

B I J L A G E I

SUGGESTIONS CONCERNING THE BREEDING OF NEW POTATO VARIETIES
IN PERU.

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Suggestions concerning the breeding of new potato-varieties in Peru.

by

Dr. H.J. Toxopeus

Institute for Agricultural Plant Breeding

Agricultural University, Wageningen

CENTRAL COLLECTION

If one wants to breed better varieties than are used up to a certain moment, the situation may be that:

- a. such varieties already exist, their special characters not being realized.
- b. such varieties do not exist but can be obtained by recombining characters of existing material by crossbreeding.

Therefore a thorough study of the properties of existing material is "conditio sine qua non" in order to know what may be expected from breeding work. The first step in the breeding of the potato, in fact of the breeding of any crop, is to collect as many varieties as possible. This may be of special importance for the potato in Peru as this country is considered to be its home and there it displays an enormous variability. A second step is to study the material collected.

Roughly the material available in Peru can be divided into two main groups:

- a. a group of clones containing the more or less selected varieties like "Chata blanca" from Huasi-huasi "Casablanca" from the surroundings of Tarma, "Ccompis" from Cuzco etc. These "variedades" have been compared in a series of experiments and have shown to be good producers regionally. Of this restricted group of types several characters are already known and possibly weak points can be mentioned for each of them. A crossbreeding programme can be set up aiming at combining all favourable characters in one or more new varieties.

- b. a second group of clones containing a large number of very local varieties, that are grown in small gardens for home consumption and sometimes for special purposes. Probably most of them are low producers, but they are very important for breeding work. Some of them may possess very specific properties that do not occur in the relatively restricted number of "variedades". It is in this group that we have to look for resistance to or immunity from pests and diseases, for high content or special composition of starch and protein and for a high degree of frost tolerance. For this reason this part of the material should be planted under widely diverging conditions so that their special properties may come to the fore.

There should be one person in charge of the collections, who looks after the propagation and who studies the characters, in close collaboration with the specialists. This person should have a special mentality for cooperation with others and he should be allowed to do part of the breeding work.

BREEDING WORK THAT CAN BE STARTED RIGHT AWAY

As the breeding of new varieties needs a very long time - from cross to established variety at least 10 years - one should not wait till all is known of the properties of the collection, but start breeding work as soon as possible for such characters as are known to be of great importance. Such breeding projects are:

1. the selection of clones within the "variedades"
2. crossbreeding of the "variedades" among each other and with foreign high producing clones derived from Solanum andigenum as well as from Solanum tuberosum.
3. breeding for resistance to Phytophthora infestans.
4. breeding for resistance to wart disease.
5. breeding for resistance to Heterodera rostochiensis.
6. breeding for resistance to "frost"

1. Selection within the "variedades".

Most of these regional varieties are not pure clones. Therefore one should attempt to make clonal selections. In "Chata blanca" in the mountains above Huasi-huasi I saw many types differing in production, in shape and size of the tubers and depth of the eyes. It is evident that selection for resistance to Phytophthora, wart disease and virus will be successful too. Such work is of special importance in regions where seed-potatoes are grown. In some regions such work has been started.

2. Crossbreeding.

It is a well-known fact, that in crossing varieties grown in different and distant regions one has a fair chance to effect heterosis and has a reasonable chance to encounter exceptionally high producers among the F 1 seedlings.

For that reason crosses between the best regional Peruvian varieties should be made, but also with varieties selected in other Andean countries. Especially the effects of crossing the andean cultivated potatoes with the highly selected group of andigenum-varieties that occur in Europe under the species-name Solanum-tuberosum should be studied.

I trust that this kind of work will be successful as even after many backcrosses of the wild species Solanum demissum with Solanum tuberosum a marked heterosis effect could be established. As in the case of maize one "combining ability" and not each cross-combination will show heterosis effect. In my opinion many cross-combinations have to be tried and judged on the basis of the average production of 50-100 seedlings. Of the best combinations much more seedlings should be grown the next year in order to be able to select also for other characters than production .

3. Breeding for resistance to Phytophthora infestans.

In the coastal areas as well as in the mountains Phytophthora is one of the most dangerous diseases. For that reason breeding for resistance is of major importance. This resistance can be obtained by using:

a. The genes R 1 - R 4 of Solanum demissum. Several varieties from the United States containing the gene R 1 have been

tried in Peru and have been attacked by local strains of the fungus. In Holland we now have available other genotypes and about 3400 seeds of 20 different cross-combinations have been placed at the disposal of the Agricultural Experiment Station La Molina. One of the parents of these crosses is a variety of Solanum tuberosum and the other a good backcross seedling, derived from Solanum demissum possessing the gene-combinations R_1R_3 , R_3R_3 , $R_1R_2R_3$ or $R_1R_3R_4$. From these seeds plants with many different genotypes can be raised and some of them may be immune. With the aid of a method described by me (Euphytica 3(1954):233-239) the genotype of each of the immune plants can be ascertained. More seeds and possibly tubers of this kind can be sent from Holland in the future, when this kind of breeding work appears to be successful in Peru.

With most diseases the danger is imminent that new biotypes of the parasite may arise which attack the resistant material. For this reason we should not only use the R-genes but also pay attention to:

b. the degree of damage done to susceptible material. There are great differences between the varieties of Solanum tuberosum in this respect and in Solanum andigenum there will be even greater differences. In collections it will be apparent very soon, which of the clones displays the highest degree of resistance. The "variedades" should be crossed with this highly resistant material in order to combine this high resistance with other favourable characters.

4 and 5. Resistance to wart-disease "verruca" and Heterodera rostochiensis.

Both diseases are soil-borne and harmless in regions where only once in 6-10 years potatoes are grown. However, in places, where the population is denser, or may be expected to grow denser in the near future, the soil will be used more intensively and proportionally the damage done by these diseases will increase. According to ing. Agron. Garcia Pittman, in many fields in the district of Puno the potato-plantations suffer severely from Heterodera rostochiensis, the golden nematode. Many fields around Cuzco are known to be heavily infested with Synchytrium

endobioticum, the fungus that causes "verruca". As human populations will grow, both diseases have to be considered as a serious threat in the future; therefore the breeder and the pathologists should start their studies right now in order to be able to meet future disastrous developments.

For both diseases resistant varieties exist, at least in Europe. However not only the potato is endemic in the Cordillera de los Andes but to all appearances Heterodera rostochiensis and Synchytrium endobioticum as well. Therefore in Peru both parasites probably are much more variable than in Europe, where these diseases must have been imported with soil adhering to the Solanum andigenum-tubers from which Solanum tuberosum has been developed. Consequently clones being resistant in Europe may be susceptible to many strains of both parasites in Peru. It is of great importance to study this question with the aid of material from the Netherlands, that is resistant to the European strains and to look for resistance in the vast reservoir of variability of the cultivated Solanum species occurring in the Andean region.

At the Potato Genetics Station at Cambridge the reaction of about 500 andigenum clones to the European strain of wart-disease has been studied. About half of them appeared to be resistant. It should be interesting to know whether the resistant clones are collected throughout the Andean region or in special districts. As it is known where each clone has been collected such a study can be made from the literature.

The resistance to "verruca" can easily be studied in heavily infested fields, that are known to occur in several regions. In such fields resistant and susceptible Dutch varieties should be planted and in addition a great number of andigenum clones. If such experiments are conducted in several regions, one is quickly informed on the occurrence of different strains of the fungus. Besides it would appear whether there are andigenum clones resistant to the whole array of Synchytrium biotypes.

As concerns Heterodera rostochiensis the same situation prevails except that resistance is a rare phenomenon. Among 780 clones of cultivated potato-clones collected from Columbia to Chili, Ellenby found only five to be resistant. The resistant material bred in Holland derived from one of these clones and

contains a dominant gene H that prevents the maturation of the female larvae.

A collection, comprising 10 tubers each of 80 resistant andigenum-tuberosum hybrids have been sent to Lima and in the course of November 1955 experiments with this material will be conducted by the specialists of the Estaciones Experimental de Agricultura "La Molina" at the hacienda Maco in central Peru.

6. Frost-resistance.

Every year great damage is done by frost in the Peruvian potato-fields. Therefore breeding for frost-resistance should be an important point on the programme.

The most resistant species is Solanum acaule, the leaves of which can stand up to -8°C . Crossing this species with Solanum tuberosum is difficult. However after doubling the chromosome number of Solanum acaule seeds of this species can be obtained quite easily.

The F₁ hybrids are highly frost-resistant and backcrossing to Solanum tuberosum is possible. According to experiences of Dr. Mastenbroek (Holland), in the first backcross-generation highly resistant plants occur and by backcrossing with potato varieties once or twice more, seedlings can be obtained combining good commercial characters with a high degree of frost-resistance. As Solanum tuberosum is so closely related to Solanum andigenum it may be expected that seeds of acaule-crosses with this latter species also can be obtained.

In Holland one is never sure that a nightfrost will occur in the field. For that reason the seedlings have to be tested in a refrigerator. However, in Peru frosts are much more frequent in certain periods and testing may be done under conditions in the field. This method is considered to be much better as testing can be performed under circumstances prevailing in practice. This can never be reproduced in full in a refrigerator.

There is some danger, however, that the temperature falls down too much and that consequently all seedlings are lost. To prevent this loss the work should be arranged in such a way that the plants grown from hybrid seed are selected for tuber characters first, without exposing them to the danger of night-frosts. A study of frost-resistance can be made subsequently at

plants grown from part of the tubers of the first or second clonal generation.

VIRUS PROBLEMS AND METHODS OF POTATO-BREEDING

Virus-situation in Peru.

According to Silberschmidt who visited several potato regions in Central and Southern Peru, hardly any plant seems to be free from virus diseases (Informe sobre las observaciones hecha en los campos de la papa en la sierra de Pera. Informe no.93 Dec. 1954. Estacion experimental agricola de "La Molina").

When this assertion is right, it will have been so for ages, as such a situation does not develop in the course of some few years over such a large and scattered area in the Andean republics. It is more likely to assume that the Andean region is not only the centre of origin of potatoes, but also the cradle of many of its pests and diseases and among them those caused by virus.

Exactly a year after the visit of Dr. Silberschmidt I saw many potato fields in the central region and among them those of the haciendas Tambo and Casablanca, which had been inspected by him. At both farms I was impressed by the magnificent stand of the crop and also in the fields above Huasi-huasi I observed many well-developed and very productive plants.

At both farms Dr. Silberschmidt stated a very high percentage of plants showing symptoms that might be caused by virus. One of these symptoms resembles very much those caused by "calico" virus in the U.S.A. and was found in 17 out of 25 plants inspected at Hacienda Casablanca. Every plant at that farm showed a blackening of the veins at the underside of the leaves which according to Dr. Silberschmidt was caused by a severe and complex infection with virus.

To what extent these symptoms really are caused by virus is as yet unknown and considering the excellent stand and the high production of the potato fields of Tambo and Casablanca in 1955 we are enforced to conclude, that either many potato varieties are highly tolerant to virus diseases or that much of the symptoms indicated by Dr. Silberschmidt are not caused by

by virus at all and consequently that the virus situation is not so alarming. As concerns the "calico" symptoms and the chlorose of the young leaves the influence of low temperature in these high regions has to be considered. It is a well known fact that several varieties react on low temperatures with these symptoms and it may be of some interest to note that during my visit both symptoms only could be observed in a low percentage of plants.

In this connection observations made on plants grown in Holland from tubers collected by me in Peru are of great interest. The plants were raised in a glasshouse and were protected against infection by aphids by fumigating with nicotine twice a week. Such virus as could be ascertained in the plants must have been present in the tubers when harvested in Peru. The incidence of virus was stated in combined symptomological and serological studies. The results of these investigations are given in the following table.

Virus present in tubers collected in different regions in Peru.

Provenance	altitude in m	number of samples	number of samples containing virus:					% of samples containing virus:					% of plants without virus
			X	S	Y	LR	M	X	S	Y	LR	M	
Cantha valley	2800	18	3	6	0	7	2	16	33	0	40	10	33
Rarga pata	3800	23	3	2	1	0	1	13	9	4	0	4	83
Ocallama	3800	11	8	1	0	0	0	73	9	0	0	0	18
Anch	3600	10	2	6	0	0	0	20	60	0	0	0	40
Market Lima	100	31	8	15	1	2	1	26	50	3	7	3	35
Chinchero	3800	23	12	5	2	0	2	50	22	8	0	4	35
Paucartombo	3800	10	3	5	0	0	1	30	50	0	0	10	33
Kcaira	3200	23	12	16	15	0	0	50	70	65	0	0	0
Puno	4000	30	14	3	1	0	3	47	10	3	0	10	33
Northern Argentina		87	32	48	1	0	1	38	57	15	13	1	13

*) LR = leafroll M = mozaic

These data indicate that:

- 1) the percentage of plants in which no virus could be stated varies from 0 to 83, in most fields amounting to 30-40.
- 2) virus Y and leafroll, both needing insects for transmission, are nearly absent high in the mountains, while in the Cantha valley and at the experimental farm Kcaira in the lower parts of the potato region leafroll and virus Y are of frequent occurrence.
- 3) virus X and S, both transmitted by contact and not by insects, are met with in low as well as in high regions to a varying extent.
- 4) probably insect-transmission is of minor importance in potato fields high in the mountains (3600-4200 m), whereas transmission by contact takes place at any altitude.
- 5) consequently it must be easy to raise healthy seed potatoes in many regions at high altitude if appropriate care for isolation is taken.

The climate is very different locally in the potato regions. At many places the conditions though not adverse to the normal development of the potato, certainly are far too rough for the main vector of virus diseases the aphid Myzus persicae. From the climate alone it can be concluded potato regions must exist, which are comparatively free from insect transmitted virus diseases. This is confirmed by the above studies.

Production of virus-free seed potatoes.

From the above studies it is apparent that there are regions high in the mountains, where potatoes are comparatively free from virus diseases and where the danger of infection by aphids is small. However, even in such regions one should take all possible precautions to prevent contamination. Especially one should take care to plant his material at as large a distance as possible from commercial potato fields and if possible in the midst of large fields of other crops such as oats and barley.

As one never can be absolutely sure that a healthy looking plant does not carry some virus, one should start his programme with one tuber each of a series of attractive plants. These tubers should be planted in a field of oats or barley at some meters distance from each other.

At regular intervals the plants should be inspected and every individual showing symptoms whatsoever should be suspected and discarded. The tubers should be harvested as soon as they are sufficiently developed and long before the plants are dead ripe; in most cases a fortnight after flowering. When doing so the plants are exposed for as short a time as possible to the danger of infection.

After the harvest 5-10 tubers of each healthy plant are available and they should be planted next season in isolated plots. These small groups of plants again should be inspected frequently and individual plants should be discarded at the slightest symptom. In the third season about 50 tubers of each completely healthy group are available and again these larger groups should be planted out in isolated plots and so on.

At a certain stage the area of each clone derived from one tuber at the outset is growing too large for very intensive inspection and from that stage on the seed potatoes should be delivered to the practice. In the meantime every year new healthy plants should be selected and propagated according to the above programme in order to keep the "foundation" stock in healthy condition.

In rough outline the above method is the most successful one used in Holland (hill-selection). Whether it can be developed in Peru depends very much on local conditions and the care and perseverance of the people in charge. There is no doubt that climatic and virological conditions in some regions are favourable.

The crucial point is the roguing. Much depends on the intensity of the symptoms shown by the variety. If the symptoms of a certain virus are clearly visible it is easy to keep the variety free from it; when not it will be very difficult. However in the latter case the virus probably does little harm and keeping the variety free from the special virus is of no concern.

Breeding and virus infection.

Breeding new varieties starts with the sowing of true seeds. As viruses are not transmitted with seeds, the breeder is in the favourable position that his seedlings initially are free from virus. He can raise healthy new varieties if he is able to prevent infection of his material during the time he needs for multiplication and testing.

Therefore the breeder should choose a healthy region for his establishment and use the methods roughly described for seed potatoes. He should adapt them to local conditions. Below the methods used by breeders in Holland are described to demonstrate how they try to cope with difficulties presented by climate and virus.

The seeds are sown in March in a glasshouse in the very beginning of the spring and the seedlings emerge after about 10 days. After one or two weeks when the young plantlets have developed one or two leaves, they are transplanted in to flats or wooden boxes at distances of about 2 x 3 cm. Two or three weeks after transplanting, the plants have 4-5 normal leaves and a well-developed root system. Now they are transplanted into small pots (Ø 10-12 cm).

Towards the end of March and in the beginning of April the temperature on the field is low and especially the danger of nightfrost is great. Therefore the potted plants have to be raised under glass cover in cold frames. As the temperature gradually rises in the course of April and May the glass is lifted by day and towards the middle of May also at night.

In the second part of May the danger of nightfrost is so low that the seedlings can be planted out in the field. In the meantime they have grown to a height of about 20 cm and some have already started tuber formation. On the field holes of the same diameter as the pots are made with a special tool at distances of 40 x 50 or 50 x 50 cm. If the soil is sufficiently moist they do not suffer at all from transplanting.

In order to escape virus infection of the tubers the plants have to be lifted in the first half of July as the main vector of these diseases, Myzis persicae is developing rapidly in that period. Therefore the seedlings are on the field only for about

6 or 7 weeks. On the one side there is the danger of freezing until the middle of May, on the other side the danger of contamination with virus six or seven weeks later.

As the seedlings are already well-developed at the time they are planted on the field, nearly all have produced tubers. Though these tubers are not ripe by far, they can be used as seed potatoes for the following season when stored at a low temperature. Seed potatoes in the Netherlands have to be planted in the month of April and consequently the tubers have to be stored during a period of 8-9 months. During the first two or three months the storage temperature need not be very low but from that time on it should be around 4°C. A month before planting the temperature has to be raised gradually to enable sprouting.

If the breeder has a glasshouse at his disposal he can manage otherwise, as in a glasshouse his seedlings can be protected against virus infection by spraying or fumigating at regular intervals with some powerful insecticide. In the glasshouses of the Foundation for Agricultural Plant Breeding the seedlings are raised in small pots as described by Thijn in *Euphytica* 3(1954):140-146.

This method of growing seedlings in pots in glasshouses comes more or less to the replacement of a seed by a few very small tubers. As plants grown from small tubers are not as much endangered by nightfrost as plants grown from true seeds, these tubers can be planted out on the field in the course of April. In the beginning of May the plants are already well-developed; in the first half of July the tubers of these plants are much more developed than those of the plants grown from true seed and planted out according to the above programme.

So far the methods used in Holland to raise healthy breeding material. It is evident, that every breeder has to adopt his methods to the conditions prevailing in the region where he is working. Though his programme certainly will be different from the scheme described above, in principle he has to handle his material more or less in the same way.

Though the breeder should try to keep his seedling-varieties as free as possible from virus diseases, he has to realize, that in the practice of potato-growing his future new varieties will be exposed to a severe virus attack in most potato-regions and that they can be accepted only, when they do not degenerate too fast.

Therefore 10-12 tubers of the fourth or fifth tuber-generation of each seedling-clone should be planted out in a badly infected region and the reaction of this material should be studied for some years in succession. Those clones degenerating too quickly should be discarded at once, even when they are very promising in other respects.

About six years after sowing the breeder possesses a series of new varieties with desirable commercial characters and more or less resistant to degeneration. Of each of these varieties a small quantity of healthy tubers is available and with this healthy "foundation stock" experiments on the agricultural value in different regions of Peru can be started.

The resistance of Andean cultivated potatoes.

If one accepts the supposition that virus diseases have been present in the Andean regions for ages, one has to assume that an equilibrium has established itself between the potato- and virus-populations. It is worth while to try and figure out at what level the situation will have stabilized as concerns resistance or tolerance of the population of the potato.

The following facts are pertinent to this question:

- 1) the potato fields of the indians are planted with such a mixture of potato varieties, that within half an hour one can collect from a small field at least 20 varieties differing in visible characters of the tuber.
- 2) on an average only the smallest tubers are used for seed and in general no attention is paid to the state of health of the plants.
- 3) as a rule two or three and even more small tubers are planted in one hole and consequently two or three often widely different plants are growing on one hill.

Planting more than one tuber in a hole favours the spreading of all types of virus. Taking small tubers for seed increases the percentage of virus-infection as plants severely suffering from virus produce small tubers only. On the other hand small tubers of well-developed plants on an average are less infected than the big ones.

The combined effect cannot be predicted and for that reason one cannot be sure that in the course of time the composition of the potato population will more and more shift into the direction of tolerance or resistance. One has even to consider the possibility, that the indian methods of potato-growing tend to prevent or at least to slow down the extinction of highly susceptible varieties. Therefore there is no reason to suppose that under the conditions prevailing in Peru only resistant or highly tolerant varieties dominate in the potato population.

Possibly some of the widespread "variedades" are more or less resistant or tolerant as the owners of large fields are more conscious of production than the small holders.

Though as a consequence of methods of cultivation, the highly resistant or tolerant varieties may not come to the fore, they certainly are present and may be discovered by planting a great collection of types in as large a number of highly infested regions as possible.

The material should be studied during some years in succession and those clones, remaining free from a virus that attacks most other members of the collection, may supposed to be resistant. In these studies it will be very difficult or nearly impossible to distinguish between resistance and a very high degree of tolerance in the absence of characteristic symptoms. Such a high degree of tolerance is useful in itself, safe for the fact that such a variety is a carrier that may be a dangerous source of infection for a susceptible variety.

It is obvious that such studies have to be conducted by a specialist who has the disposal of an experimental garden and a well-equipped laboratory to test the presence or absence of several kinds of virus in a plant that does not show clear-cut symptoms. If resistant material has been discovered a breeding

programme has to be developed and the execution of such a programme also needs a well-trained and well-equipped specialist.

Up to the present the results of breeding work aiming at the creation of potato-varieties that are not attacked by virus is far from satisfying and for that reason a continuous and thorough search for new resistant material in the Andean wild and cultivated potatoes is highly desirable.