta Horticulturae**, The Hague, v.528, p.221-9, 2000.

VERMA, M.K.; SINGH, S.K.; PRAKASH, J.; SINGH, A.K.; JHA, S.K. Mechanical behaviour of seed hardness in relation to physico-chemical composition of grape. **Indian Journal of Horticulture**, New Delhi, v.71, n.4, p.469-475, 2014.

WEI, X.; SYKES, S.R.; CLINGELEFFER, P.R. An investigation to estimate genetic parameters in CSIRO's table grape breeding program 2. Quality characteristics. **Euphytica**, Dordrecht, v.128, p.343-51, 2002.

ZHU, P.; GI, B.; LI, P.; SHU, X.; ZHANG, X.; ZHANG, J. New cold-resistant, seedless grapes developed using embryo rescue and marker-assisted selection. **Plant Cell Tissue Organ Culture**, Dordrecht, v.140, p.551-62, 2020.