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Production and selection of accessions of *Opuntia* spp. with resistance to false carmine cochineal

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Abstract

The genetic improvement program for *Opuntia* spp. aims to select new genotypes to meet the demands of rural producers in the Brazilian Semiarid region and to expand the genetic base of the crop. This study aimed to select accessions of *Opuntia* spp. with forager potential and resistance to false carmine cochineal. The research was carried out at the Active Germplasm Bank (BAG) of *Opuntia* spp. of Paraíba Company Research, Rural Extension and Land Regularization (EMPAER), Pendência Experimental Station, Soledade, State of Paraíba, Brazil. Accessions were cultivated in rainfed and evaluated in August 2019, 12 months after the implementation of the BAG. The measurement of the Total Green Mass weight of the plants of 121 accessions of the BAG was carried out and the productivity (ton ha^{-1}) was estimated in dense cultivation of 100 thousand plants ha^{-1}. The accessions of *Opuntia* spp. nº 10, 110, 115, and 119 have growth potential in the Brazilian Semiarid region, as a function of productivity (532.6, 118, 164, and 481 tons ha^{-1}, respectively) and resistance to false carmine cochineal, in addition to genetic divergence (specific agronomic characteristics) about currently cultivated varieties.

Keywords: *Dactylopius opuntiae*; genetic resources; plant breeding

Introduction

The forage cactus (*Opuntia* spp.) is the main xerophilic plant cultivated in the Brazilian Semiarid region, due to its productive potential and mainly because of its proven resistance to drought, being used to feed ruminants (goats, sheep, and cattle). Despite its economic importance, the false carmine cochineal (*Dactylopius opuntiae* Cockerell, 1896) (Hemiptera, Dactylopiidae), the main pest of the crop in Brazil, decimated extensive areas of the Northeast, especially palm groves of *Opuntia ficus-indica* (L.) Miller, in the states of Pernambuco and Paraíba (Santos et al., 2013; Torres & Giorgi, 2018).

Dactylopius opuntiae was detected in Brazil in the late twentieth century and several attempts were made to control it, such as mechanical, biological, and chemical control, using natural products and insecticides. Due to the inefficiency of these forms of control, the cultivation of resistant varieties has become the main strategy to solve the damage caused by the occurrence of this pest (Santos et al., 2013; Araújo et al., 2019).

Researchers contributed to the control of *Dactylopius opuntiae*, when they selected clones resistant to this pest (Vasconcelos et al., 2009; Lopes et al., 2010; Borges et al., 2013), in addition to recording cultivars (Lopes, 2012; Santos et al., 2013). Despite the contribution of scientific research in the selection of varieties resistant to false carmine cochineal, the genetic improvement program of *Opuntia* spp. aims to expand the genetic base of the crop and select new genotypes with resistance to this pest (Almeida et al., 2019), as well as others, or even to different types of pathogens, in an attempt to make life easier for the rural producer and to promote the increased resistance, with the diversification of cultivated areas.

In Brazil, the genetic improvement program for *Opuntia* spp. is aimed at forage production and the

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selection of new genotypes with resistance to *Dactylopius opuntiae* has been of great importance, with the function of meeting the demands of producers and raising the income of rural properties in the Brazilian Semiarid region (Almeida et al., 2019; Araújo et al., 2019). In this sense, this study aimed to select accessions of *Opuntia* spp. with foraging potential and resistance to false carmine cochineal (*Dactylopius opuntiae* Cockerell, 1896).

Materials and Methods

The research was carried out at the Active Germplasm Bank (BAG) of *Opuntia* spp. of the Paraíba Company Research, Rural Extension and Land Regularization (EMPAER), Pendência Experimental Station, Soledade, State of Paraíba, Brazil (Table 1).

Table 1. List of accessions of the Active Germplasm Bank (BAG) of *Opuntia* spp., belonging to the Paraíba Company Research, Rural Extension and Land Regularization (EMPAER), Pendência Experimental Station, Soledade, State of Paraíba, Brazil.

Accessions	Name	Origin	Species
1	Moradilla - V03	La Purificación, Texcoco, Mexico	*O. ficus-indica* (L.) Mill
2	Verdura Morado - V26	Faculdade Agronomía, Marin, Nuevo León, Mexico	*O. ficus-indica* (L.) Mill
3	Texas - V13	Nopalera UACH, Chapingo, Mexico	*O. atropes* Rose
4	FX Italiana	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
5	Copena V1 - V04	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
6	Nopalea Uruapan - V20	Uruapan, Michoacán, Mexico	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
7	Oaxaca - V10	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
8	Polotitlán - V09	Nopalera UACH, Chapingo, Mexico	*O. atropes* Rose
9	California - V14	Nopalera UACH, Chapingo, Mexico	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
10	Negro Michoacán - V07	Uruapan, Michoacán, Mexico	*O. atropes* Rose
11	Manso San Pedro - V21	San Pedro de los Naranjos, Guanajuato, Mexico	*O. ficus-indica* (L.) Mill
12	Blanco San Pedro - F24	San Pedro, Guanajuato, Mexico	*O. stricta* Haw
13	Negro Michoacán - F07	Nopalera UACH, Chapingo, Mexico	*O. atropes* Rose
14	Blanco San Pedro -V19	San Pedro de los Naranjos, Guanajuato, Mexico	*O. atropes* Rose
15	Oreja de elefante - V17	Nopalera UACH, Chapingo, Mexico	*O. stricta* Haw
16	Rosa - T64	Rancho M.R. Ramos Arizpe, Coahuila, Mexico	*O. ficus-indica* (L.) Mill
17	Rojo 3589 (s) -T26	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
18	FR mineira	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
19	Direkteur - FD	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
20	Villanueva - V22	Villanueva, Zacatecas, Mexico	*O. ficus-indica* (L.) Mill
21	Huatusco - V30	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
22	Rosa liso - T63	Rancho M.R. Ramos Arizpe,Coahuila, Mexico	*O. ficus-indica* (L.) Mill
23	FR - redonda	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
24	Liso Miguel Alemán - V23	Guardados de Arriba, Miguel Alemán, Tamaulipas, Mexico	*O. ficus-indica* (L.) Mill
25	Amarillo 2289 (s) - T32	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
26	Oaxaca - F10	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
27	Rojo Vigor (s) - T03	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
28	Plátano - T57	Las Papas, Ojuelos de Jalisco, Jalisco, Mexico	*O. ficus-indica* (L.) Mill
29	Tuna Amarilla - T79	Socorro Rios, Bill Maltsberger, Cotulla, Texas, EUA	*O. ficus-indica* (L.) Mill

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Accessions	Name	Origin	Species
30	Rojo liso 4	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
31	Pelona Doble objeto - T73	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. ficus-indica* (L.) Mill
32	Blanco michoacán - F08	Nopalera UACH, Chapingo, Mexico	*O. atropes* Rose
33	Amarillo Milpa Alta (s) - F18	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
34	Pabellón (s) - T30	CRUCEN - UACH, Zacatecas, Mexico	*O. ficus-indica* (L.) Mill
35	Oreja de elefante - F16	José Montero Guardados de Arriba, Miguel Alemán, Tamaulipas, Mexico	*O. stricta* Haw
36	Pabellón - T30	CRUCEN - UACH, Zacatecas, Mexico	*O. ficus-indica* (L.) Mill
37	Tamazushale - V12	Nopalera UACH, Chapingo, Mexico	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
38	Amarilla UACH - T42	Nopalera UACH, Chapingo, Mexico	*O. ficus-indica* (L.) Mill
39	Rosa San Luis Potosí - T75	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. ficus-indica* (L.) Mill
40	Villanueva - F22	Faculdade Agronomía, Marin, Nuevo León, Mexico	*O. ficus-indica* (L.) Mill
41	Copena Cell (s) - T12	Colección UACH-Barrientos, CRUCEN-UACH, Zacatecas, Mexico	*O. ficus-indica* (L.) Mill
42	Palmepa PB1	EMEPA, Lagoa Seca, Paraíba, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
43	Palmepa PB2	EMEPA, Lagoa Seca, Paraíba, Brazil	*O. undulata* Griffiths
44	Palmepa PB3	EMEPA, Lagoa Seca, Paraíba, Brazil	*O. stricta* Haw
45	Palmepa PB4	EMEPA, Lagoa Seca, Paraíba, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
46	Tapón pelón - T81	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. robusta* Wendl.
47	Forrajero Cenizo - F27	Rancho M.R., Ramos Arizpe, Coahuila, Mexico	*O. rzedowskii* Scheinvar
48	Camueso - T35	La Tinaja, San Diego de la Únion, Guanajuato, Mexico	*O. megacantha* Salm-Dyck
49	Blanco Valtierrilla - F48	Valtierrilla, Guanajuato, Mexico	*O. atropes* Rose
50	Rubí del Sitio (8) - T53	Ojo de Agua de la Palma, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
51	Naranjona - T40	Rancho Las Papas, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
52	Jarilla Grande - T14	La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
53	Naranjona - T37	La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
54	Espinhoso Rojo Vigor - T03	Nopalera UACH, Chapingo, Mexico	*O. megacantha Salm-Dyck*
55	Picochulo - T05	Rancho Las Papas, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
56	Sangre de Toro - T71	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. megacantha Salm-Dyck*
57	Teca - T70	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. megacantha* Salm-Dyck
58	Tapón	Nopalera UACH, Chapingo, Mexico	*O. robusta* Wendl
59	Fafayuco - T23	CRUCEN - UACH, Zacatecas, Mexico	*O. albicarpa* Scheinvar
60	Durasnillo - F25	La Pila, San Luis Potosí, Mexico	*O. leucotricha* DC.
61	Solferino 2589 (s) - T20	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
62	Amarilla San Luis Potosí - T67	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. megacantha* Salm-Dyck
63	Amarillo Aguado - T08	La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck

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Accessions	Name	Origin	Species
64	F Espinoso	Nopalera UACH, Chapingo, Mexico	*Opuntia* sp.
65	Cuijo - F45	Rancho la Cenicera, San luis de la Paz, Guanajuato, Mexico	*Opuntia* sp.
66	Espinoso Amarillo - T32	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
67	Rosalba - T43	La Tinaja, San Diego de la Únion, Guanajuato, Mexico	*O. megacantha* Salm-Dyck
68	Copena T18 - T76	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
69	Rosa com espinas - T61	Rancho M.R., Ramos Arizpe, Coahuila, Mexico	*O. megacantha* Salm-Dyck
70	Morada - T10	San Martín de las Pirámides, Mexico, Mexico	*O. megacantha* Salm-Dyck
71	Cristalino - T82	Faculdade Agronomía, Marin, Nuevo León, Mexico	*O. megacantha* Salm-Dyck
72	Cristalina - T27	La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
73	Monteza - T17	La Monteza Villa Garcia, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
74	Rojo Liso (s) - T07	Matehuala, La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
75	Penca Alargado - F34	Vivero SEMARNAP, Saltillo, Coahuila, Mexico	*O. megacantha* Salm-Dyck
76	Amarillo - T62	Rancho M.R., Ramos Arizpe, Coahuila, Mexico	*O. megacantha* Salm-Dyck
77	Colorada - T06	CRUCEN - UACH, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
78	Gigante com espinho - T46	Axapusco, Mexico, Mexico	*O. albicarpa* Scheinvar
79	Liso forrajero (s) - T18	CRUCEN - UACH, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
80	Frida (copena torreoja) - T11	Rancho Las Papas, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
81	Copena Moradilla - T77	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
82	Lingua de vaca	Soledade, Paraíba, Brazil	*O. ficus-indica* (L.) Mill
83	Espinoso Amarillo - F46	Rancho Bill Maltsberger, Cotulla, Texas	*O. robusta* Wendl
84	Sangre de toro - T28	Rancho Las Papas, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
85	Espinhosa redonda - T23	CRUCEN - UACH, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
86	Alfajayucan - T16	San Martín de las Pirámides, Mexico, Mexico	*O. megacantha* Salm-Dyck
87	Copena de Fernando Torres (5) - T51	Ojo de Agua de la Palma, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
88	Apastillada - T19	La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
89	Blanco de la Victoria - T31	La Victoria, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
90	Copena T5 - T15	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
91	Aguamielilla Hgo. - T72	Campo Narro, Matehuala, San Luis Potosí, Mexico	*O. joconostle* A. Web.
92	Amarilla naranjona (11) - T55	Ojo de Agua de la Palma, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
93	Roja Morada - T60	La Era, Ojuelos de Jalisco, Jalisco, Mexico	*O. megacantha* Salm-Dyck
94	Xoconostle - T34	La Tinaja, San Diego de la Unión, Guanajuato, Mexico	*O. joconostle* A. Web.
95	Mansa - T36	La Tinaja, San Diego de la Unión, Guanajuato, Mexico	*O. megacantha* Salm-Dyck
96	Presefio - T65	La Tinaja, San Diego de la Unión, Guanajuato, Mexico	*O. megacantha* Salm-Dyck
97	Rojo Lírio (7) - T52	Ojo de Agua de la Palma, Zacatecas, Mexico	*O. megacantha* Salm-Dyck
98	Espinhoso Rojo - T26	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
99	Copena Grande - T78	Nopalera UACH, Chapingo, Mexico	*O. megacantha* Salm-Dyck
100	Tuna Morada - T80	Faculdade Agronomía, Marin, Nuevo León, Mexico	*O. megacantha* Salm-Dyck

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Accessions	Name	Origin	Species
101	G 21. IPA100500 - Clone 1 OEM Lisa	IPA, Arcoverde, Pernambuco, Brazil	*O. stricta* Haw
102	G1. IPA-100415 - Clone 1 (F21)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
103	G2. IPA-100422 - Clone 4 (F21)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
104	G3. IPA-100419 - Clone 12 (F21)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
105	G4. IPA-100417 - Clone 25 (F21)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
106	G5. IPA- 200016 - Orelha de elefante mexicana (OEM)	IPA, Arcoverde, Pernambuco, Brazil	*O. stricta* Haw
107	G6. IPA-200174 - Orelha de elefante africana (OEA)	IPA, Arcoverde, Pernambuco, Brazil	*O. undulata* Griffiths
108	G7. IPA-100429 - Clone 1 OEA	IPA, Arcoverde, Pernambuco, Brazil	*O. undulata* Griffiths
109	G8. IPA-100430 - Clone 6 OEA	IPA, Arcoverde, Pernambuco, Brazil	*O. undulata* Griffiths
110	G9. IPA-100431 - Clone 9 OEA	IPA, Arcoverde, Pernambuco, Brazil	*O. undulata* Griffiths
111	G10. IPA-100004 - Miúda/ Doce	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
112	G11. IPA-200205 - IPA Sertânia	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
113	G12. IPA-200021 - F21	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
114	G13. IPA-200008 - F08	IPA, Arcoverde, Pernambuco, Brazil	*O. atropes Rose*
115	G14. IPA-200149 - V19	IPA, Arcoverde, Pernambuco, Brazil	*O. robusta* var. larreyi (F.A.C.Weber) Bravo
116	G15. IPA-100423 - Clone 23 (Seleção de cruzamento)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
117	G17. IPA-100425 - Clone 25 (Seleção telado)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
118	G18. IPA-100426 - Clone 26 (Seleção telado)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
119	G19. IPA-100427 - Clone 27 (Seleção telado)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
120	G20. IPA-100428 - Clone 28 (Seleção telado)	IPA, Arcoverde, Pernambuco, Brazil	*O. cochenillifera* (L.) Salm Dyck subgênero *Nopalea*
121	Palma de espinho	Soledade, Paraíba, Brazil	*O. dillenii* (Ker-Grawl.) Haw.

Accessions were cultivated in rainfed and evaluated in August 2019, 12 months after the implementation of the BAG. The measurement of the Total Green Mass weight of the plants of 121 accessions of the BAG was carried out and the productivity (ton ha^{-1}) was estimated in dense cultivation of 100 thousand plants ha^{-1}. Four accessions (nº 10, 110, 115 e 119), belonging to different species, were selected, taking into account genetic divergence, forage potential, resistance to false carmine cochineal, in addition to specific characteristics (Figure 1).

Figure 1. Selected accessions of *Opuntia* spp. A) access 110; B) access 115; C) access 119; and D) access 10.

The estimate of productivity of the accessions was submitted to analysis of variance (ANOVA) and the means were compared by the F test ($p<0.01$) and Scott-Knott test at 5 % probability of error. A dissimilarity analysis was also carried out using the Euclidean distance and a dendrogram was formed using the Ward hierarchical grouping method. For the formation of clusters, the connection distance of 6.0 was considered as a cutoff point. Both analyzes were performed using R software version 3.6.1 (R Core Team, 2019).

Results and Discussion

There was a significant difference ($p<0.01$) by the F test, indicating that there is genetic variability among the 121 accessions to estimate yield (ton ha^{-1}). By the Scott-Knott test ($p<0.05$), 4 distinct groups were formed, represented by the letters (“a”, “b”, “c”, and “d”). The accessions classified with the letter “a” reached estimates above 453.3 t ha^{-1}. Accessions with the letter “b” (between 293.8 to 435.2 t ha^{-1}); in the letter “c” (between 164.0 to 283.0 t ha^{-1}) and in the “d” (less than 257.2 t ha^{-1}) (Table 2).

The significant differences ($p<0.01$) observed between the averages of *Opuntia* accessions for productivity, demonstrate evidence of sufficient genetic variability to carry out the selection of the best accessions (Araújo et al., 2008). It is noteworthy that the results obtained show high production differences within the same species, for example, for *O. ficus-indica* (L.) Mill, which had accessions with productivities classified within the 4 distinct groups of means by the Scott-Knott test. These results reinforce the existence of expressive variability present in the BAG.

To detail the dissimilarity between the 121 accessions, a dendrogram was used, obtained through cluster analysis using the WARD hierarchical method, based on the Euclidean distance. This method significantly represented the genetic diversity existing among the accessions, with the formation of 3 distinct groups, represented by the color’s red, green, and blue (Figure 2).

The red group included accessions with the highest yields, such as accession 10 (Negro Michoacán - V07, *O. atropes Rose*) and accession 119 (*O. cochenillifera* (L.) Salm Dyck subgenus *Nopalea*). It should be noted that *O. atropes* is still very little cultivated in Northeast Brazil, where the fields of cactus production are cultivated almost in their majority with O. ficus-indica and *O. cochenillifera* (L.) Salm Dyck subgenus *Nopalea*, which are the most used species to feed livestock (Silva et al., 2022). Thus, the propagation of accessions with nº 10, can contribute in a satisfactory way to the local livestock, especially because it has high productivity and resistance to false carmine cochineal.

Table 2. Yield estimates (ton ha^{-1}), in dense cultivation 100,000 plants ha^{-1}, of 121 accessions of the Active Germplasm Bank (BAG) of *Opuntia* spp., belonging to the State Paraíba Company Research, Rural Extension and Land Regularization (EMPAER), Pendência Experimental Station, Soledade, State of Paraíba, Brazil.

Access.	t ha^{-1}	Access.	t ha^{-1}	Access.	t ha^{-1}	Access.	t ha^{-1}	Access.	t ha^{-1}
1	407.5 b	26	310.9 b	51	220.2 c	76	91.0 d	101	225.9 c
2	145.8 d	27	435.2 b	52	638.9 a	77	140.5 d	102	202.7 c
3	594.2 a	28	200.6 c	53	180.3 c	78	245.5 c	103	293.8 b
4	155.1 d	29	218.2 c	54	110.0 d	79	446.1 b	104	467.1 a
5	270.1 c	30	269.3 c	55	223.4 c	80	302.5 b	105	241.6 c
6	222.2 c	31	222.7 c	56	73.0 d	81	220.5 c	106	355.3 b
7	185.9 c	32	486.2 a	57	88.6 d	82	75.8 d	107	331.3 b
8	54.8 d	33	350.5 b	58	30.9 d	83	66.3 d	108	233.5 c
9	382.6 b	34	72.1 d	59	32.6 d	84	409.8 b	109	377.1 b
10	532.6 a	35	355.7 b	60	336.1 b	85	101.16 d	110	118.0 d
11	64.6 d	36	225.7 c	61	154.6 d	86	358.2 b	111	343.3 b
12	241.0 c	37	137.3 d	62	172.0 c	87	205.5 c	112	526.3 a
13	332.5 b	38	242.3 c	63	294.6 b	88	72.3 d	113	329.8 b
14	267.9 c	39	88.9 d	64	50.66 d	89	82.9 d	114	194.6 c
15	374.6 b	40	295.8 b	65	122.5 d	90	107.3 d	115	164.0 c
16	147.5 d	41	157.3 d	66	168.5 c	91	198.8 c	116	536.9 a
17	169.5 c	42	193.6 c	67	140.4 d	92	58.33 d	117	213.5 c
18	236.8 c	43	152.2 d	68	209.3 c	93	257.2 d	118	588.7 a
19	89.8 d	44	418.3 b	69	395.66 b	94	144.5 d	119	481.0 a
20	283.0 c	45	216.1 c	70	120.0 d	95	376.6 b	120	407.3 b
21	239.5 c	46	95.0 d	71	276.5 c	96	426.0 b	121	108.3 d
22	83.3 d	47	144.5 d	72	143.0 d	97	270.0 c		
23	453.3 a	48	182.8 c	73	166.6 c	98	221.0 c		
24	591.5 a	49	121.5 d	74	190.1 c	99	184.1 c		
25	264.0 c	50	113.3 d	75	104.0 d	100	159.1 d		

Means followed by the same letter do not differ from each other by the Scott-Knott test ($p<0.05$).

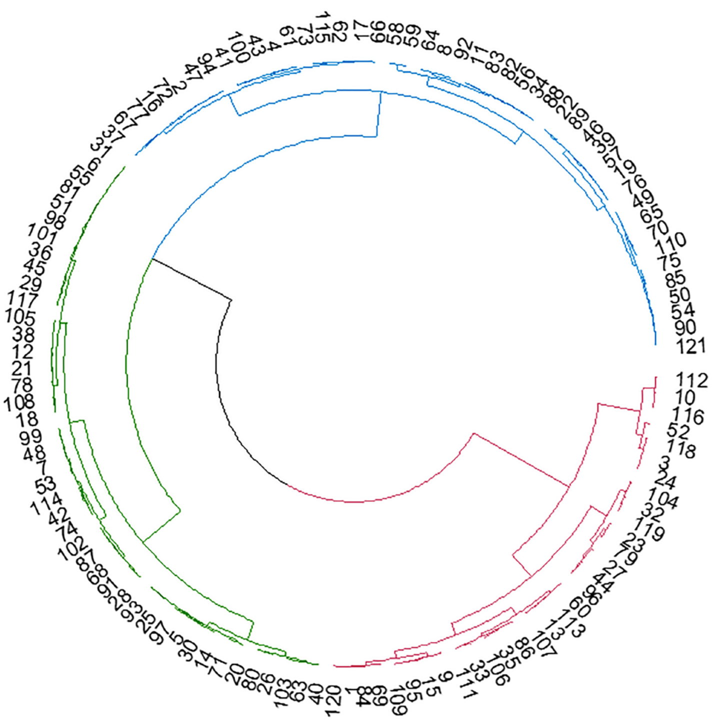

Figure 2. Dendrogram obtained by Ward's Method, from the Euclidean distance of the 121 accessions of *Opuntia* spp., based on the productivity estimate (ton ha^{-1}).

Although accession 119 has lower productivity than other accessions, it stood out about other genotypes of the same species, due to its low mortality rate, lack of flowering, and greater elasticity, important characteristics for agricultural activity in the Brazilian Semiarid Region. Most accessions of the BAG belonging to *O. cochenillifera*

(L.) Salm Dyck subgenus *Nopalea* have high production of flowers and fruits, with consequent abortion, being a negative point for the forage plant, due to the loss of nutrients. The selection of accessions such as nº 119 is of great relevance due to the importance that this species has for the northeastern livestock, especially dairy farming, in which *O. cochenillifera* (L.) Salm Dyck subgenus *Nopalea* is one of the mainstays of feeding lactating cows (Rocha Filho et al., 2021).

Despite the importance of BAG accessions as genetic resources for use in the crop genetic improvement program, many of them are not of immediate interest to rural producers, even reaching high yields, such as the accessions clustered in the red color group, due to susceptibility to *D. opuntiae*, or even the excessive occurrence of thorns, structures that can compromise the palatability and handling of these accessions (Mendonza et al., 2020).

The green group grouped accessions with intermediate yields and the blue color grouped the lowest estimates. Even reaching low yields, accessions as 110 and 115, they are important for livestock in the Semi-Arid region, as they have proven resistance to the false carmine cochineal *D. opuntiae*, in addition to being genetically divergent from the varieties cultivated in the Northeast currently, they can be used, for example, in artificial hybridization and other stages of the genetic improvement program, aiming to expand the genetic base of the crop, as recommended by Almeida et al. (2019).

Conclusions

Accessions of *Opuntia* spp. nº 10, 110, 115, and 119 have growth potential in the Brazilian Semiarid region, as a function of productivity (532.6, 118, 164 and 481ton ha^{-1}, respectively) and resistance to false carmine cochineal (*Dactylopius opuntiae* Cockerell, 1896), in addition to genetic divergence (specific agronomic characteristics) in relation to currently cultivated varieties.

References

Almeida, I.V.B., Souza, J.T.A., Batista, M.C. 2019. Melhoramento genético de plantas forrageiras xerófilas: Revisão. *Pubvet* 13: e382.

Araújo, F.P.D., Silva, N.D., Queiroz, M.A.D. 2008. Divergência genética entre acessos de *Passiflora cincinnata* Mast com base em descritores morfoagronômicos. *Revista Brasileira de Fruticultura* 30:723-730.

Araújo, J.S., Pereira, D.D., Lira, E.C., Félix, E.S., Souza, J.T.A., Lima, W.B. 2019. Palma Forrageira: plantio e manejo. Instituto Nacional do Semiárido, Campina Grande, Brasil. 59p.

Borges, L.R., Santos, D.C., Cavalcanti, V.A.L.B., Gomes, E.W.F., Falcão, H.M.; Silva, D.M.P. 2013. Selection of cactus pear clones regarding resistance to carmine cochineal *Dactylopius opuntiae* (Dactylopiidae). *Acta horticulturae* 995: 359-365.

Lopes, E.B. 2012. Cultivares registradas de palma forrageira resistentes à cochonilha-do-carmim. EMEPA, João Pessoa, Brasil. p. 61-62.

Lopes, E.B., Brito, C.H., Albuquerque, I.C., Batista, J.L. 2010. Seleção de genótipos de palma forrageira (*Opuntia* spp. e *Nopalea* spp.) resistentes à cochonilha-do-carmim (*Dactylopius opuntiae* Cockerell, 1929) na Paraíba, Brasil. *Engenharia Ambiental* 7: 204-215.

Mendonza, P.V., Santos, M.V.F.D., Sousa, T.C.D., Dubeux Júnior, J.C.B., Santos, D.C.D., Marín, J.M.C. 2020. Nopal clones Oreja de Elefante Mexicana with forage potential. *Revista Mexicana de Ciencias Agrícolas* 11:231-237.

R Core Team. 2019. *R: A Language and Environment for Statistical Computing*. Viena, Áustria. http://www.R-project.org

Rocha Filho, R.R., Santos, D.C.,Véras, A.S.C., Siqueira, M.C.B., Novaes, L.P., Mora-Luna, R., Monteiro, C.C.F., Ferreira, M.A. 2021. Can spineless forage cactus be the queen of forage crops in dryland areas?. *Journal of Arid Environments* 186: e104426

Santos, D.C., Silva, M.C., Dubeux Júnior, J.C.B., Lira, M.A., Silva, R. M. 2013. Estratégias para uso de cactáceas em zonas semiáridas: novas cultivares e uso sustentável das espécies nativas. *Revista Científica de Produção Animal* 15: 111-121.

Silva, R.T., Nollet, F., Santos, D.C.D., Felix, L.P., Buril, M.T., Bruno, R.L.A. 2022. Heterochromatin and polyploidy in *Opuntia* Mill. (Cactaceae: Opuntioideae): implications for plant breeding. *New Zealand Journal of Crop and Horticultural Science* 2022:1-20.

Torres, J.B., Giorgi, J.A. 2018. Management of the false carmine cochineal *Dactylopius opuntiae* (Cockerell): perspective from Pernambuco state, Brazil. *Phytoparasitica* 46: 331–340.

Vasconcelos, A.G.V., Lira, M.A., Cavalcanti, V.L.B., Santos, M.V.F., Willadino, L. 2009. Seleção de clones de palma forrageira resistentes à cochonilha-do-carmim (*Dactylopius* sp). *Revista Brasileira de Zootecnia* 38: 827-831.

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