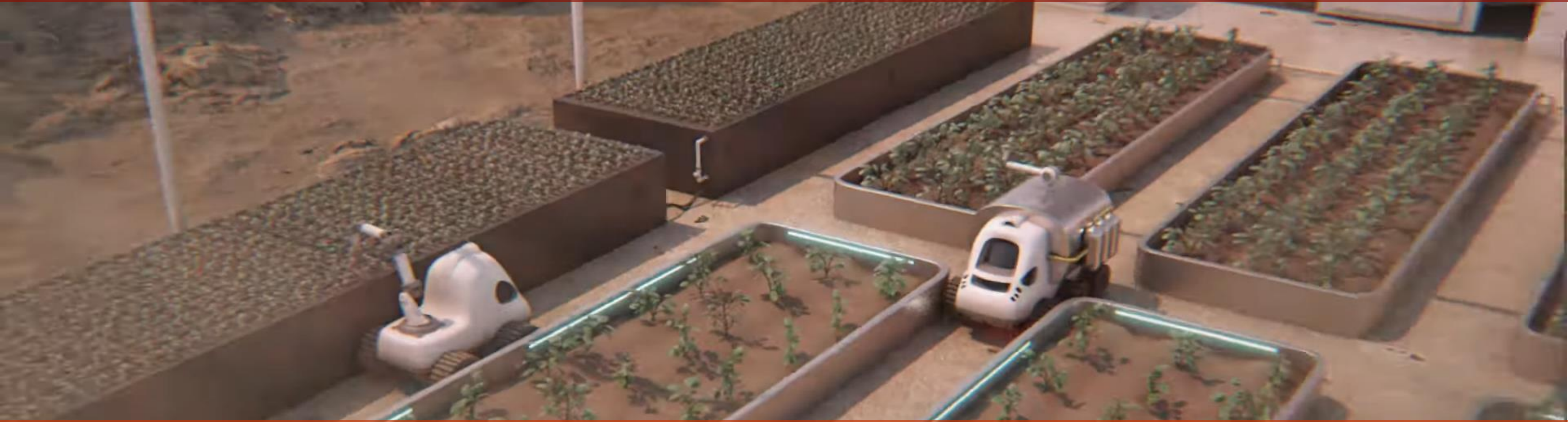
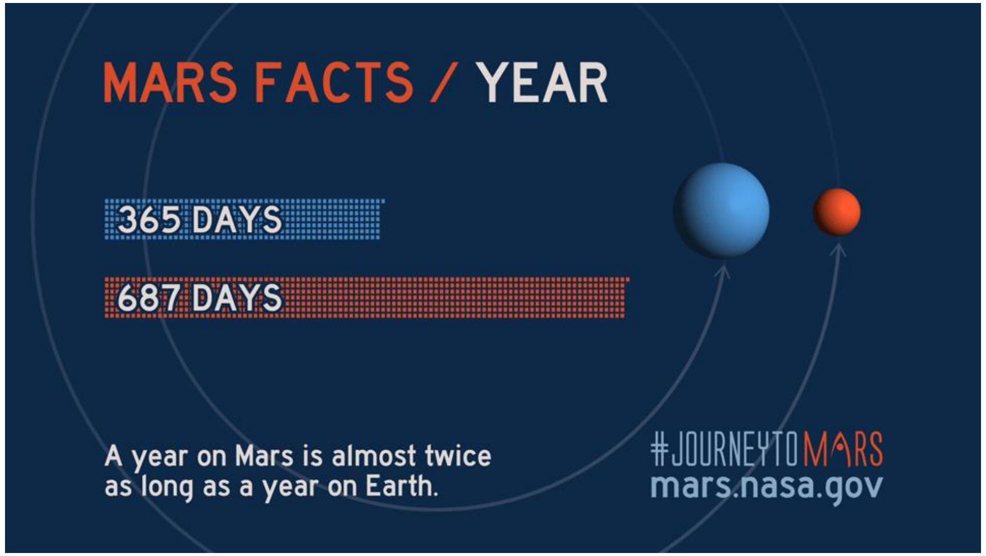
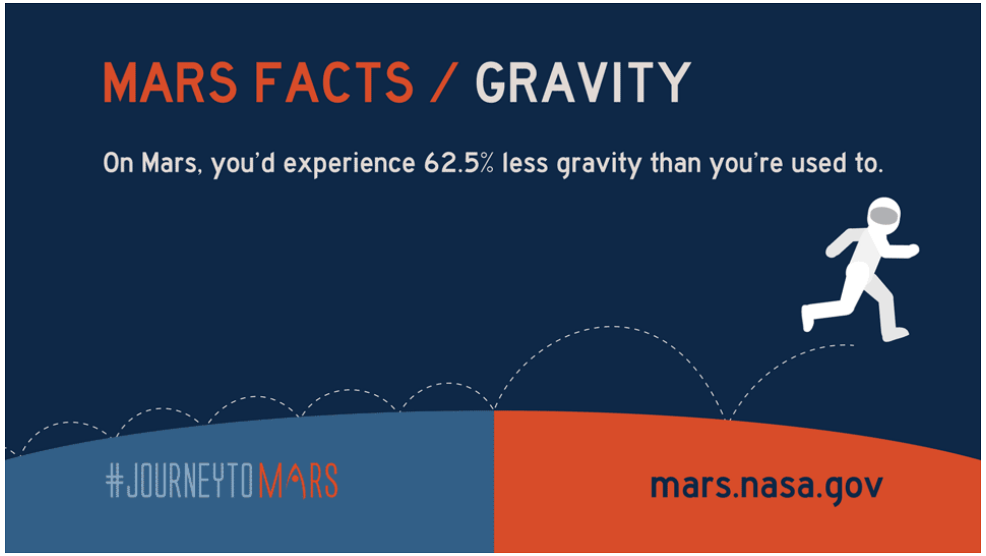
The Potato on Mars

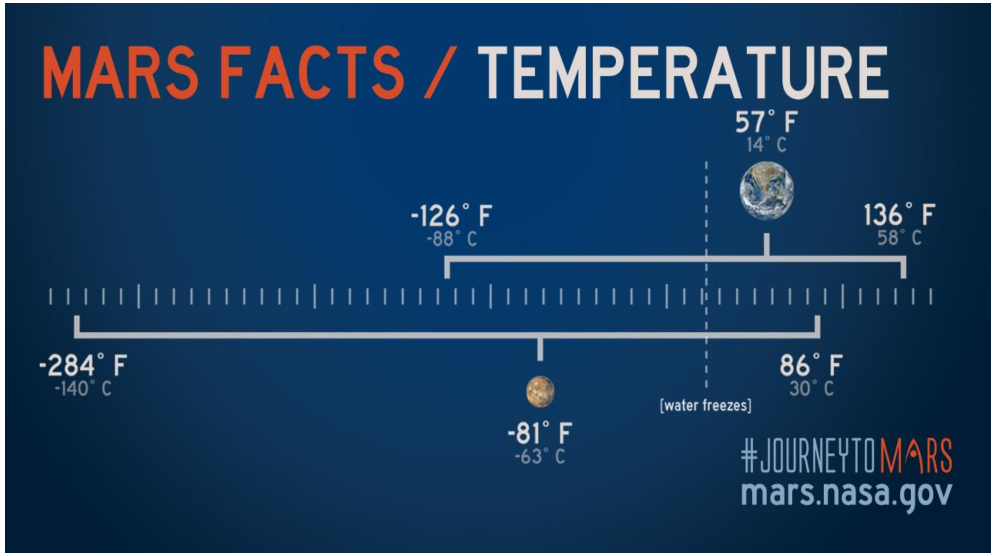


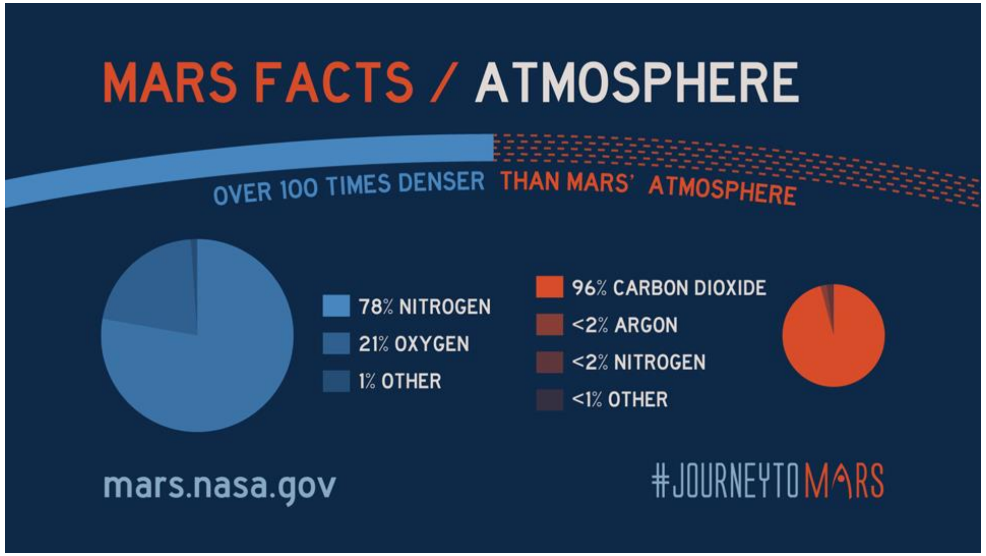
Jan Kreuze, David A. Ramírez, Walter Amoroz, Julio Valdivia-Silva, Sady Garcia, Elisa Salas, Wendy Yactayo

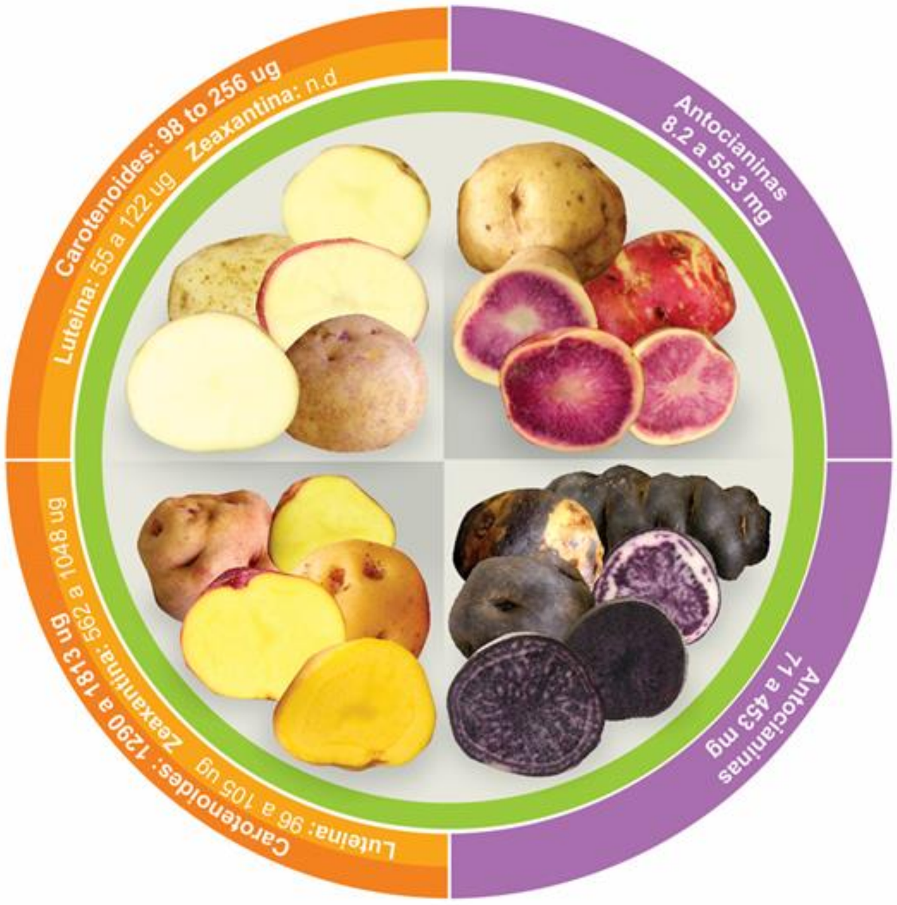
Dublin, June 1, 2022


MARS FACTS / YEAR
365 DAYS
687 DAYS
A year on Mars is almost twice as long as a year on Earth.
#JOURNEYTOMARS
mars.nasa.gov


MARS FACTS / GRAVITY
On Mars, you'd experience 62.5% less gravity than you're used to.
#JOURNEYTOMARS
mars.nasa.gov


MARS FACTS / TEMPERATURE
57° F
14° C
-126° F
-88° C
136° F
58° C
-284° F
-140° C
86° F
30° C
[water freezes]
-81° F
-63° C
#JOURNEYTOMARS
mars.nasa.gov


MARS FACTS / ATMOSPHERE
OVER 100 TIMES DENSER THAN MARS' ATMOSPHERE
78% NITROGEN
21% OXYGEN
1% OTHER
96% CARBON DIOXIDE
<2% ARGON
<2% NITROGEN
<1% OTHER
mars.nasa.gov
#JOURNEYTOMARS



Energía	96 a 123 Kcal	Magnesio	16 a 40 mg
Almidón	16 a 20 g	Hierro	0.29 a 0.69 mg
Proteína	1.76 a 2.95 g	Zinc	0.29 a 0.48 mg
Lípidos	0.1 a 0.5 g	Vitamina C	7.8 a 20.6 mg
Fibra dietaria	1.8 g a 2.1 g	Vitamina B6	0.299 mg
Potasio	150 a 1386 mg	Ácido clorogénico	19 a 399 mg
Fósforo	42 a 120 mg	Glicoalcaloides	0.7 to 18.7 mg

Burgos et al. (2020) The Potato and Its Contribution to the Human Diet and Health. In: *The Potato Crop*.

Partition Efficiency

Plant Type	Crop Type	Crop	ε_p
C4	Perennial grass	Sugarcane	81.2
	Grain	Maize	47.1
	Grain	Sorghum	20.0
C3	Grain	Winter wheat	44.0
	Grain	Rice	62.0
	Leguminous	Soybean	60.0
	Tuber root	Sugar beet	86.0
	Tuber root	Cassava	70.5
	Tuber root	Sweetpotato	46.0
	Tuber	Potato	87.0 †

Silva-Diaz et al. (2020). *Plants 9, 0787*

Nutritional Productivity

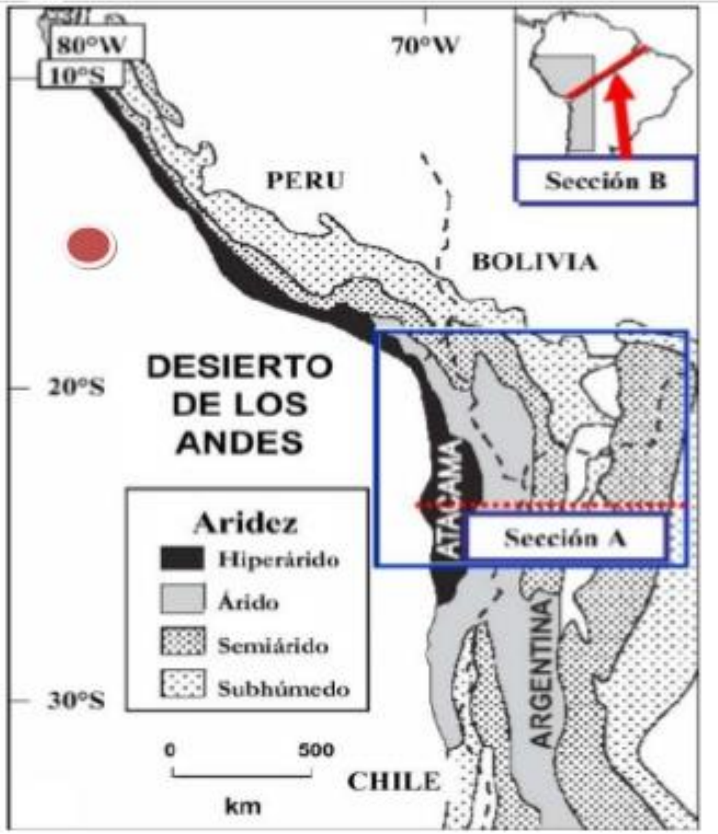
	Cal (kcal/m^3)	Prot (g/m^3)	Fat (g/m^3)	Calcium (mg/m^3)
Wheat	2279	74	9	279
Rice	1989	49	5	132
Maize	3856	77	17	63
Potatoes	5626	150	9	543
Sugar beet	2520	0	0	574
Pulses (beans)	1188	76	4	473
Treenut	521	14	45	79
Groundnut	2382	111	206	296
Soybean oil	547	0	62	0
Cotton seed oil	721	0	81	0
Tomatoes	1416	65	11	200
Onions	2259	85	0	1673
Orange	663	13	0	556
Lemon	504	0	0	423
Grapefruit	553	0	0	204
Banana	432	11	0	29
Apple	1140	6	6	141
Pineapple	1136	0	0	168
Dates	731	0	0	87
Grape	1356	14	0	202
Bovine meat	102	10	7	3
Pork meat	408	21	35	7
Poultry meat	330	33	21	14
Eggs	519	41	36	166
Milk	659	40	38	1233
Butter	404	1	45	11

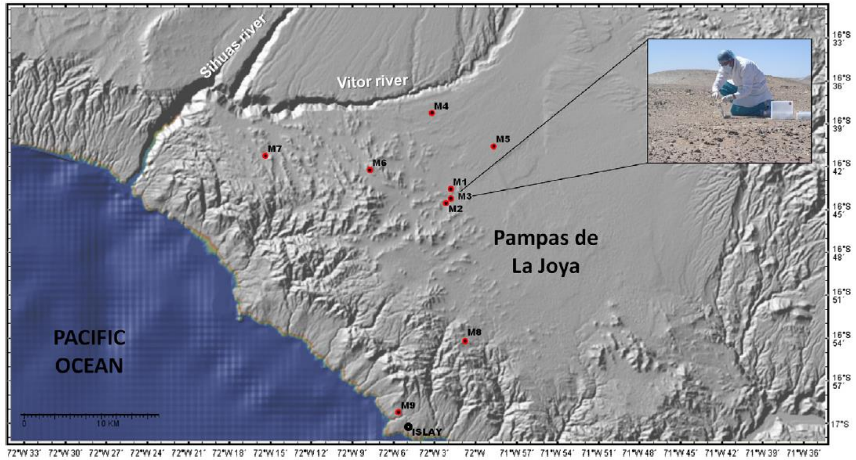
Renault et al. (2000). Nutritional water productivity and diets. *Agric. Wat. Man.*

Available online at www.sciencedirect.com
ScienceDirect
Geochimica et Cosmochimica Acta 75 (2011) 1975–1991
Geochimica et Cosmochimica Acta
www.elsevier.com/locate/gca

Multidisciplinary approach of the hyperarid desert of Pampas de La Joya in southern Peru as a new Mars-like soil analog

Julio E. Valdivia-Silva [a,b,*], Rafael Navarro-González [a], Fernando Ortega-Gutierrez [c], Lauren E. Fletcher [b], Saúl Perez-Montaño [d], Reneé Condori-Apaza [b], Christopher P. McKay [b]





UNIVERSIDAD NACIONAL AGRARIA LA MOLINA

FACULTAD DE AGRONOMIA - DEPARTAMENTO DE SUELOS

LABORATORIO DE ANALISIS DE SUELOS, PLANTAS, AGUAS Y FERTILIZANTES

ANALISIS DE SUELOS : SALINIDAD

Procedencia
Departamento : AREQUIPA
Distrito : LA JOYA
Referencia : H.R. 54164-076S-16 **Solicitante:** JAN KREUZE - CIP

Provincia: AREQUIPA
Predio :

Número de Muestra		C.E.	Análisis Mecánico				pH	$CaCO_3$	M.O.	P	K	Cationes Cambiables						Suma de Cationes	Suma de Bases	% Sat. De Bases
Lab.	Campo	dS/m 1:1	Arena %	Limo %	Arcilla %	Textura	1:1	%	%	ppm	ppm	CIC (meq/100g)	Ca^{2+}	Mg^{2+}	K^+	Na^+	$Al^{+3} + H^+$			
6766	Suelo 1	19.33	72	22	6	Fr.A.	6.90	0.0	0.32	13.0	678	6.72	5.74	0.18	0.51	0.29	0.00	6.72	6.72	100

A = Arena ; A.Fr. = Arena Franca ; Fr.A. = Franco Arenoso ; Fr. = Franco ; Fr.L. = Franco Limoso ; L = Limoso ; Fr.Ar.A. = Franco Arcillo Arenoso ; Fr.Ar. = Franco Arcilloso; Fr.Ar.L. = Franco Arcillo Limoso ; Ar.A. = Arcillo Arenoso ; Ar.L. = Arcillo Limoso ; Ar. = Arcilloso

Saline – Sodic

Conductivity > 4
pH < 8.5
Sodium Absorption Rate

No Muest. Lab	Saturación %	pH Pasta Sat.	C.E. Ext.St. dS/m	Cationes Solubles (meq/L)					Aniones Solubles (meq/L)						Boro Soluble ppm	Yeso Soluble %	PSI
				Ca^{2+}	Mg^{2+}	K^+	Na^+	SUMA	NO_3^-	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-	SUMA			
6766	33	6.70	52.60	76.00	198.36	23.85	403.39	701.60	44.24	0.00	2.56	74.79	580.00	701.59	23.64	0.04	4.27

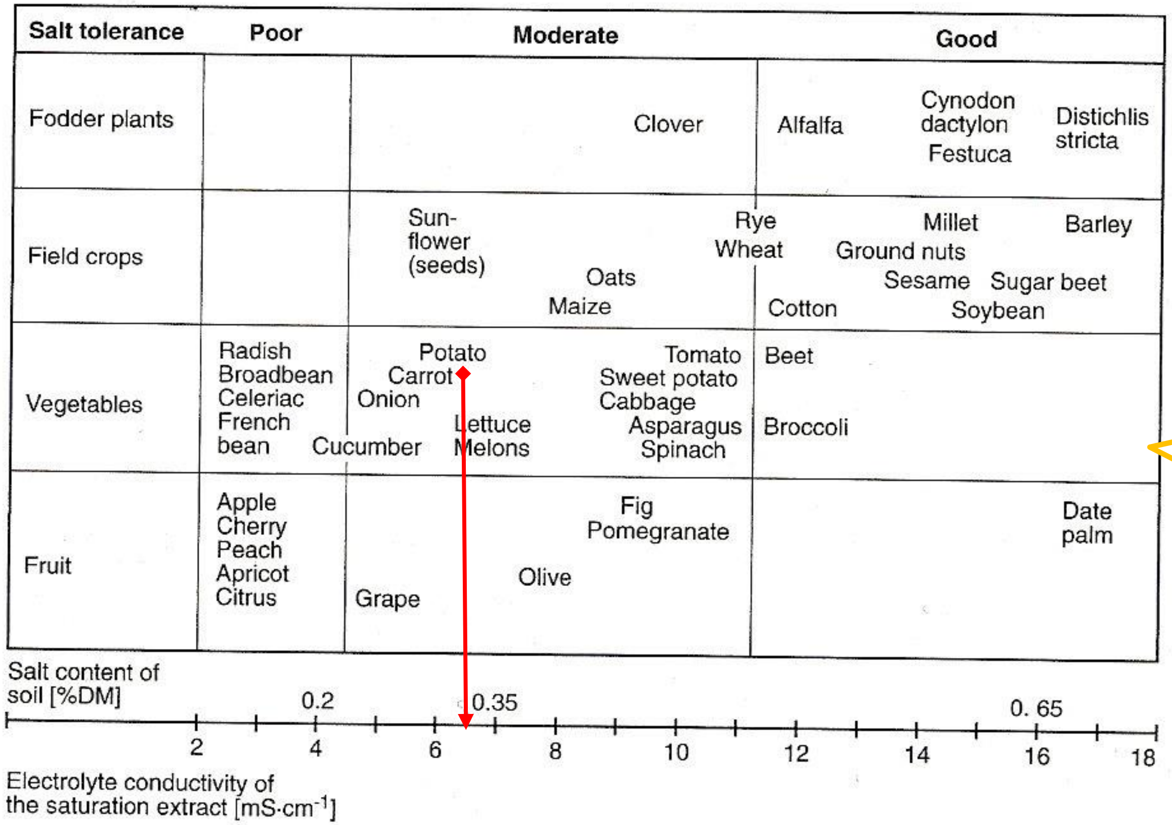
Número de Muestra		B	Cu	Fe	Mn	Zn	Pb	Cd	Cr	S Disp.	S Total
Lab.	Campo	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%
6766	Suelo 1	13.32	3.90	7.80	1.00	2.50	10.02	0.97	19.08	1004.17	0.17

La Molina, 17 de Mayo del 2016

Dr. Sady García Bendezú
Jefe de Laboratorio

Lab. Análisis de Suelos, Plantas, Aguas y Fertilizantes - LASPAF - UNALM

Soil in good conditions (<2 dS/m) / Soil with problems (4 dS/m) / See water (44 dS/m)



15-20 dS/m is the limit for germination and subsequent growing

Larcher, W. 2003. Physiological plant ecology, Ecophysiology and Stress Physiology of Functional Groups. 4th Edition. Springer

Salt resistance of various economic plants. The species are placed above the soil salt content at which 50% less yield is to be expected

Is potato salt sensitive or tolerant?

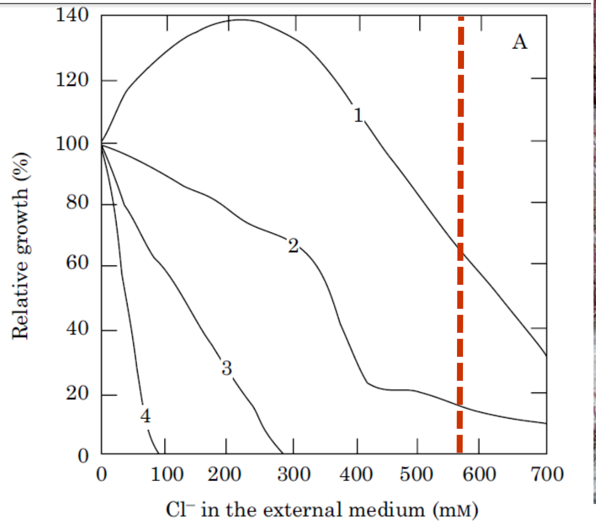
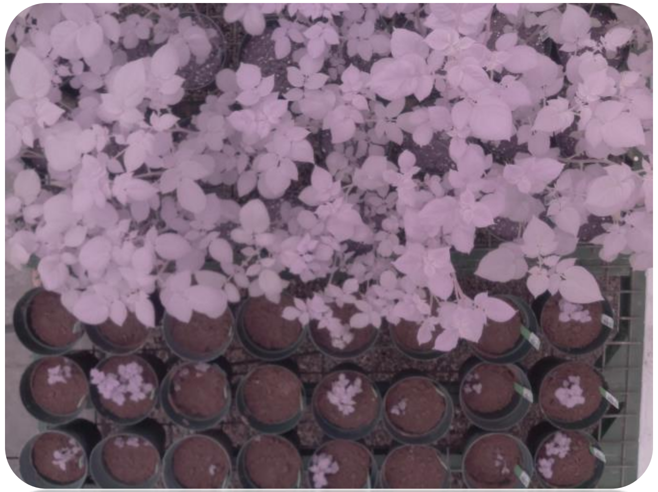


FIG. 2. A, Growth responses of different species to salinity. Growth was determined after 1 to 6 months at high $[Cl^-]_{ext}$. Curve 1 represents extreme halophytes (Group IA). Curve 2 represents halophytes (Group IB). Curve 3 represents plants whose growth is reduced substantially by 100 mM $[Cl^-]_{ext}$ (Group II). Curve 4 represents very salt-sensitive non-halophytes (Group III). Figure redrawn from Greenway and Munns (1980). B, Divisions for classifying crop tolerance to salinity based on the relationship between relative crop yield and salinity (expressed in terms of electrical conductivity at 25 °C). Redrawn from Maas and Hoffman (1977).

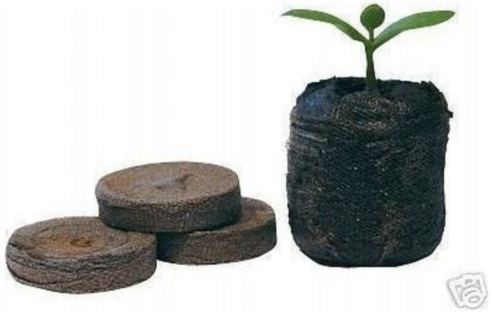
White and Broadley (2001). Chloride in soils and its uptake movement whitin plants: a review. Annals of Botany 88:967-988

Sowing of botanical seeds

Sprouts from tubers



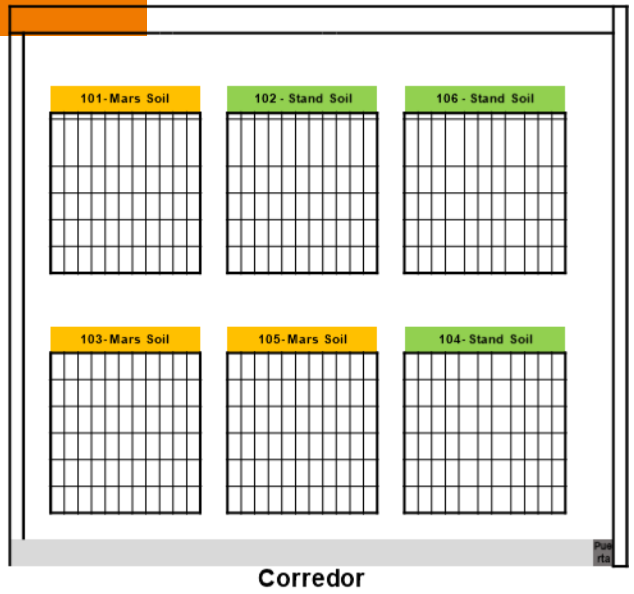
In-vitro plantlets grown in “jiffy pellets” and after transferred to salty substrate



Experimental Design

65 genotypes x 3 blocks x 1 sample

(38 Advance clones + 22 natives + 5 improved varieties)



Stomatal conductance as key indicator of the water status in plants

Medrano et al. — *Regulation of Photosynthesis of C_3 Plants Under Drought*

Annals of Botany 89:895-905, 2002

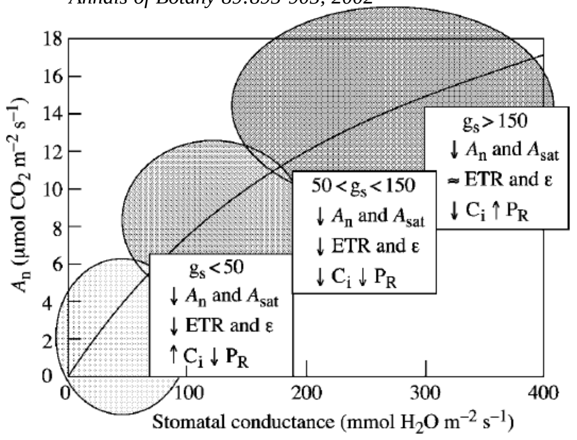
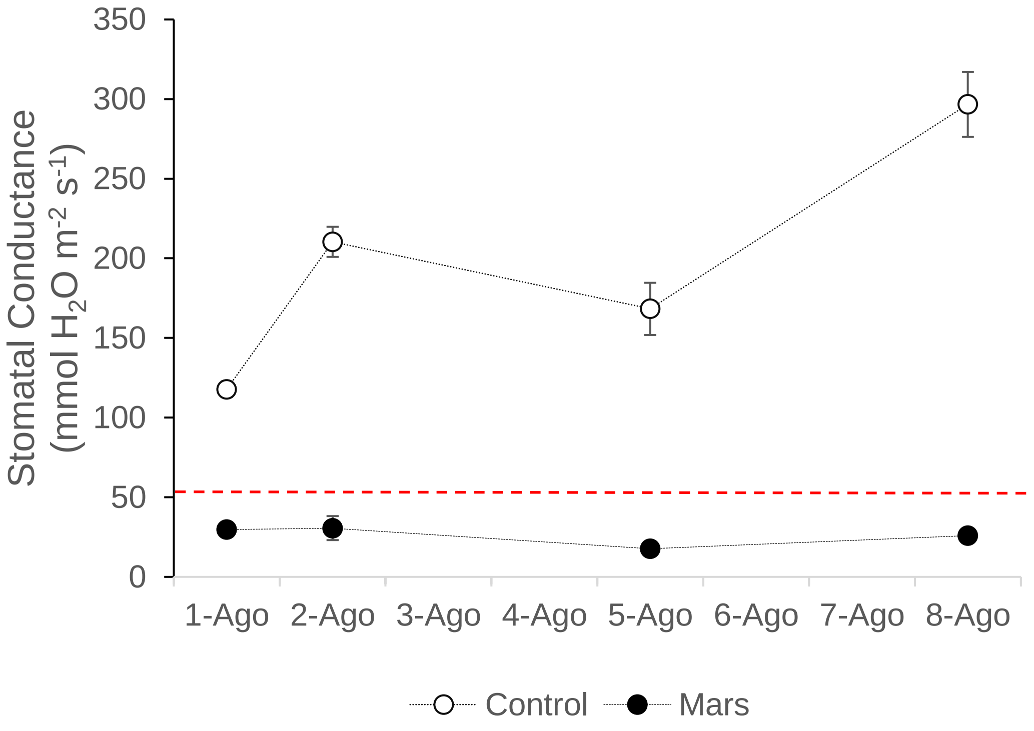
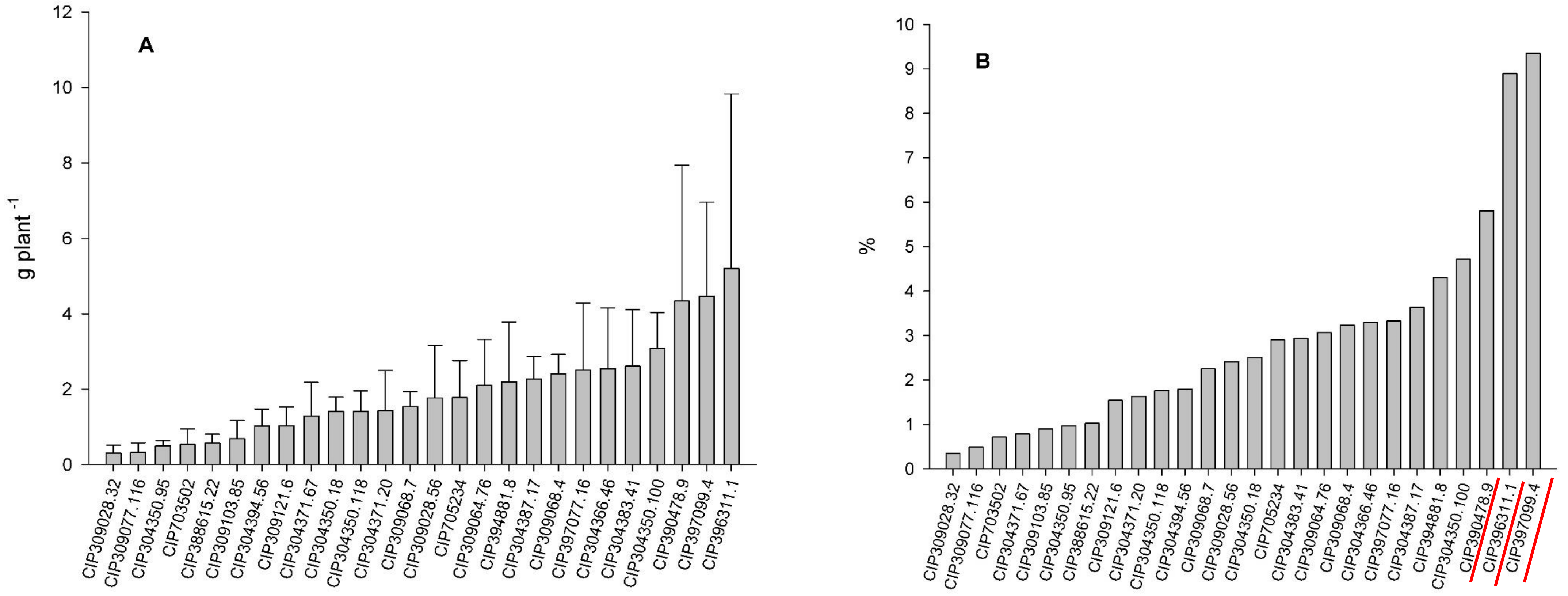


FIG. 3. Schematic pattern of response of photosynthesis in grapevines to drought, using g_s as a reference parameter. Three main regions are distinguished, and the down-regulation of different photosynthetic parameters is indicated for every region.



Tuber yield of the survivor potatoes genotypes growing in high salinity soil condition expressed as: - Average dry tuber yield (A), and - Average percentage of tuber yield in in relation to the yield under standard soil (B).



CIP397099.4 - WA.073

(392822.3 (LR93.073) x 391207.2 (LR93.050))

Population: LTVR

Tuber skin predominant color	White-cream	Tuber flesh predominant color	Cream
Tuber skin secondary color	Absent	Tuber flesh secondary color	Absent
Tuber skin secondary color distribution	Absent	Tuber flesh secondary color distribution	Absent
Tuber shape	Long-oblong	Tuber shape depth of eyes	Shallow
Tuber shape unusual	Absent		

Resistance traits	
Late blight (LB)	Susceptible
Potato virus X (PVX)	Extreme resistance
Potato virus Y (PVY)	Extreme resistance
Potato leaf roll virus (PLRV)	Moderately resistant

Agronomical performance	
Tuber yield (kg/plant)	0,70
Adaptability	Lowland tropics
Growing period lowland	Early
Growing period highland	Medium
Dormancy period - DLS highland	94
Sprouting pattern	Apical dominance

Post-harvest performance	
Dry matter (%)	20
Oil absorption rate (%)	31
Chipping color	Dark
Cooking quality	Solid
Cooking time (min.)	21-25
After cooking darkening	Moderately dark
Flesh color after cooking	Cream

CIP396311.1 - C95.276

(391925.2 x C92.030)

Population: LTVR

Tuber skin predominant color	Red	Tuber flesh predominant color	Pale yellow
Tuber skin secondary color	Absent	Tuber flesh secondary color	Absent
Tuber skin secondary color distribution	Absent	Tuber flesh secondary color distribution	Absent
Tuber shape	Oblong	Tuber shape depth of eyes	Slightly deep
Tuber shape unusual	Absent		

Resistance traits	
Late blight (LB)	Highly susceptible
Potato virus X (PVX)	Extreme resistance
Potato virus Y (PVY)	Extreme resistance
Potato leaf roll virus (PLRV)	Moderately susceptible

Agronomical performance	
Tuber yield (kg/plant)	1,10
Adaptability	Lowland tropics
Growing period lowland	Early
Growing period highland	Medium
Dormancy period - DLS highland	109
Sprouting pattern	Apical dominance

Reproductive biology	
Pollen viability (%)	85,8

Post-harvest performance	
Dry matter (%)	22
Oil absorption rate (%)	30
Chipping color	Moderately dark
Cooking quality	Solid
After cooking darkening	Moderately light

Nutrient concentrations in tubers	Ranks		Average
	Minimum	Maximum	
Vitamin C (mg/100g, dry weight basis)	88,58	89,08	88,83

CIP 390478.9 - Tacna

Parentage: 720087 x 386287.1

Country of Selection: Peru

Is a variety with extreme resistance to PVY and resistance to PLRV; is also tolerant to draught and salinity. The plant can grow in tropical climate and is insensible to photoperiod; have an early vegetative period with decumbent habit with pale white flowers. The tubers have ovoid shape with cream flesh, with good yield production are good for processing as chips (crisps) and French fry (chips). The variety was realized in Peru in 1993.

Tuber skin predominant color	White-cream	Tuber flesh predominant color	Cream
Tuber skin secondary color	Absent	Tuber flesh secondary color	Absent
Tuber skin secondary color distribution	Absent	Tuber flesh secondary color distribution	Absent
Tuber shape	Ovoid	Tuber shape depth of eyes	Shallow
Tuber shape unusual	Absent		

Reaction traits	
Late blight (LB)	Moderately resistant
Potato virus X (PVX)	Extremely resistant
Potato virus Y (PVY)	Extreme Resistance
Potato leaf roll virus (PLRV)	Resistant
Agronomical performance	
Adaptability	
Growing period	Early
Sprouting pattern	Apical dominance

Post-harvest performance	
Use	
Dry matter (%)	20

"Jizhangshu 8" (China) – "Pskem" (Uzbekistan)

CIP396311.1 - C95.276

(391925.2 x C92.030)

Population: LTVR

Tuber skin predominant color	Red	Tuber flesh predominant color	Pale yellow
Tuber skin secondary color	Absent	Tuber flesh secondary color	Absent
Tuber skin secondary color distribution	Absent	Tuber flesh secondary color distribution	Absent
Tuber shape	Oblong	Tuber shape depth of eyes	Slightly deep
Tuber shape unusual	Absent		

Resistance traits	
Late blight (LB)	Highly susceptible
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Potato virus Y (PVY)	Extreme resistance
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Post-harvest performance	
Dry matter (%)	22
Oil absorption rate (%)	30
Chipping color	Moderately dark
Cooking quality	Solid
After cooking darkening	Moderately light

Agronomical performance	
Tuber yield (kg/plant)	1,10
Adaptability	Lowland tropics
Growing period lowland	Early
Growing period highland	Medium
Dormancy period - DLS highland	109
Sprouting pattern	Apical dominance

Nutrient concentrations in tubers	Ranks		Average
	Minimum	Maximum	
Vitamin C (mg/100g, dry weight basis)	88,58	89,08	88,83

Reproductive biology	
Pollen viability (%)	85,8

DE GRUYTER OPEN

Open Agriculture. 2016; 1: 189–197

Research Article

Open Access

Abdullah Al Mahmud*, Mohammad Hossain, Bimal Chandra Kundu, E.H.M. Shofiur Rahaman, Mohidul Hasan, Monower Hossain, Enamul Haque, Atikur Rahman, Mahabub Alam Patwary, Hafizur Rahman, Shahidul Islam Khan, Abu Kawochar, Biresh Kumar Goswami, Jahangir Hossain, Mohinder Singh Kadian, Merideth Bonierbale

Evaluation of CIP bred clones for expansion of potato production in the coastal areas of Bangladesh

DOI 10.1515/opag-2016-0024

Received November 21, 2016; accepted December 19, 2016

Abstract: A set of International Potato Center (CIP)-bred potato clones was evaluated for their salt tolerance and productivity in replicated field trials in three coastal districts of Bangladesh, namely, Chittagong, Patuakhali and Satkhira. In each year of experimentation from 2011 to 2015, salinity levels increased progressively during the season and varied with time and place. Evaluation and selection were carried out using GGE biplot analysis and mean yield across the test sites; and the best performing clones were selected for the next year's trial. Of the original fifteen test clones, two (CIP 301029.18 and CIP 396311.1) were selected for evaluation in the regional yield trial with cvs. Diamant and Asterix as checks. In the regional yield trial, across locations, CIP 301029.18 was the highest (21.8 ton/ha) and CIP 396311.1 (21.3 ton/ha) was the 2nd highest yielder such that CIP 301029.18 produced 64.0% higher yield and CIP 396311.1 produced 32.4% higher yield compare to their corresponding check varieties Diamant and Asterix. Similar ranking was found under farmers' field conditions. Finally, these 2 clones CIP 301029.18 & CIP 396311.1 were found promising for their good productivity under saline conditions and CIP 396311.1 was released by the National Seed Board in Bangladesh in 2016.

Keywords: CIP bred potato clone, salt tolerance, yield, Bangladesh

1 Introduction

Potato is becoming the number one non-grain crop in the world to ensure food security. It gives an exceptionally high yield with more nutrition per unit area per unit time than any other crop. According to FAOSTAT (2013), total potato production in Bangladesh ranks 7th in the world and it is second only to rice in Bangladesh, where about 8.95 million tons of potato was produced from about 0.46 million hectares of land in 2014 (BBS, 2014).

Soil salinity is a worldwide problem and Bangladesh is no exception. In Bangladesh, salinization is one of the major natural hazards hampering crop production. The total area of Bangladesh is 147570 km². The coastal area

BARI Alu-73

Research reveals potential for growing potatoes on Mars, and challenging areas of Earth

February 9, 2018

n experiment conducted by researchers at the International Potato Center (CIP) to determine whether potatoes could be grown on Mars not only produced encouraging results for proposals to ut people on the Red Planet, it also provided valuable information for CIP's efforts to help farmers roduce food on this planet's marginal lands.

he National Aeronautics and Space Administration (NASA) has set a goal of sending people to Mars y 2030, whereas the possibility of establishing a long-term human presence on the Red Planet has ed scientists to investigate the feasibility of growing food there. CIP researchers undertook an xperiment in 2016 to see if potato could be grown in the harsh soil of Pampas de la Joya – a hyper-rid section of Peru's coastal desert – that is considered the closest thing to Martian soil available on arth. The results of that experiment, recently published in the on-line version of the *International ournal of Astrobiology*, are encouraging for both astrobiologists and scientists who are tapping the otato's potential for feeding people on an increasingly hot and crowded Earth.

Researcher collects a sample of the closest thing to Martian soil on Earth from the La Joya desert

avid Ramirez, a crop ecophysiologist at CIP and the lead author of the article, explains that he and his colleagues placed in-vitro plantlets of 65 different potato enotypes inside peat pellets, watered them for two weeks, and then transplanted them into pots filled with soil from la Joya, as well as p

International Journal of Astrobiology, Page 1 of 7
doi:10.1017/S1473550417000453 © Cambridge University Press 2017

Extreme salinity as a challenge to grow potatoes under Mars-like soil conditions: targeting promising genotypes

David A. Ramírez[1,2,3], Jan Kreuze[1], Walter Amoros[1], Julio E. Valdivia-Silva[4,5], Joel Ranck[1]*, Sady Garcia[2], Elisa Salas[1] and Wendy Yactayo[1]

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[2]*Universidad Nacional Agraria La Molina, Av. La Molina s/n, Lima 12, Peru*
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[5]*Space Science and Astrobiology Division, NASA Ames Research Center, Moffett Field, CA 94035, USA*

https://cipotato.org/blog/research-reveals-potential-growing-potatoes-mars/


POTATOES ON MARS
NASA AMES - CIP

CIP is a research-for-development organization with a focus on potato, sweetpotato and Andean roots and tubers. It delivers innovative science-based solutions to enhance access to affordable nutritious food, foster inclusive sustainable business and employment growth, and drive the climate resilience of root and tuber agri-food systems. Headquartered in Lima, Peru, CIP has a research presence in more than 20 countries in Africa, Asia and Latin America.

www.cipotato.org

CIP is a CGIAR research center

CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 research centers in close collaboration with hundreds of partners across the globe.

www.cgiar.org