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Progress Report
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"ISOZYME MARKERS FOR MEASURING GENETIC EROSION IN POTATOES IN ANDEAN FARMS"

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TRAINING:

The short term training of two Peruvian scientists were completed last year. Ms. Maria del Rosario Herrera a technician from the International Potato Center and Professor Ramiro Ortega from the University San Antonio Abad of Cusco. During their stay they learned all aspects of enzyme gel electrophoresis including gel reading, analysis and data collection. Both worked closely with Mr. Cisneros, a Research Assistant and Ph.D. student, also from Peru, hired to work on this project. They analyzed the following materials: 1) parental stocks of segregating progenies, 2) tubers of cultivated potatoes collected in Andean farms for a genetic erosion study, and 3) Selected tubers of various cultivated and wild species sampled at fields located above 3500 m of altitiude for and introgression study.

Survey of cultivated potatoes:

Cultivars from twenty eight Andean markets sampled by Ella Schmidt, another student research assistant involved in the project, and Ramiro Ortega were analyzed electrophoretically. Approximately 500 cultivars named by the seller were analyzed for 12 enzyme loci. In addition a series of morphological descriptors were used to describe these cultivars.

The purpose of this work was to document the amplification of cultivar diversity by the Andean farmer through sexual propagation by botanical seed and genotypic selection for the creation of new cultivars.

Three traditional farmers from different communities in Cusco, where potato is grown as a subsistence crop, were questioned regarding the origin of their potato cultivars,cultural and planting potato techniques, and selection of tubers.

Community	Province	Altitude	Farmer
Yanacona	Urubamba	3500-4000	Tomasa Quispe
Yanacona	Urubamba	3500-4000	Eugenio Auccapuma
Matinga	Calca	3600	Eduardo Huarancca

The main crops grown in these communities are potato, olluco, mashua, tarwi, barley, faba beans, wheat and oats.

All four growers exploited to some extent botanical seed propagation. They recalled using this technique in their community for at least 40 to 50 years. It was used in small scale only when the yields decreased due to tuber "tiring" and "degeneration". This deterioration, is most likely due to virus disease accumulation in the tubers. Propagation by botanical seed will eliminate many of these diseases which are not seed transmitted, resulting in "clean tubers". The prefered cultivars for sexual propagation were Q'ompis, K'usi and Bole, which are some of the most popular. These cultivars were chosen also because of their ability to produce abundant berries ('tamboroccotos'). The fruits are collected from the plants when they are ripe, and from the furrows before the tuber harvest. They are left to rotten in ceramic containers to facilitate the seed extraction with water. The seed is planted in beds of well prepared soils. The seedlings are either transplanted to the field of left in place until tuberization. The resulting mini- tubers are re-planted later on in the field.

Selection of the best tubers is based on size, number and quality. The selected tubers are used as seed in their farm and also sold to other farmers to rejuvenate their potato crop. In two of the communities, four of these selections has become known new cultivars, 'Olones'and 'Wiraccocha' in Yanacona, and 'Q'ompis blanca and 'Chillo K'usi' in Tihuicty.

To determine the genetic make-up of some of the potato cultivars grown and market in the area, 542 tubers from 18 local markets were collected and described on the basis of tuber traits of high heritability and isozymes disclosed by starch electrophoresis.

The analysis revealed a total of 229 different genotypes, which could be clustered by unweighted arithmetic averages in four discrete groups and a fifth highly heterogeneos group pooling the rest of the genotypes.

In general, low structure was found in the dataset resulting in a highly artificial separation of the varieties. Furthermore, no specific tuber traits could be segregated in each group. Thus, the analysis indicates that the varieties sampled form a common gene pool.

Because of the large number of named cultivars in the sample, most likely due to the extensive number of makets and vendors surveyed, we selected three samples comprising three main tuber skin colors for further analysis. In the first group, consisting of Q'ompis type potatoes, two main types were observed: pink skin, cream flesh and pink/brownish skin, cream flesh. These two types, however included 9 different isozymic phenotypes (Table 1).

Table 1. Percentage of isozymic phenotypes for Q'ompis type potatoes sampled in 18 markets in the Cusco area.

Tuber Traits	Pgi-1	Mdh-1	Got-1	Got-2	Percentage
Pink skin, cream flesh					
	12	3	3	4	32
	1	3	3	4	6
	1	13	3	24	3
	12	13	3	24	3
	15	1	23	4	3
	1	3	3	24	1.6
	1	13	3	24	1.6
	15	2	3	4	1.6
	15	3	23	4	1.6
	1	2	3	4	1.6
Pink/brown skin, cream flesh					
	12	13	3	4	32
	12	3	23	4	3
	1	13	3	24	3

The second group included purple skin potatoes of the type known as "Yana Imilla". Three flesh colors were observed in this group.

Table 2. Percentage of isozymic phenotypes for "Yana Imilla" type potatoes sampled in 18 markets in the Cusco area.

Tuber Traits	Pgi-1	Mdh-1	Got-1	Got-2	Percentage
Purple skin,cream/purple flesh					
	12	1	3	4	41
	125	2	3	14	13
	15	13	34	14	3
Purple skin,yellow					
	15	3	3	24	10
	15	3	3	14	8
Purple skin,yellow/purple flesh					
	25	13	3	4	5
	15	2	3	14	18
	125	13	3	134	3

The third group, included yellow to brown skin tubers of the type "Yuraq Kusi". Three flesh colors could be distinguished in this group.

Table 3. Percentage of isozymic phenotypes for "Yuraq Kusi" type potatoes sampled in 18 markets in the Cusco area.

Tuber Traits	Pgi-1	Mdh-1	Got-1	Got-2	Percentage
Brown skin, white flesh					
	12	13	3	4	25
Brown skin, cream					
	12	134	3	14	17
	125	24	23	14	19
	1	1	3	14	11
	1	13	3	4	6
Brown skin, yellow flesh					
	12	3	3	4	22

Table 4. Common and rare alleles for three potato skin colors:

	Common				Rare			
Skin	Pgi-1	Mdh-1	Got-1	Got-2	Pgi-1	Mdh-1	Got-1	Got-2
Pink	1,2	1,3	3	2,4	5	2	2	
Purple	2,5	1,2,3	3	1,4			4	2,3
Brown	1,2,5	1,2,3,4	2,3	1,4				

Within each group, the number of isozymic phenotypes ranged from 13 for Q'ompis type to 6 for Yuraq Kusi type. However, the number of alleles among groups was similar. The majority of the alleles were common to all three skin color groups. The main difference among isozymic phenotypes was due to homozygosity or heterozygosity of the various loci. The structure of these phenotypes within each group indicate that they may have derived as segregants after natural outcrossing of similar phenotypes.

Outcrossing most likely takes place at two levels. At the first level, between varieties of contrasting tuber traits. This will generate extensive segregation for skin and tuber colors as well as the introgression of rare alleles. At the second level, between varieties of similar tuber traits. This will result in individuals with sufficiently uniform tuber traits to be considered a single variety, however, they will differ in homozygosity for various isozyme loci. Human selecion of new types combining different skin and flesh color and shape, as well as better and uniform types will result in the amplification of phenotypes. Our previous studies demonstrated that outcrossing among Andean potatoes is very high, resulting many times in interspecific hybridization between closely related species, including weedy and cultivated species.

Although we did not attempt to separate the varieties by ploidy levels in the present study, the majority of the potatoes sampled were tetraploid.

In order to prove further the origin of new types by hybridization we crossed two diploid varieties of purple skin, white/purple flesh to two yellow skin, yellow flesh varieties. In the resulting F1, practically all the different tuber phenotypes observed in the Andean

varieties were reproduced in this cross. Thus, one of these crosses generates an ample number of phenotypes for selection of different types.

In conclusion, the present survey strongly indicates that the Andean potatoes is a large and plastic gene pool being amplified and renovated by outcrossing followed in some cases by human selection of desirable phenotypes.

Introgression study:

Professor Ortega collected tubers and berries from plants grown in four mixed ploidy fields surrounded by *Solanum* wild species in the Cuzco area. The altitude of these fields ranged from 3600 to 4000 m above sea level. The accessibility of the fields was only by foot, taking sometimes 12 hrs walking to reach them. Thus, this is the first time that this material is available for analysis. Seedings collected from open pollinated diploid, triploid and tetraploid cultivares will be surveyed for ploidy and for specific markers derived from some of the wild species surrounding the fields. This analysis will tell us whether andigena (4x) and chaucha (3x) types are still being generated in the growers fields. This information will shed light into the evolution of the cultivated potato in the Andes. The seed of this material is still in USDA quarantine. It should be released to us by the end of February.

Other activities:

We published two papers summarizing our work on the variability of Andean potatoes and levels of interspecific hybridization in Andean fields. Reprints are enclosed.

FINANCIAL STATUS REPORT (Follow instructions on the back)	1. FEDERAL AGENCY AND ORGANIZATIONAL ELEMENT TO WHICH REPORT IS SUBMITTED: AID/M/FM/PAFD/LOC, 7th Floor, SA-2, Washington, D.C. 20523	2. FEDERAL GRANT/OTHER IDENTIFYING NUMBER: DPE-5542-G-SS-8003	OMB Approved No. 80-R0180	PAGE 1 OF 1 PAGES
3. RECIPIENT ORGANIZATION (Name and complete address, including ZIP code): University of California, Accounting Office, Davis, CA 95616	4. EMPLOYER IDENTIFICATION NUMBER: 94-6036494W	5. RECIPIENT ACCOUNT NUMBER AND IDENTIFYING NUMBER: 3-222958-22958	6. FINAL REPORT: ☐ YES ☒ NO	7. BASIS: ☒ CASH ☐ ACCRUAL
	8. PROJECT/GRANT PERIOD (See instructions) FROM (Month, day, year): 09/01/88 TO (Month, day, year): 08/31/91		9. PERIOD COVERED BY THIS REPORT FROM (Month, day, year): 10/01/90 TO (Month, day, year): 12/31/90	

10. STATUS OF FUNDS

PROGRAMS/FUNCTIONS/ACTIVITIES	(a) DPE-5542-G-SS-8003	(b)	(c)	(d)	(e)	(f)	TOTAL (g)
a. Net outlays previously reported	$ 125,407.53	$	$	$	$	$	$ 125,407.53
Total outlays this report period	14,149.48						14,149.48
c. Less: Program income credits	0.00						0.00
d. Net outlays this report period (line b minus line c)	14,149.48						14,149.48
e. Net outlays to date (line a plus line d)	139,557.01						139,557.01
f. Less: Non-Federal share of outlays	0.00						0.00
g. Total Federal share of outlays (line e minus line f)	139,557.01						139,557.01
h. Total unliquidated obligations	0.00						0.00
i. Less: Non-Federal share of unliquidated obligations shown on line h	0.00						0.00
Federal share of unliquidated obligations	0.00						0.00
k. Total Federal share of outlays and unliquidated obligations	139,557.01						139,557.01
l. Total cumulative amounts of Federal funds authorized	146,116.00						146,116.00
m. Unobligated balance of Federal funds	6,558.99						6,558.99

11. INDIRECT EXPENSE

a. TYPE OF RATE (Place "X" in appropriate box): ☐ PROVISIONAL ☒ PREDETERMINED ☐ FINAL ☐ FIXED

b. RATE	c. BASE	d. TOTAL AMOUNT	e. FEDERAL SHARE
39.2%/41.2%	17,997.16/79,957.04	7,054.88/32,942.30	39,997.18

12. REMARKS Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation

13. CERTIFICATION

I certify to the best of my knowlege and belief that this report is correct and complete and that all outlays and unliquidated obligations are for the purposes set forth in the award documents.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL: [signature]

DATE REPORT SUBMITTED: 01/15/91

TYPED OR PRINTED NAME AND TITLE: G.R. Max. Pr. Accountant/JF

TELEPHONE (Area code, number and extension): (916) 757-8525