



PERÚ

Ministerio  
de Desarrollo Agrario  
y Riego



Instituto Nacional de Innovación Agraria

 **Siempre**  
con el pueblo

# XXIV REUNIÓN LATINOAMERICANA DE MAÍZ

Cajamarca - Perú  
Junio de 2022

Organizado por:  
Instituto Nacional de Innovación Agraria



Del 15 al 17  
de junio  
**2022**



# Mejoramiento

# Genetico del Popcorn

**FERNANDO NINAMANGO CARDENAS**

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*Your Future is our Foundation*



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# QUE ABORDAREMOS:

01

AG Alumni Seed overview

02

Importancia comercial del Popcorn

03

Mejoramiento Genético del Popcorn





## The Agricultural Alumni Seed Improvement Association, Inc.

- Fundada en 1938
  - Sin fines de lucro
  - Soporte a la Universidad de Purdue
  - Comercialización de tecnologías de la Universidad de Purdue
- Líder mundial en semillas de popcorn de alta calidad

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Romney, IN





Romney, IN





# Producción de semillas

- 1,000 hectareas en Romney
- Aproximadamente 50% irrigada
- Estructura de secado y almacenamiento
- Camaras de frio
- Convenio con laboratorios para analisis de la calidad de semillas produzida

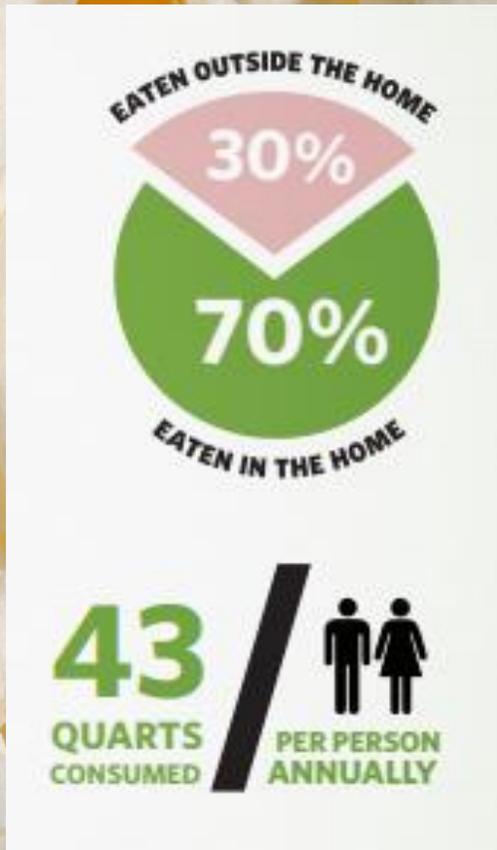


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13 billones de litros

The Popcorn Board  
**INDUSTRY FACTS**

AMERICANS CONSUME  
**14 BILLION\***  
QUARTS OF POPCORN ANNUALLY

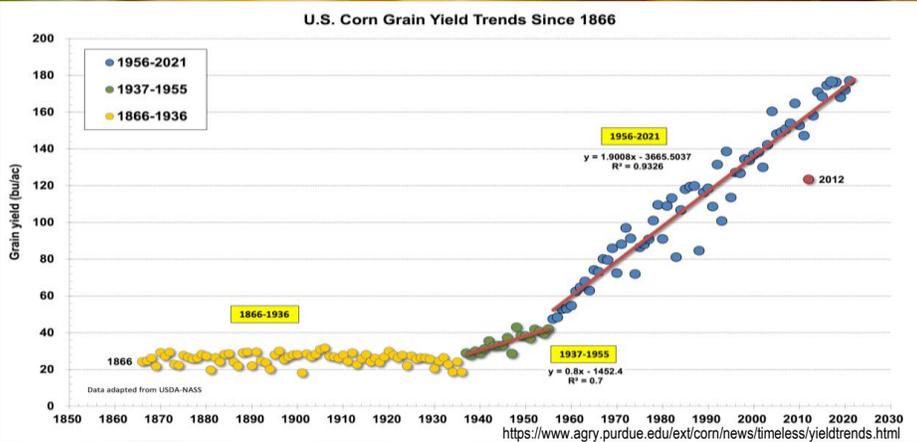


40.6 litros

Fuente: <https://www.popcorn.org/>



11 Ton/ha

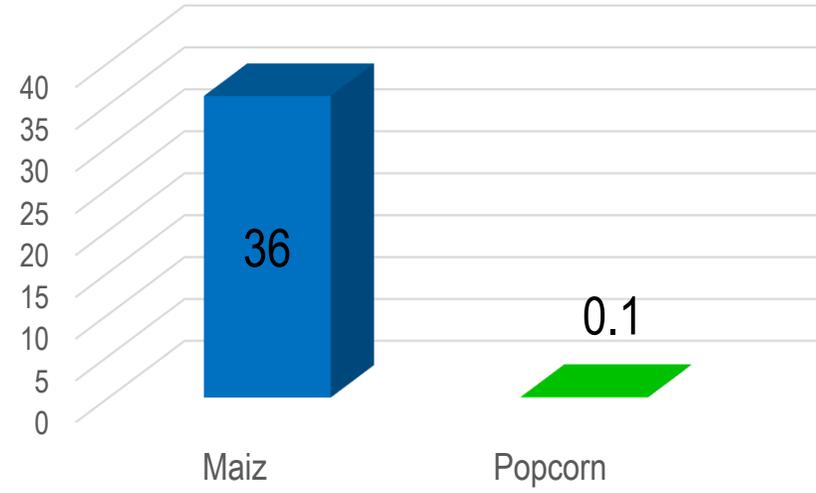


5 – 7 Ton/ha

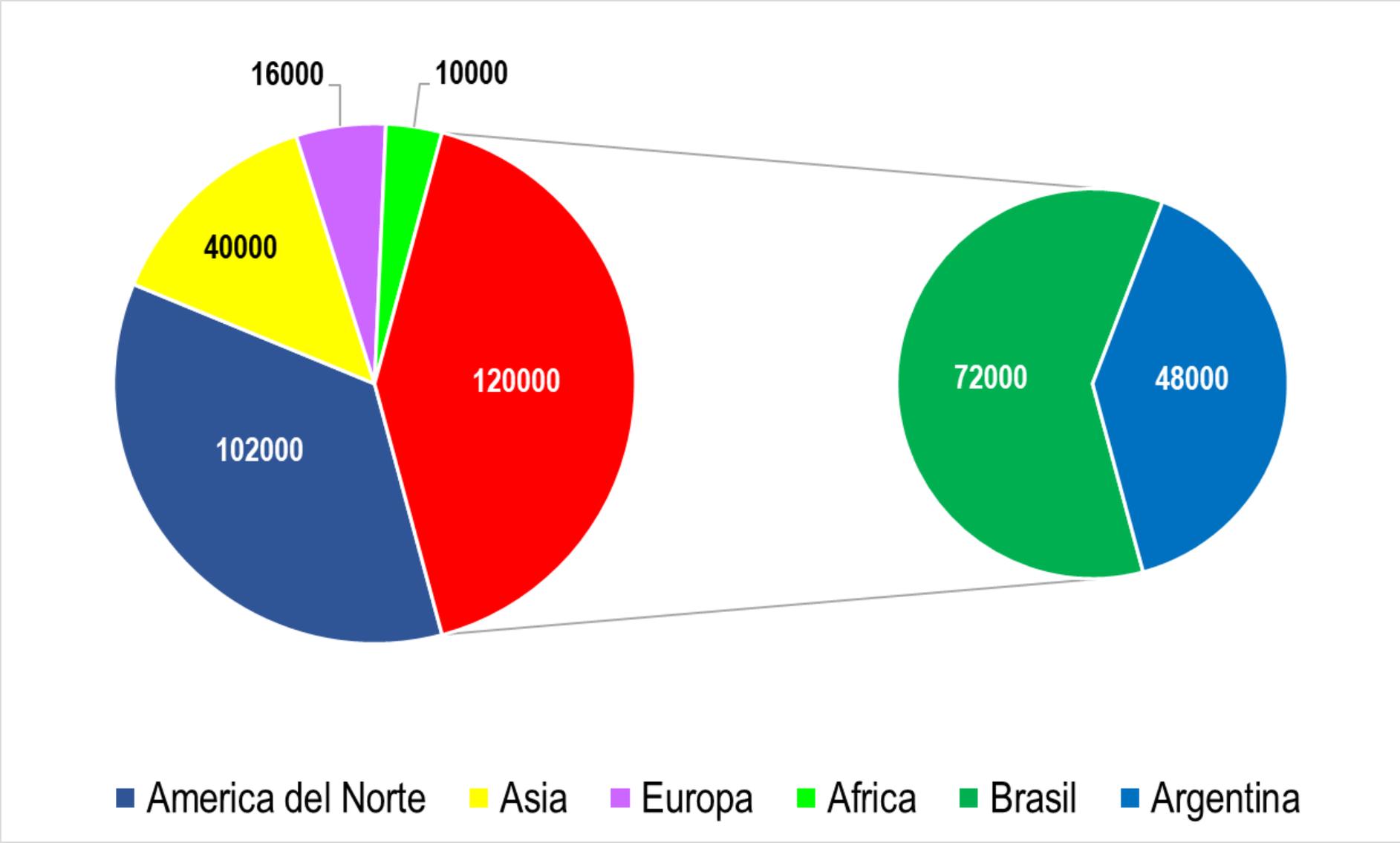


# Area sembrada con maiz y popcorn en USA 2021

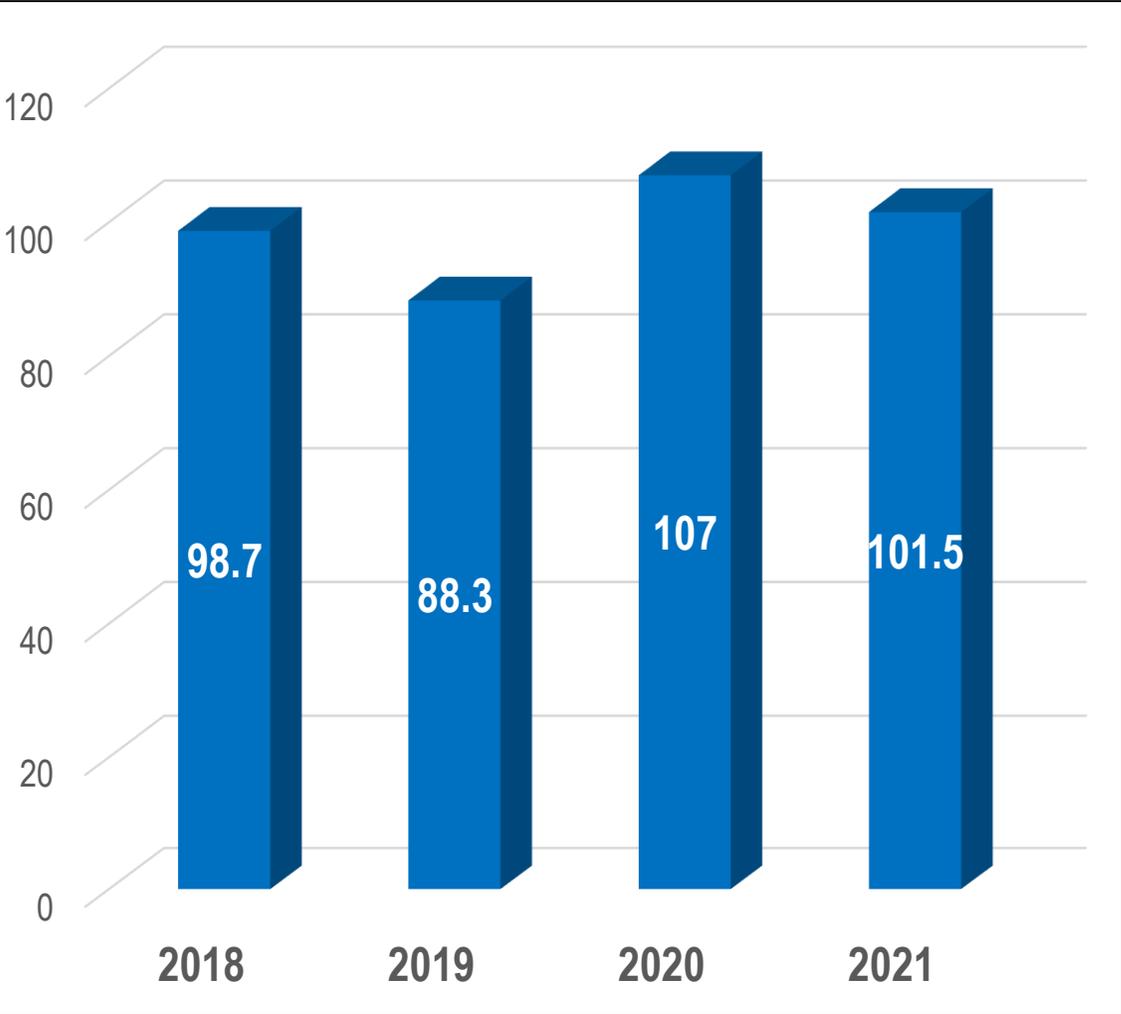
(en millones de ha)



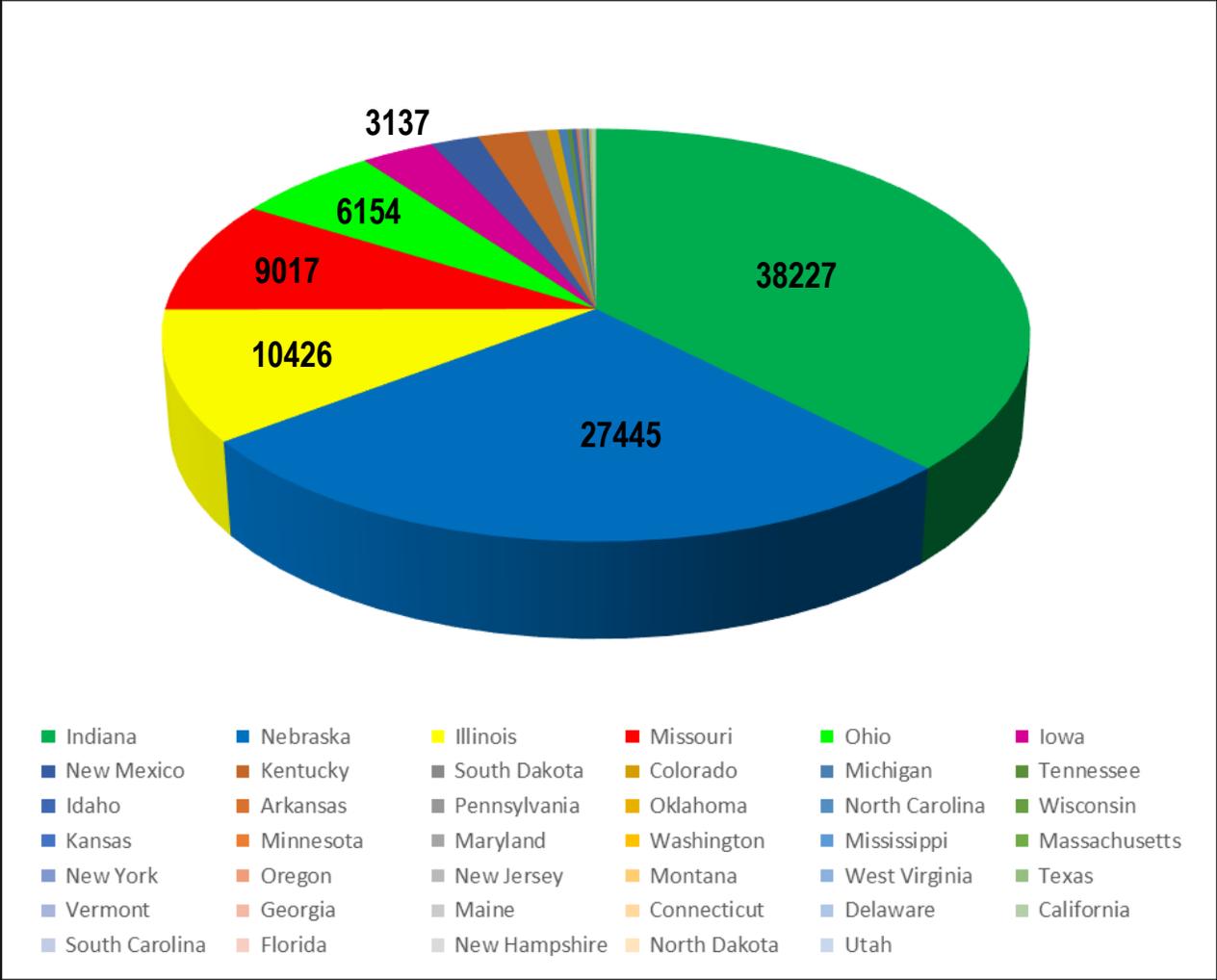
# Estimativa de Area de Producción Mundial (Ha)



**Area Total Sembrada en USA (2018-2021) en 1000 ha**

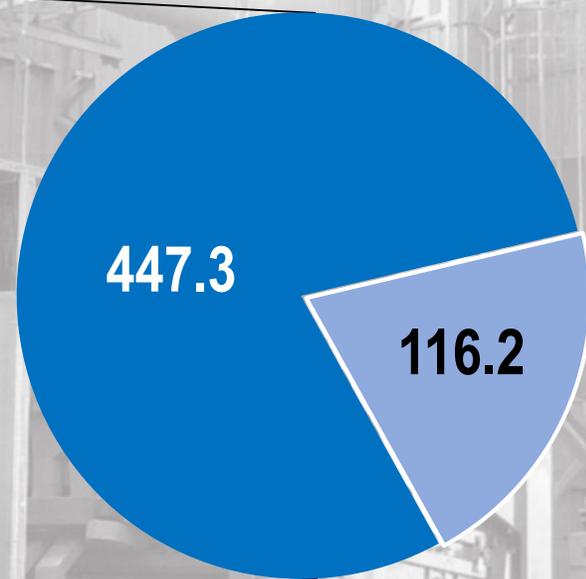
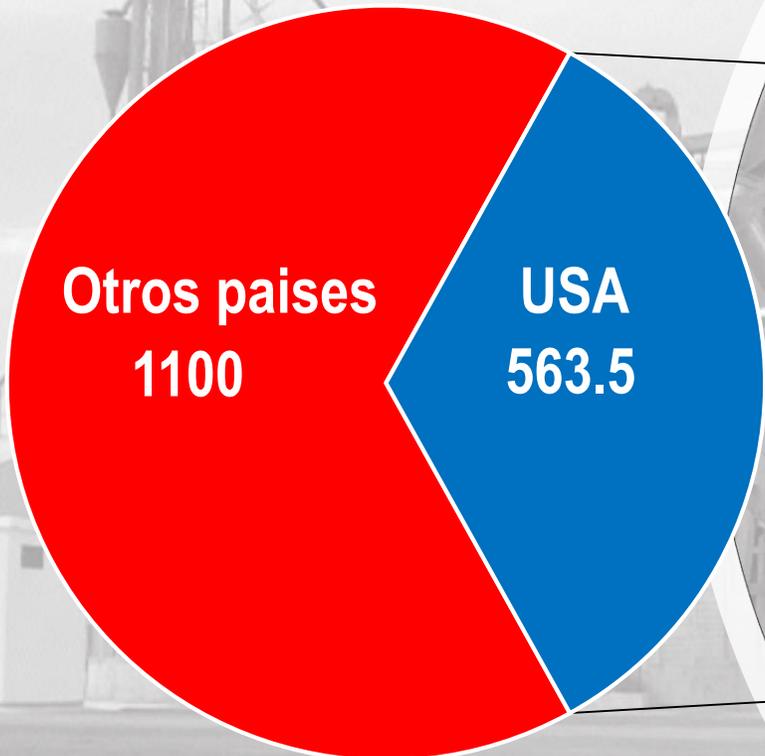


**Estados Productores de Popcorn en USA – 2021 (ha)**



Fuente: FSA / USDA

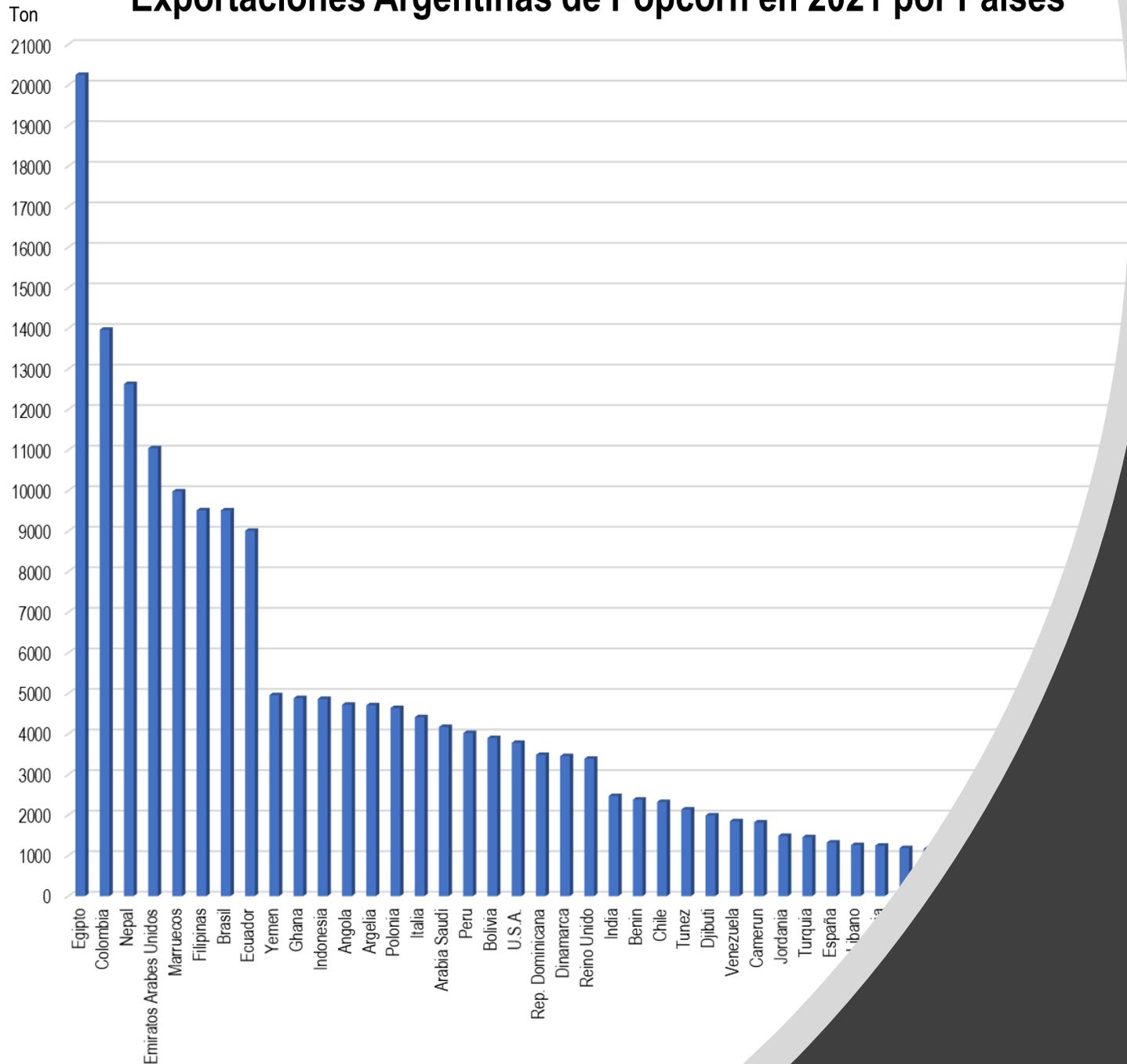
# Estimativa de Popcorn Procesado Mundial en 2021 (en 1000 Ton)



■ Otros países    ■ Consumo interno    ■ Exportación

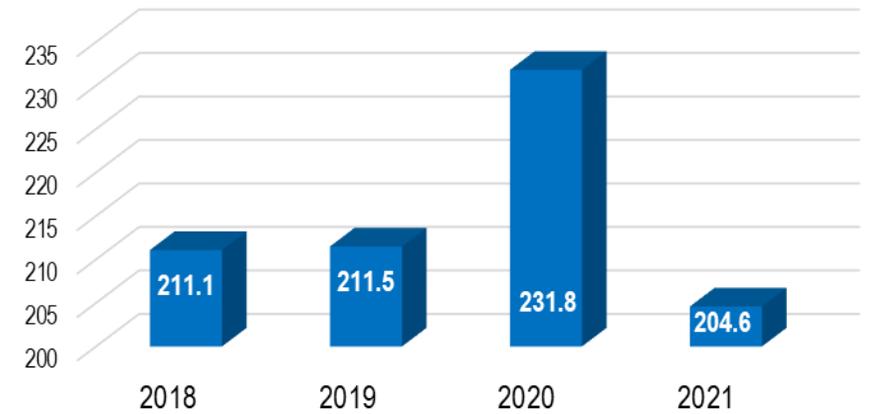


# Exportaciones Argentinas de Popcorn en 2021 por Países



# EXPORTACIONES ARGENTINAS DE POPCORN

Exportaciones Argentinas de Popcorn (2018-2021) en 1000 Ton.

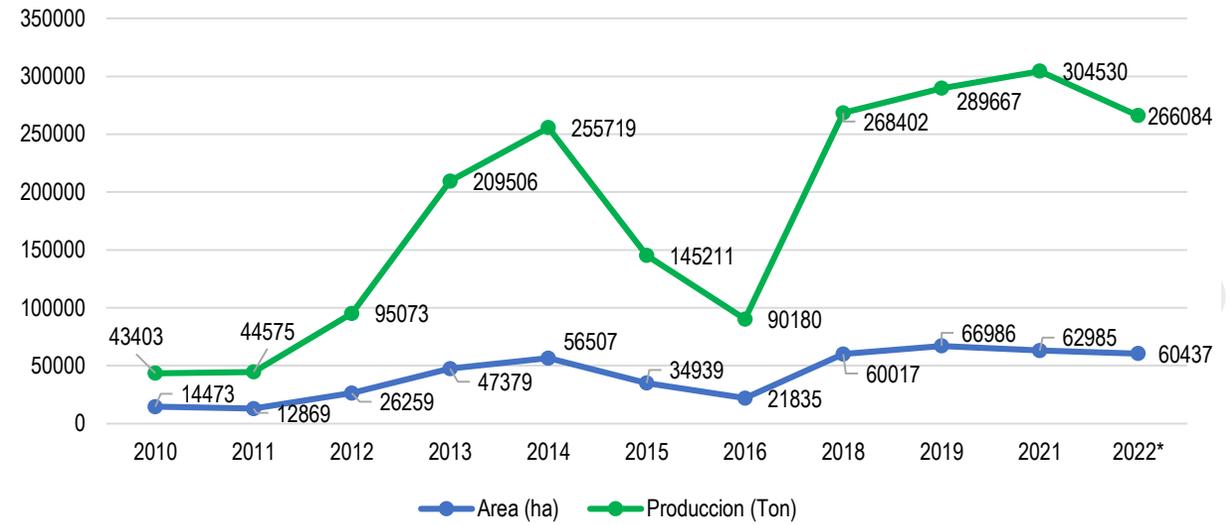


Fuente: Camara de Procesadores y Exportadores de Maiz Pisingallo, 2021

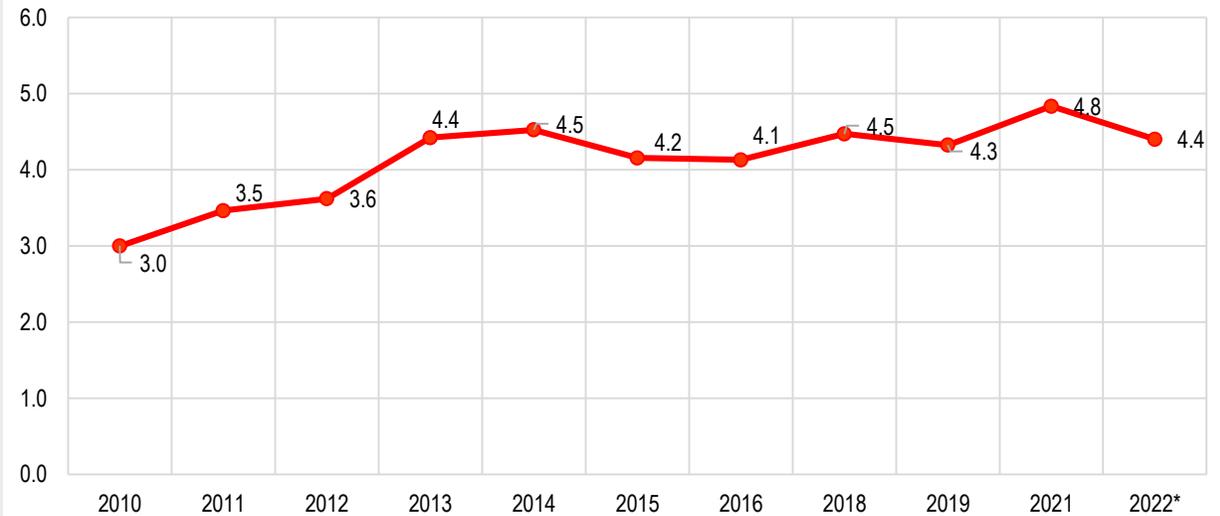
# Mato Grosso, Brasil



Area (ha) y Produccion Total (Ton) de Popcorn



Rendimiento medio (Ton/ha)

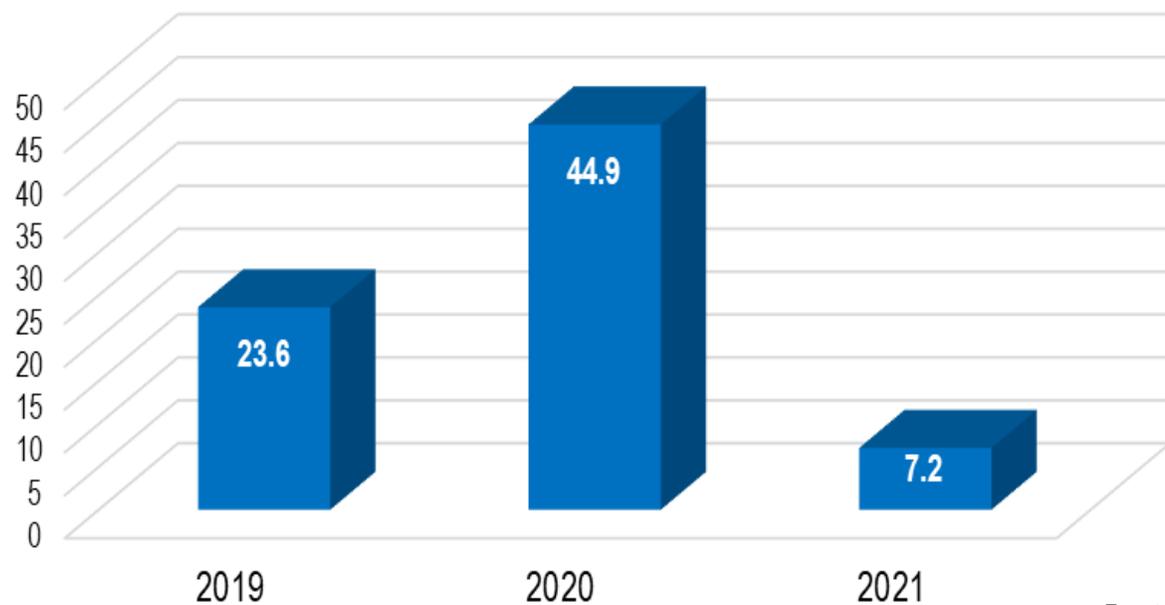


Fuente: IBGE 2022, Brasil

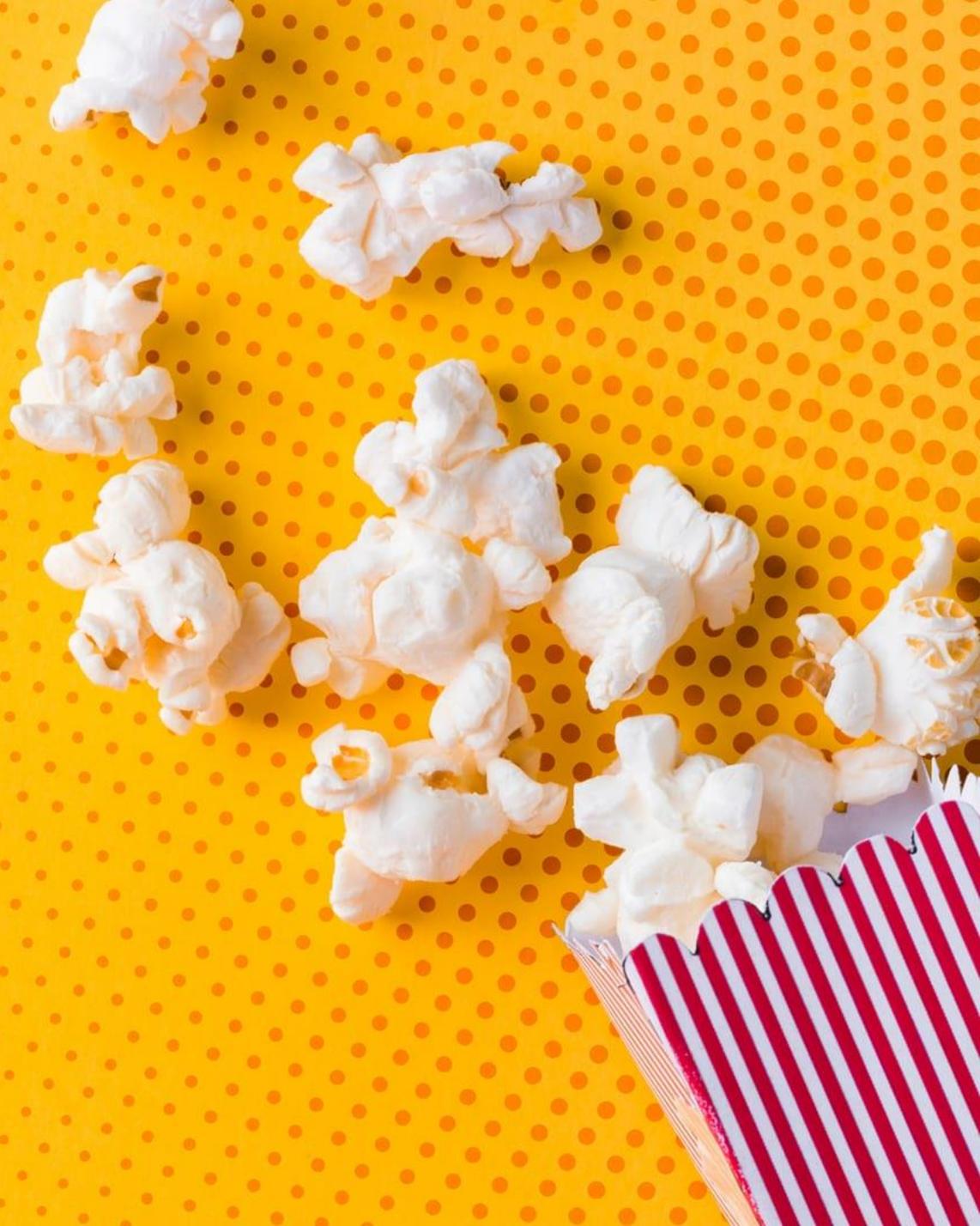
\* Estimativa



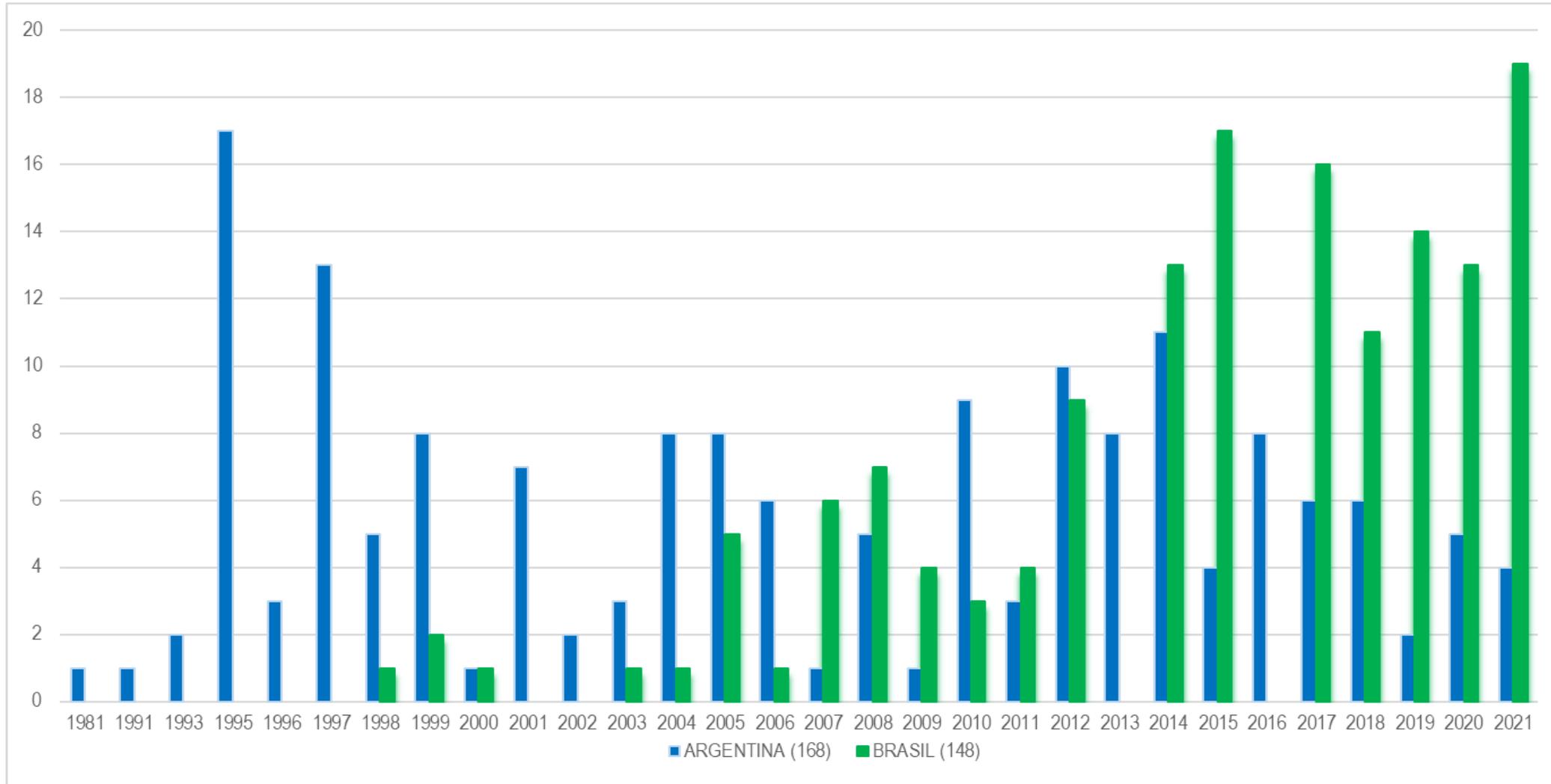
## Importaciones Peruanas de Popcorn (2019-2021) en 1000 Ton.



Fuente: SUNAT



# Cultivares Registrados en Argentina y Brasil



Fuente: Inase (Argentina), RNC (Brasil) – Actualización: 3 de Mayo 2022





# Mejoramiento Genético



# Razas Primitivas de Popcorn Era Pre-ceramica

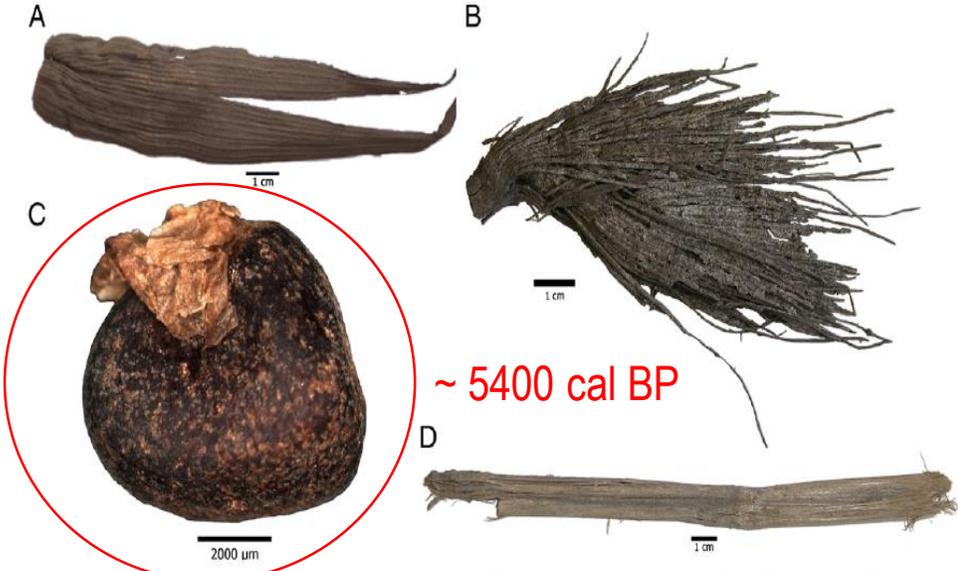
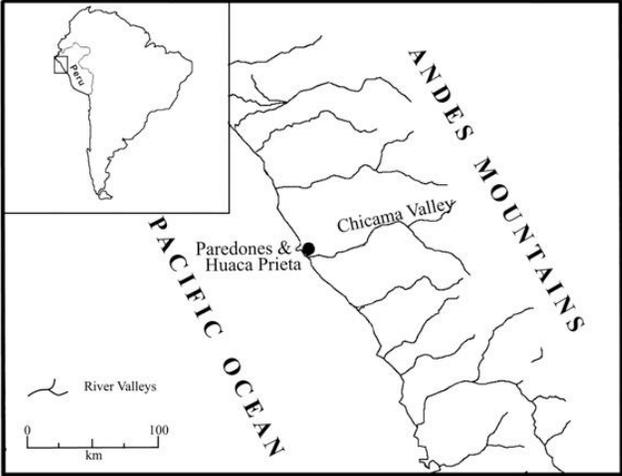


Fig. 2. Various preceramic maize elements from the Paredones site. (A) Husk with high venation index. (B) Tassel showing no condensation, unlike tassels from most Mexican maize. (C) Popcorn grain. (D) Stalk internode from a slender plant, probably no taller than ~1.5 m.

~ 6775 - 6504 cal BP



Fig. 3. Races of preceramic maize cobs from Paredones and Huaca Prieta. (A) Proto-Confitte Morocho cob with large soft glumes; the extreme lower right tip of the cob shows the remainder of a partially charred shank fragment (arrow), a portion of which with its attached husk fragment was removed and AMS dated to 6775–6504 cal BP. (B) Confitte Chavinense cob exhibiting fasciation and cupules underlying very small kernels. (C) Proto-Alazan cob.

Grobman *et al.* 2012



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# Heredabilidad en Popcorn

Característica	Estimativas de la Heredabilidad					
	Sentido amplio			Sentido restricto		
	Mínimo	Máximo	Amplitud	Mínimo	Máximo	Amplitud
Rendimiento	0.2193	0.9984	0.7791	0.1572	0.6784	0.5212
Expansión	0.1692	0.9995	0.8303	0.1585	0.8273	0.6688

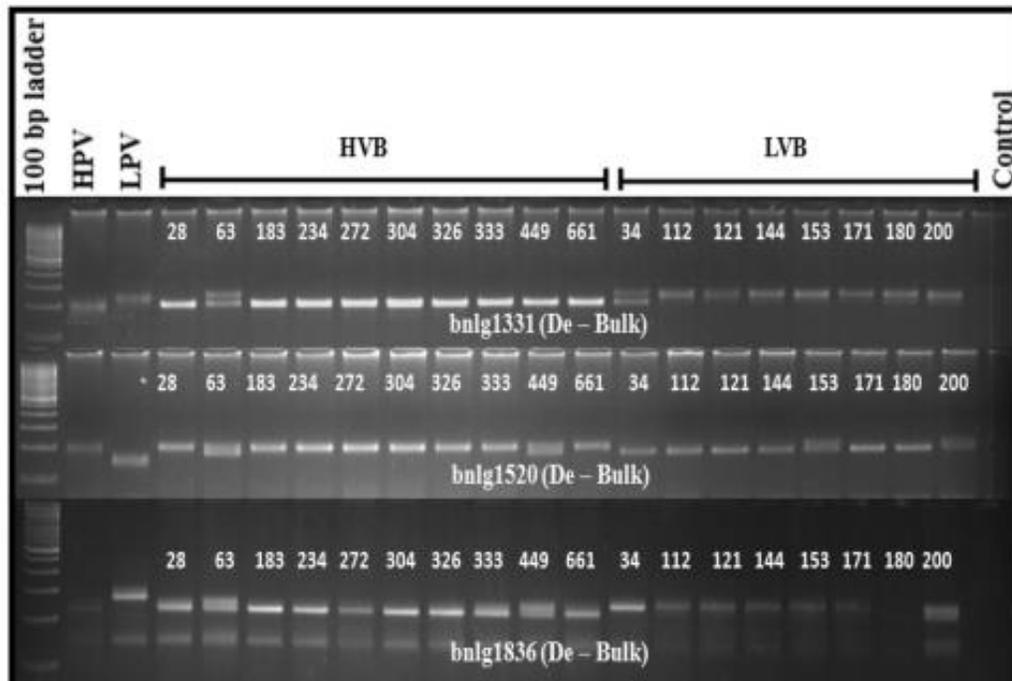
## Meta analisis

Característica	Estimativas de la Heredabilidad			
	Sentido amplio		Sentido restricto	
	H <sup>2</sup>	s	h <sup>2</sup>	s
Rendimiento	0.5208	0.0229	0.4126	0.025
Expansión	0.6356	0.0209	0.4233	0.023



Variable	R <sup>2</sup>	Cromosoma / Bin							Material	Accion genica	Authors
Porcentagem de granos no expandidos (UPK)	57	1.05	3.07	4.06	5.06	9.04			F3: A-1-6 (popcorn) x V273 (flint)	D, DP, SD	Babu et al. 2006
Volume de expansion (PEV)	62	1.05	3.04	8.01	10.04					D, DP, SD	
Volume de focos (FV)	44	1.05	5.03	9.04	10.03					D, DP, SD	
Volume de expansion (PV)	54	1.01	1.05	1.08	6.07	7.03	8.03		F3: Dan232xN04 (popcorn)	D, DP, SD	Li et al. 2007
Tamano de focos (FS)	34.5	1.01	2.1	5.07	7.03					A, D, DP, SD	
Tasa de expansion (PR)	39.1	1.01	1.05	1.08	6.07	8.02				D, DP, SD	
Volume de Expansion (PEV)	49.8	1	3						RILs: B73xHP301 (popcorn)		Jain-Poster & Woodford-Thomas, 2015
Eficiencia de expanon (KPE)	85.7	7	8								
Tamano de grano (AKS)	64.6	1	3								
Forma del flocos (PP)	32	2									
Caracterisitcas relacionadas a expansion	7.6 - 24.5	1.01	1.02	1.02-1.03	1.07	1.09	1.1	1.11	F3, BC2F2 y RILs: Dan232xN04 y A-1-6xV273		Kaur et al. 2021
Volume de expansion (PEV)	4 - 32.4	1	2	3	5				F2:3: HPVxLPV	A, D	Thakur et al. 2021

**Fig. 3** Screening of positive and negative de-bulks with bnlg1331, bnlg1520, bnlg1836 and bnlg1144 SSR markers. M: 100 bp ladder, P1: HPV, P2: LPV, HVB: high volume bulk, LVB: low volume bulk

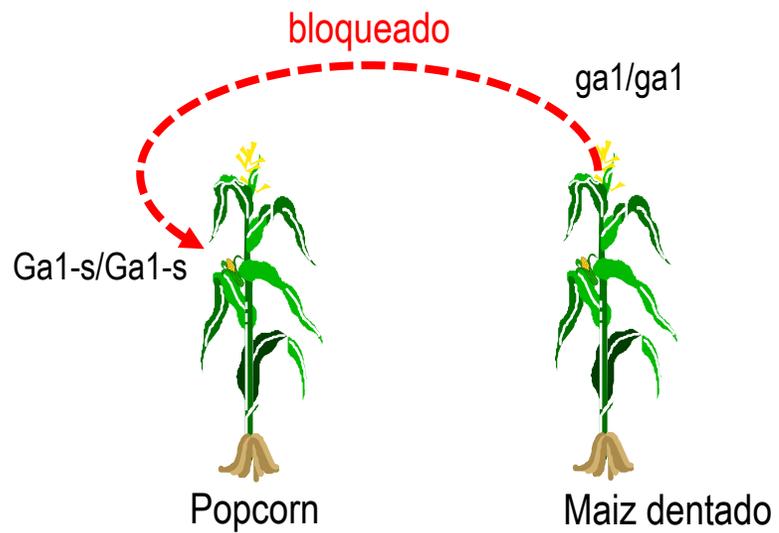


**Table 4** Single marker analysis using SSR molecular markers for popping volume QTL.

Markers	Bin	HmzA ++ (HPV)	HmzB -(LPV)	Htz ± (H)	Total	R <sup>2</sup>	A	D	D/A
bnlg1331	1.09	133	161	210	504	32.62	19.09	- 4.81	0.25
bnlg1520	2.09	135	106	262	503	14.52	12.96	- 7.42	0.58
bnlg1144	3.02	133	117	254	504	4.01	4.83	- 8.31	1.72
bnlg1836	5.01	127	161	216	504	32.41	18.85	- 5.79	0.31

# Factor gametofítico 1 (ga1)

Locus	Alelos	
ga1	{	ga1
		Ga1-s
		Ga1-m



# Resistencia a Ga1-m

**Table 4** Lines containing full-strength, weakened and no resistance to *Ga1-m* pollination

Accession	Full-strength resistance	Weak resistance	No resistance	Total plots
Guanajuato 100	1	7	11	19
Guanajuato 141	4	10	22	35
Guanajuato 181	2	10	13	25
Jalisco 78	178	99	70	296
Jalisco 300	17	5	5	29
Jalisco 304	11	9	34	49
Michoacán 412	1	8	3	11
Zacatecas 40	0	2	29	32
Zacatecas 182	7	9	45	58
Negrito-CRI223	1	7	2	10
Total	222	166	234	570

These counts are the number of individual lines segregating for a type of resistance

Due to lines segregating for multiple resistance types, numbers do not necessarily sum to total number of lines evaluated

These counts also include those fixed for a given resistance, as well as a few plots that flowered too late to assess

Thus, totals include a few plots that could not be classified

1222-2 (Jalisco 78) tiene Resistencia a ga1 y Ga1-m

Jones and Goodman, 2015



# Germoplasma

- Exploracion de complejos raciales
- Variedades locales (OPV)
- Variedades sinteticas
- Compuestos
- Germoplasma exotico
- Licenciamiento



Butterfly



Mushroom



Tipos de Flake

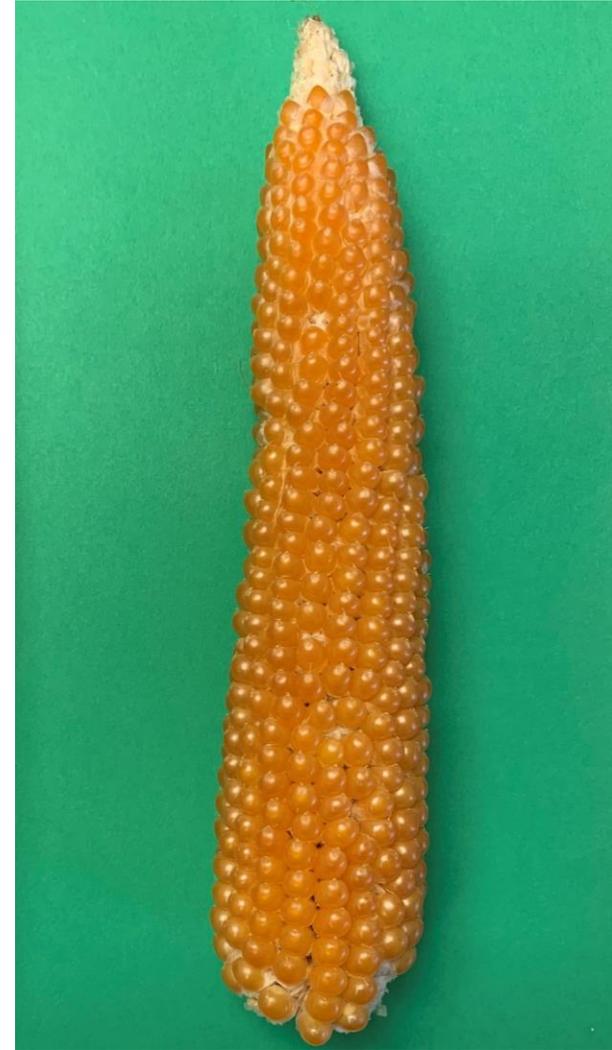
# Grupos Heteroticos



Supergold



South America



# Fases del Programa

**SINTESIS  
DE LINEAS**

**SINTESIS DE  
HIBRIDOS**

**ENSAYOS EN  
FRANJAS**

**01**

**02**

**03**

**LANZAMIENTO  
DEL HIBRIDO**



kg / ha

Indiana, USA 2021





# Acondicionamiento y expansión

480°F (248.8°C) + 100 ml aceite  
+ 250 de muestra



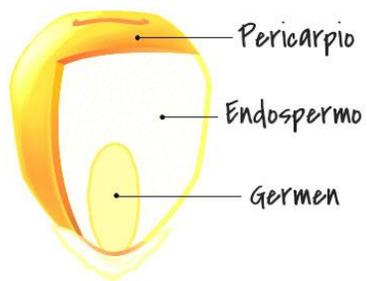
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70°F (21 °C) y 70% RH



## Características que afectan la calidad de la expansión

- Espesura del pericarpio
- Largo y ancho de granos
- Tamaño del embrión (germen)
- Endospermo
- Cantidad de granos no expandidos



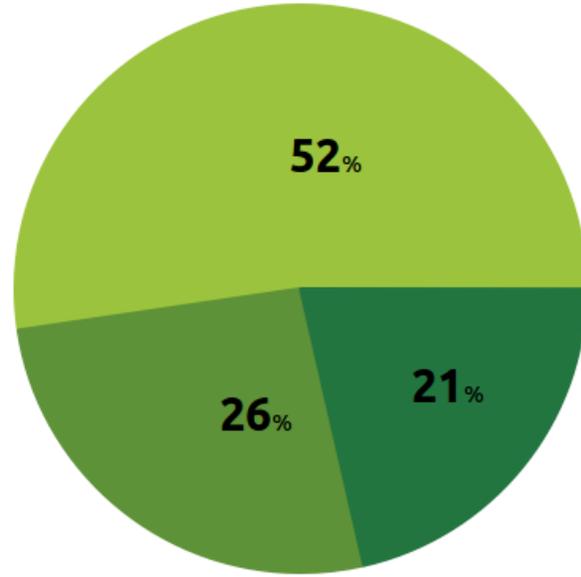
## Otras características importantes en la selección

- Color del grano
- Sabor
- Textura del grano



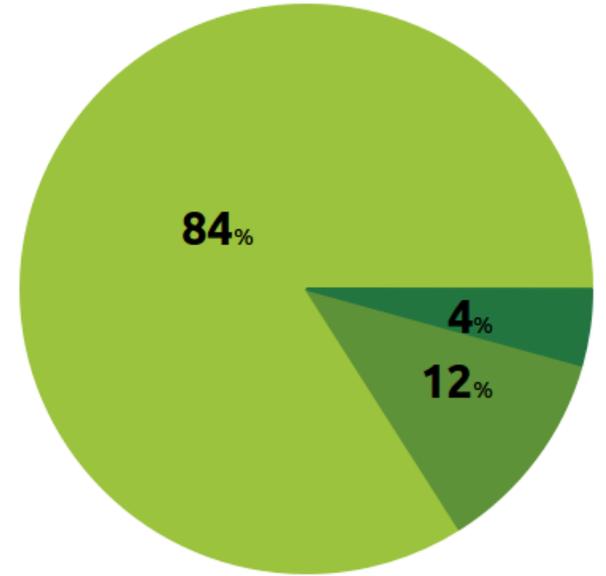


# Genotipo A



PERFECT-MUSH PART-MUSH BUTTERFLY

# Genotipo B



PERFECT-MUSH PART-MUSH BUTTERFLY

Campo Novo do Parecis MT, Brasil



Havana IL, USA



U.S.A



ARGENTINA



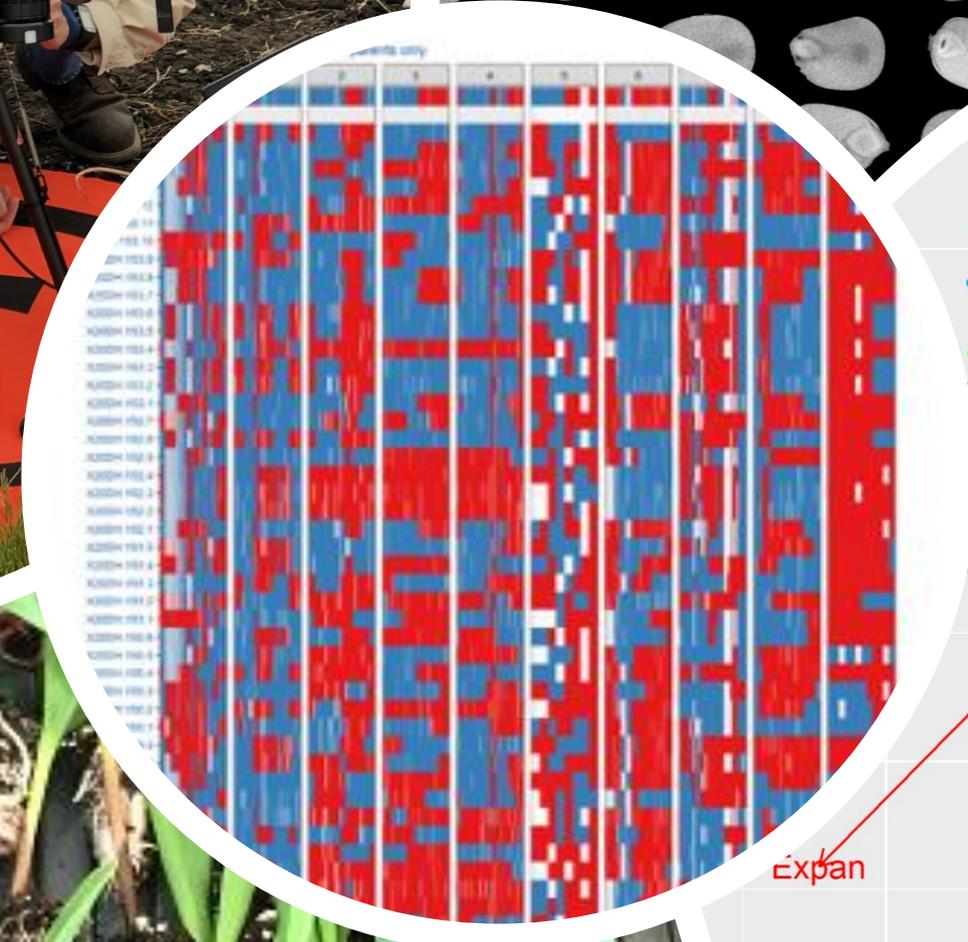
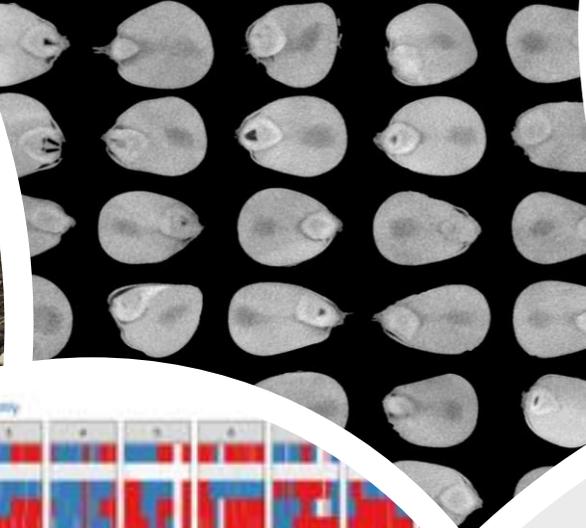
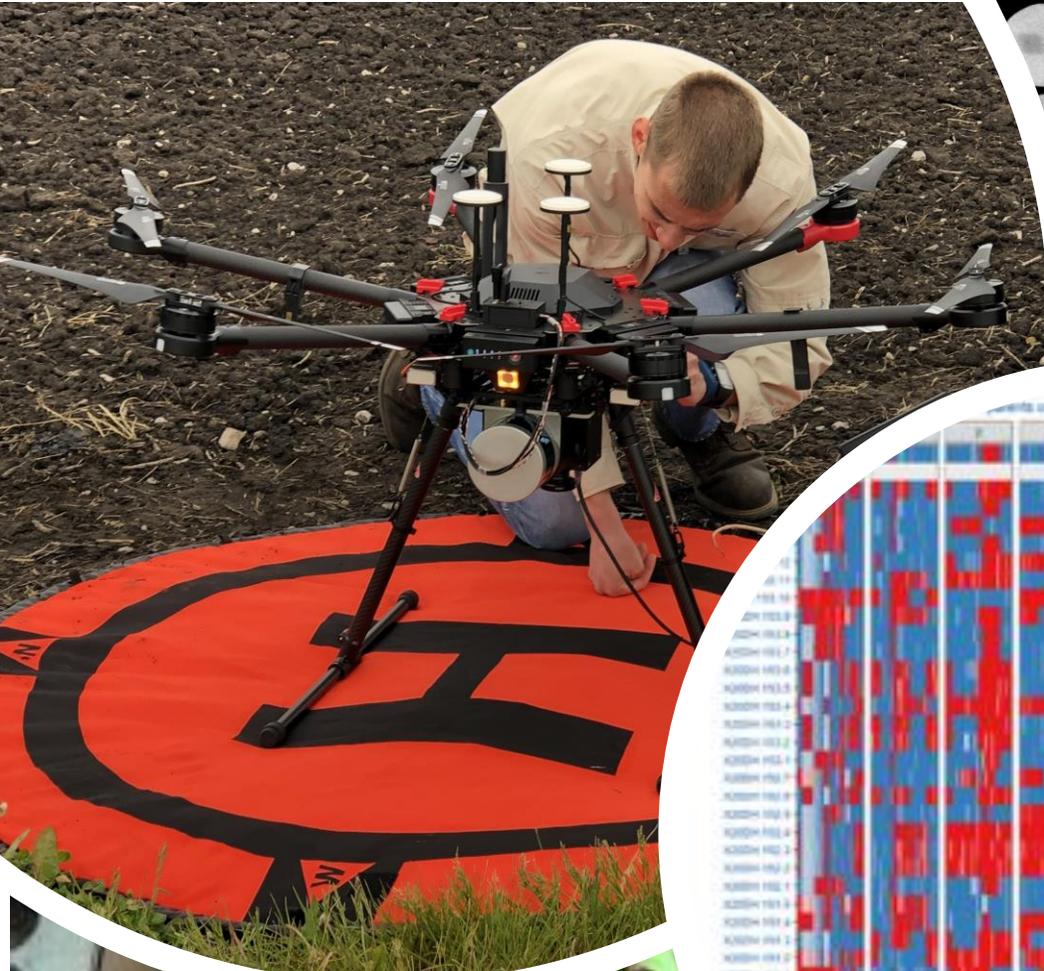
BRASIL



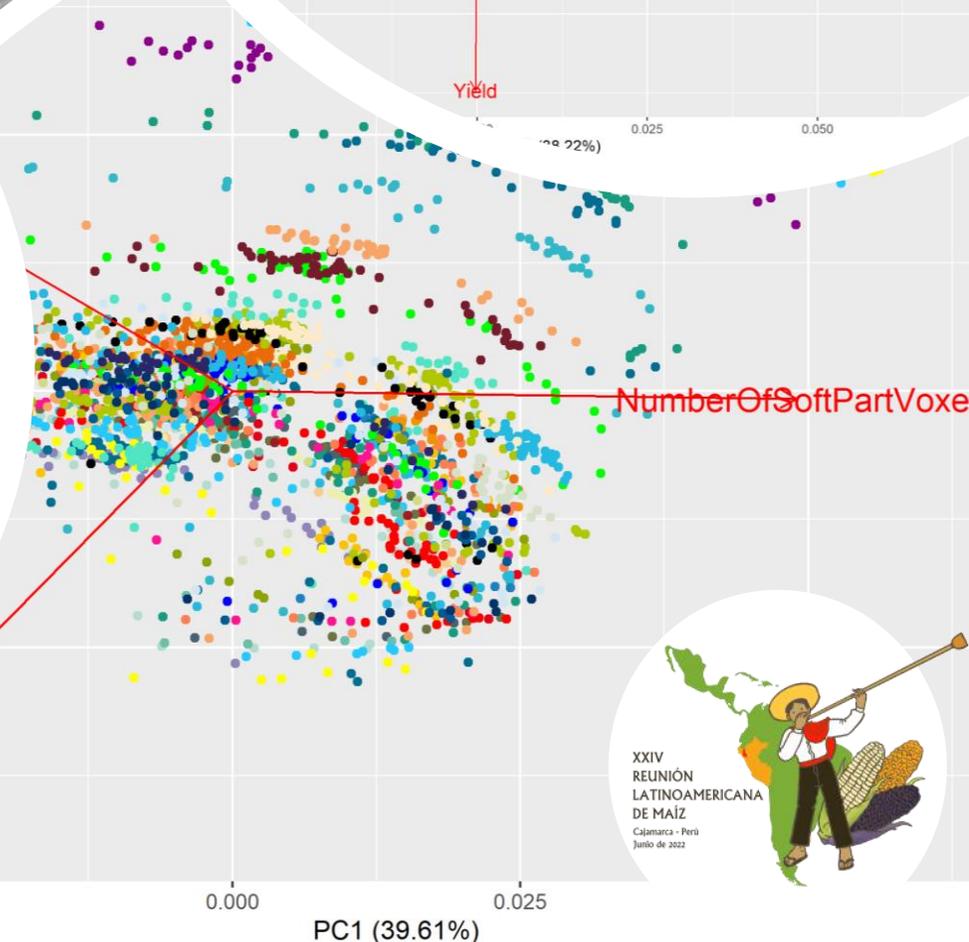
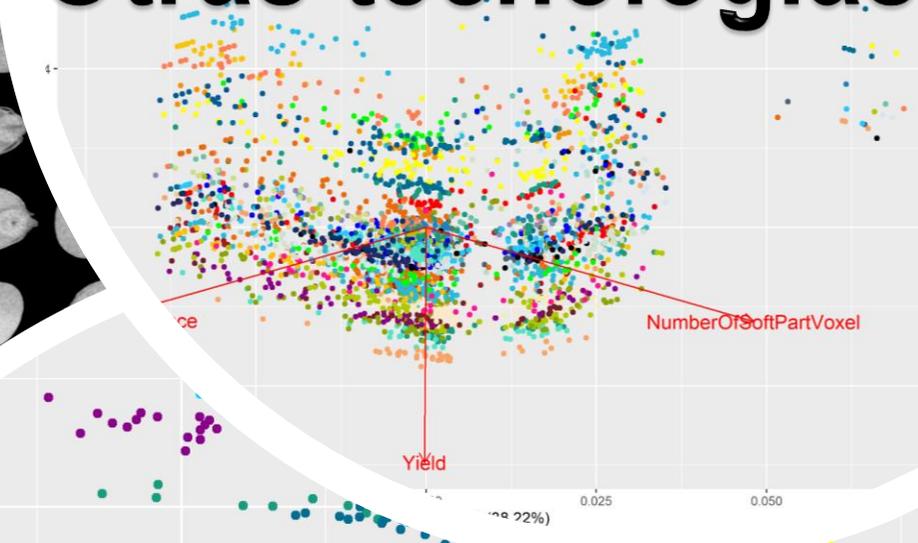


Toulouse, France





# Otras tecnologías



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**Popcorn Hybrid Performance Trials**

**2021**

**Working to Produce the Highest Quality Popcorn Seed**

702 State Road 28 East  
P.O. Box 158  
Romney, IN 47981  
1-800-822-7134 or 765-538-3145  
FAX 765-538-3600  
e-mail: agalumni@agalumniseed.com  
www.agalumniseed.com

Ag Alumni Seed  
2021 Hybrid Popcorn Performance Trials  
Twelve Eastern Location Summary  
Romney, IN (2019-2021); Greensburg, IN (2019-2021); Topeka, IL (2019-2021);  
Delphos, OH (2019-2021)

Hybrid	Ad-justed %Mean	Expan cc/g	Yield lb/A	Mois %	Popln 1,000/A	Lodge %	RL %	Mush %Ball	Mush %TTL	Hull 1-5	KC k/10g
AP2205	104.4	47.8	6283	14.8	28.5	2.9	0.0			3.0	63
AP8207	104.3	43.6	7032	18.2	27.0	3.1	0.7			2.4	51
AP6009	103.8	45.4	6626	17.4	27.1	4.4	0.6			2.8	50
AP2510	103.2	45.5	6555	15.8	28.1	2.5	0.2			3.1	54
AP8204	103.0	44.9	6631	17.9	27.0	5.5	0.2			2.6	51
AP2206	102.8	45.1	6511	15.0	28.1	4.4	0.0			2.9	53
AP4002	102.5	45.3	6474	16.4	27.5	3.8	0.8			2.8	53
AP8202	101.5	43.7	6623	18.3	28.3	3.8	1.4			2.7	51
AP2511	101.0	47.2	5961	16.5	26.5	7.7	0.1			3.0	50
AP6008	100.8	41.8	6882	18.4	28.8	6.5	0.1			2.5	46
AP2001	100.4	44.5	6368	14.1	28.2	2.6	0.4			3.2	52
AP2508	100.1	48.4	5667	15.3	27.1	6.4	0.1			2.8	54
AP2507	98.6	44.8	6106	15.4	27.4	2.7	0.2			2.8	54
AP4512	95.4	47.2	5269	17.1	26.2	3.5	0.5			2.7	53
AP2505	94.3	41.9	6040	15.8	24.2	3.1	0.1			3.0	50
AP4010M	86.0	32.3	6664	16.7	24.9	2.9	0.1	69	91	0.9	42
62272	106.5	42.7	7455	17.8	27.8	5.4	0.9			2.8	50
62650	104.0	47.4	6307	16.0	28.1	6.9	0.1			3.1	56
Mn	99.6	44.2	6320	16.4	27.0	4.5	0.4			2.6	52
CVErr		2.46	10.57								
LSD(.05)		1.1	426								

**RELATIVE DAYS TO MATURITY**

(Based on data from Romney, IN)

HYBRID	2021	2020	2019	2018	2017	Average
AP2001	103.8	105.6	103.4	103.4	102.3	103.7
AP2205	104.5	105.9	103.7			104.7
AP2508	105.0	106.1	105.6	104.8	102.4	104.8
AP2509	105.0		106.2	106.6	103.5	105.3
AP2206	104.2	106.7	105.4			105.4
AP2510	104.5	106.3	107.4	104.4	105.1	105.5
AP2511	104.8	106.4	106.1	106.8	104.2	105.7
AP2507	103.5	106.5	106.1	107.4	106.2	105.9
AP2505	106.6	106.7	107.0	106.2	105.9	106.5
AP4002	106.1	107.1	107.3	107.8	107.7	107.2
AP6009	109.6	107.5	107.5	108.3		108.2
AP4512	110.1	107.1	109.3	108.5	111.7	109.3
AP6008	109.6	107.1	110.5	110.5	108.9	109.3
AP8202	109.1	107.9	109.6	110.9	110.5	109.6
AP8207	111.1	108.5	109.0	110.5		109.8
AP8204	109.0	108.5	109.7	111.3	110.7	109.8
AP4515	109.9					109.9
AP4010M	104.3	107.5	108.1	106.4	106.9	106.6
AP4514W		105.9	104.6	104.0	102.5	104.3



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# Gracias !!!

