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Production and use of maize seed for sowing in Bolívar, Ecuador

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Abstract In the province of Bolívar in the Andean region 212 farmers, six salesmen and 14 technicians, involved in maize production, were interviewed. The majority of the farmers interviewed were small-holders; 64% of the farmers had a farm size of less than 4.5 ha. Maize is the most important crop and is often grown in association with beans. Most maize, 96%, is soft maize meant for human consumption. The cultivars grown are open pollinated ones. One cultivar, 'Guagal', was grown extensively. A few others, among which an improved version of Guagal were of some importance. In the production of maize the farmers consider damage due to insects, wind (lodging), diseases, drought and hail, the low prices for their surplus maize and the high costs of fertilizers, chemicals, sowing seed and labour as the most important constraints.The seed for sowing the next crop mainly came from seed kept from the last harvest. Farmers indicated that they select from the harvested ears the healthy looking larger ones. Kernel type also was a selection criterion. Selection for plant type in the field was rarely done. Of the farmers 71% stored the maize as kernels while 29% stored the seed kept on the ears. The storage was predominantly done somewhere in the house in plastic (56%) or cloth bags (14%), in a pile (13%), just on the floor (4%) or in cans (4%).Some farmers still had seed left from the last sowing and were willing to give a sample for testing. From 32 such samples the quality was assessed by INIAP, the Ecuadorean governmental research and breeding organisation. The samples were consistently of a low quality. Especially the vigour of the seedlings was poor and most of the seeds were infected or contaminated by fungi. In the region a few salesmen offer maize seed for sale of cultivar Guagal at prices affordable by the farmer. Of improved cultivars the prices were higher than most farmers are willing to pay. The technicians considered good seed quality and good maintenance of the cultivars effective methods in obtaining better yields. Many farmers do not have access to seed of INIAP and are not familiar with the improved cultivars.

Keywords Seed for sowing · Small-holders · Maintenance selection · Landraces · Local cultivars · Improved cultivars

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Introduction

World-wide there are still large areas where the conditions for agricultural production are marginal for a complex of diverse reasons. The farms are often small, the environmental conditions sub-optimal and highly variable in time and space and the resulting low-income position of these small-holders prevents them from investing in increased agricultural productivity. Despite numerous efforts to improve the agricultural situation in these areas and so the economic circumstances of these small-holders, little progress has been made. The farmers still use predominantly their local cultivars and locally produced seed, the informal sector (Cromwell 1990; Bebbington 1999; Morris and Bellon 2004). The dominant source of seed is withholding part of the farmer's own harvest (Friis-Hansen 1996), but there is also a lively exchange of seed between farmers and through local markets.

In the Andean regions many farmers can be classified as low input small-holders. Information about the production, use and distribution of seed for sowing their crops is still scarce. Thiele (1999) made such an analysis for the potatoes in the Andean regions. The larger part of the crops harvested is for their own use. Surpluses are marketed to produce a small income. Due to the low-income situation the inputs in their crops are low; fertilizers and pesticides are often not applied, except in potatoes. Valdivia et al. (1996) describes this situation for the Titicaca Lake basin in Peru. On farm saved seed has been and still is the dominant seed source for the majority of farmers who grow food and subsistence crops like maize, barley, wheat and potato (Almekinders and Thiele 2003). Investment in high-quality seed should be economically attractive to such farmers, the reality appears otherwise. They might consider the seed too expensive, it may arrive too late for planting, it often does not have the claimed seed quality, farmers do not have sufficient cash, the risk of investment is too high, or the higher seed quality does not come to expression under low input conditions (Almekinders and Thiele 2003). Farmers tend to be quite willing to buy small volumes of 'novelty' seed, which they thereafter could re-produce on farm. The most important source for 'new' seed is seed obtained from neighbouring farmers, including relatives. These are more important than the combined sources of markets, shops, etc. (Jones et al. 2001).

Maize is in large areas of the Andean zone the most important crop, and is grown in a diversity of open pollinated local cultivars. Chavez (2003) describes the maize situation in the Andean area of Peru. Most of the maize is grown on small plots and 95% of the farmers use seed kept from the previous harvest, which was their own, or exchanged with neighbours or obtained through a market. Only 5% uses certified seed of improved cultivars. The seed to be used for the next season is often kept on the ear under rather poor conditions somewhere in the house. Just before sowing the seed is removed from the ear, whereby the seed from the ear tip is not used as this seed is most frequently affected by diseases or insects. The situation in the province of Chota in N. Peru is described in more detail. Of the agricultural area 35% is planted with maize, usually in combination with beans. Most of the farms are small; 65% is smaller than 5 ha, 17% is between 5 ha and 10 ha and 12% is larger than 10 ha. The maize is used for human consumption and as fodder for the farm animals. In good years the surpluses go to the market. In bad years they may have to buy extra maize on the market.

This study was carried out to obtain more information about this informal seed production and distribution in maize in an area representative for the marginal areas in the Andean regions, the province of Bolívar on the west side of the Andes south of Quito.

Bolívar is divided into seven districts, with a total surface area of 4,150 km^2 (Anonymous 2001). Four districts are situated at altitudes between 2,000 m and 4,000 m (Andean districts). The other districts are situated in the west-lowland part of the country. Bolívar is one of the poorest provinces in Ecuador. Agriculture is the main economic pillar. The temperature varies little over the year, the mean depending on the altitude. The growing season ranges from October to May. Due to the large fluctuations in the precipitation the various crops frequently suffer from droughts. Maize is the most important crop in the Andean region of Bolívar. The most

important type of maize in Bolívar is soft maize, suitable to be consumed in a mature (''seco'') and an immature form (''choclo''). The other type is hard maize (''duro''), which serves as fodder for livestock. Maize is usually sown in November or December. Other crops in this region are dry beans, mostly grown in association with maize (mixed cropping), potato, wheat, barley, pea and a range of minor crops.

Materials and methods

For this study the Andean region of the province of Bolívar was chosen because it is considered to be representative for large areas of the Andean zone between 2,000 m and 4,000 m a.s.l. where agriculture is carried out to a large extent by small-holders under often marginal conditions. The study consisted of interviews with three different target groups; farmers, salesmen and technicians.

The composition and length of the questionnaire for farmers was discussed with a range of specialists familiar with the local situation. The questionnaire consisted of 31 open pre-coded questions. This approach was chosen to obtain objective information suitable for analysis.

- About the crops grown by the farmers.
- On how maize seed is obtained, maintained and stored by the farmers.
- What the farmers think about certified maize seed in relation to quantity and quality of yield.
- The possibilities of farmers to obtain certified seed.

In total 212 farmers were interviewed, divided over the four Andean districts in proportion to the number of farmers in these districts. The farms participating in this interview can be considered representative for the whole area with possibly a slight bias towards farms of less than 5 ha. Only two farmers of those approached refused to be interviewed. The respondents were 71% male and 29% female. A few questions were not answered by all respondents. In the results the number of farmers that answered the question is given if it deviates from 212.

A total of six market salesmen of maize seed for planting were asked a number of questions related to the costs and origins of the maize seeds they were offering for sale. Fourteen agricultural technicians, employed by INIAP (the Ecuadorean governmental research and breeding organisation), Bolívar University or the ministry of Agriculture and familiar with the region and their problems and having experience in the production of maize seed, were approached with questions about the importance of high-quality seed and the current and future relationship between the formal and informal seed sectors.

To test the quality of maize seed used for planting, the farmers were asked to donate about 250 g of maize seed left over from the maize season 2003–2004 Of the 33 samples obtained, one was destroyed by grain weevils (*Sitophilus zeamais*) before any testing had been conducted. The seed samples were tested at the research station of INIAP in Quito for purity, moisture content, germination, vigour and fungal infections or contamination (infestation). After cleaning, removing inferior seeds and inert material, the purity was measured as the difference in weight before and after cleaning. The moisture content was measured in 100 g by using a Steinlite 400G electronic moisture tester. Per sample 200 seeds were randomly separated into four sub-samples of 50 seeds, to be used for a germination test. The seeds were placed on germination paper, moisturized with demineralized water, rolled up and placed in a climate controlled chamber (22°C, 90% relative humidity). After 12 days, the germinated seeds were counted. The vigour was established by the percentage of seeds with a healthy seedling. Seedlings clearly smaller than the average well germinated seedling were classified as unhealthy. Fungal infestation was established by counting the seeds with visible fungal growth. The parameters were compared with the INIAP standards for seed testing.

To test whether yields of maize ears (''choclo'') and dry maize (''seco'') differed among districts and cultivars, the data were analysed with the statistical software SPSS 11.0, by means of an analysis of variance (ANOVA). Differences were regarded significant if mean yields differed more than the accompanying LSD value with a *P*-value of 0.05.

Table 1 Frequency in % of farm sizes over seven size categories in ha and the percentage of the farm area planted with maize either in association with beans or without beans

Farm size in ha	<1.5	1.6–3.0	3.1–4.5	4.6–6.0	6.1–7.5	7.6–9.0	>9.0
Frequency	20	27	17	13	6	5	13
% with maize	85	60	30	12	2	3	7

Results

Most farms (77%) are small to very small with a size from less than 1.5 ha to 6 ha (Table 1). The most important crop is soft maize often associated with beans. Other important crops are potato, wheat, pea and barley (Table 2). The percentage of the farm area occupied by maize decreases sharply with increasing size of the farm. At larger farms hard maize for fodder is of some importance. On average half of the soft maize is harvested immature (''maiz choclo''), while the other half is harvested mature to be consumed at later stages (''maiz seco''). The most popular cultivar was Guagal. 'Maíz de leche' and 'INIAP-111' were of some importance (Table 3).

'Guagal', 'INIAP-111' and 'Maíz de leche' are mealy, very soft types of maize, which mature late and are susceptible to various fungal diseases. 'INIAP-111' is an improved version of 'Guagal', resistant to lodging, shorter, better yielding and with a better kernel quality (INIAP 1997).

The farmers were asked what they considered the most important technical and economic problems in the cultivation of maize. Damage due to insects, wind (lodging), diseases, drought, hail, low prices they get for their maize and the high costs of production factors as fertilizers, chemicals, sowing seed and labour were mentioned most frequently.

The most important part of the survey asked the farmers how they select and keep their maize seeds for sowing. Most farmers (over 95%) said that they select their own seed for the next crop. When asked what the important selection criteria are, they mentioned large ears as the most important characteristic, followed by the size of the kernels, especially of those in the middle of the ear, and the absence of visible disease symptoms on the kernels. Only a few farmers, 3%, said that they also selected for plant type. This ranking of importance was consistent throughout the area investigated.

Plant type, kernel colour and shape were hardly mentioned. However, when asked what characteristics were important in recognizing good maize seed, the colour and shape of the kernels were mentioned fairly often besides size and healthiness of the kernels. Size was the most important characteristic and the farmers almost uniformly desired large kernels (over 95%) while a few preferred medium sized ones.

In most households the maize seed is selected by both man and woman (50%), or by just one of the two (man 23%, woman 11%). In less than 20% of the households one or more of the children are (also) involved in this process and in very few occasions other persons, such as neighbours.

Production of seed for own use happens in 89% of the cases. Buying at least some seed for

Table 2 Relative importance (RI) of crops (% of farms having that crop on their farm) in the cropping systems found in the Andean region of Bolívar

Crop	RI
Maize/beans	78
Maize (monoculture)	48
Wheat	50
Potato	40
Pea	38
Barley	24
Other crops	1–13

Table 3 Relative importance (RI) of maize cultivars (% of farms having that cultivar on their farm) in the Andean region of Bolívar

Cultivar	RI (%)
Guagal	67
Maiz de leche	13
INIAP-111	9
Mamasara	2
Don't know	4
Hard maize (''Maiz duro'')	4[a]

[a]Only used as fodder

sowing is done by about half of the farmers but not every year (Table 4). This seed can be the same cultivar from elsewhere or a different cultivar.

On average, in 87% of the maize fields from which the seed for sowing came from, the distance to a neighbouring maize field was less than 50 m. In 10% of the cases the distance was between 50 m and 100 m.

The maize is generally stored as kernels (71%) but a fair number of farmers store the seed still kept on the ear (29%). The storage is often done in plastic bags (56%), cloth bags (14%), or cans (4%). Storage in a pile (13%), just on the floor (4%), or in a storage place (7%) are less practised.

Treatment of the seeds takes place at about 70% of the farms. The most popular pesticide is the systemic fungicide Vitavax 300, followed by the insecticide/nematocide Furadan.

The participating farmers were questioned about seed supply systems. Of the participating farmers 65% said that they had nobody in their area that could sell them seed from the formal sector. Farmers that knew where to buy seed mentioned their neighbours (68%), INIAP (25%), Bolívar University and agricultural shops (7%).

Another form of seed distribution in Bolívar is exchange of seed between farmers, although not more than 23%, mostly neighbours, engage in this activity. This exchange is usually among agricultural neighbours (96%) and rarely with farmers from other villages. Exchange of maize seed with farmers from other districts or with salesman at (local) markets was mentioned not to occur.

About 36% of the participating farmers have bought maize seeds previous year. This includes seed bought from other farmers and on the market. They had to pay between US$ 0.35 and US$ 0.39 per kg on average. The average farmer says to be willing to buy some 50–150 kg initially to observe the quality of the new cultivar at his or her farm. The price that the farmers on average would pay for 1 kg of a new cultivar of excellent quality is US$ 0.40, but differs considerably with area and farmer.

Yield data of maize grown as monoculture were obtained from 121 farmers. The yields varied somewhat per region and much more per farmer. The average for soft maize was about 124 bags/ha and for dry maize about 1.65 ton/ha. A bag is on average somewhere between 30 kg and 35 kg, depending on ear size, cultivar and dry matter. About half the maize was harvested as soft maize and half as dry maize. The price farmers got for their maize is shown in Table 5. The soft maize is sold on the ear and a bag contains between 90 and 130 ears depending on ear size. The price they could get varied per region and even within a region. The revenue per ha would therefore range from well below 500 US$ to over 700 US$ for the soft maize. For the dry maize the revenues were clearly lower. The yields per ha of the three most frequently planted cultivars did not differ greatly with about 150 bags for 'Maíz de leche' ($N = 28$), 124 bags for 'INIAP-111' ($N = 17$) and 120 bags for 'Guagal' ($N = 121$), the differences being not significant.

When asked, 81% of the farmers ($N = 171$) said that purchased seed yielded more than self-produced seed. They estimated the yield difference on average at about 23%.

The six interviewed salesmen were selling their mercantile in two of the four districts, San Miguel and Guaranda (Table 6). The seed of 'Guagal' they had for sale was produced by a local farmer. The seed of 'INIAP-111' in San Miguel came from the same farmer, while the seed of 'INIAP-111' sold in Guaranda came from Bolívar University, which obtained it originally from INIAP.

Table 4 Percentage of farmers[a] buying at least some seed for sowing

Frequency of buying seed	(%)
Every year	20
Every 2 years	18
Every 3 years	4
After more than 3 years	6
Never	52

[a] $N = 209$

Table 5 Prices obtained for soft maize (''choclo'') per bag and for dry maize (''seco'') per kg in US$

Type of maize	Range	Mean	*N*
Price ''choclo''	4.00–5.60	5.20	151
Price large grains ''seco''	0.20–0.24	0.23	184
Price small grains ''seco''	0.14–0.18	0.16	184

Cultivar INIAP-101 was selected from a mixture of local and foreign landraces (INIAP 1984) and the seed was produced by INIAP. The higher prices in Guaranda were partly caused by the more expensive production through INIAP and Bolívar University. Two of the salesmen selected the seeds they sold for characteristics as size, colour, purity and health. The others did not select, because their suppliers had already done so.

When the technicians were asked their opinion about the best way to produce and select maize seed, seven considered selection on the ear after harvest sufficient. The other seven thought that the addition of plant selection in the field would be an improvement. The most important aspects for the selection on the level of ears were large ears, ears well covered with leaves, containing large grains in straight rows, pure, free from diseases, with a uniform shape and blank colour. The middle part of the ear was considered the part with the best grains. Plants need to be selected for health (without diseases), with a strong stem, early maturing, reduced height, and ears located low on the plants. The plots where the seed for sowing is produced should be sown distant from other maize plots or on a different date to prevent cross contamination and so degeneration of the cultivar. All technicians agreed that higher yields can be obtained with seed of a good quality. Especially good seed quality combined with good maintenance of the cultivar is seen as effective in obtaining better yields.

Most technicians think that INIAP produces seed of a good quality, but insufficient to satisfy the demand, while the price is considered too high for most farmers. Many farmers do not have access to seed of INIAP and are therefore not familiar with the quality of that seed.

The quality of the 32 seed samples obtained from the farmers was considerably lower compared to the standard requirements for certified seed in use by INIAP. Especially the vigour of the seedlings and the percentage without fungal infestation remained considerably below the standard requirements (Table 7).

Table 6 Prices of maize seed for sowing in US$/kg asked by six salesmen in two districts of the province of Bolívar

Salesman and district	Cultivar and source of seed[a]		
	Guagal	INIAP-101	INIAP-111
1 San Miguel	0.36*		0.36*
2 San Miguel	0.36*		
3 San Miguel	0.36*		
4 Guaranda	1.00*	1.80**	1.00***
5 Guaranda		1.90**	0.56***
6 Guaranda		2.00**	1.00***

[a] *Farmer, **INIAP Quito, ***INIAP/Bolívar University

Discussion

About $\frac{2}{3}$ of the farmers in the Andean region of Bolívar have less than 5 ha of land, which occupies roughly 40% of all farmland in that region as estimated from Table 1. This is consistent with the data given by Anonymous (2001), who reported that 42% of the farmland of the whole province was occupied by farms less than 5 ha.

Maize, predominantly of the soft type, is the most important crop in this region. The cultivars grown, except INIAP-111, are not based on cultivars originating from formal breeding programmes and have been reproduced by the farmers themselves for a long time and without proper maintenance selection. They are landraces with the characteristic wide genetic diversity (Parlevliet 2003).

Maize seed for sowing is obtained through different channels, but to withhold seed for the next sowing is the most popular method, applied by 89% of the farmers. These farmers not necessarily restrict themselves to using their own seed. They do try out other seed sources usually on a smaller scale.

Farmers generally do not grow plants for seed production separate from production fields and do not select plants for seed production. They only select for ear and kernel characteristics, after harvest. This selection is not only weak, it also may result in undesirable effects on the long term. Selection for larger ears without plant selection for the right type of maturity may lead to late maturing populations, what farmers may not really want (Chavez 2003). That is also the reason why INIAP breeds for earlier cultivars like INIAP-111, an improved version of the local cultivar Guagal.

The distance between the field where the farmer takes his seed from and the nearest other field is in 87% of the cases less than 50 m. This small distance between fields together with the usually small size of many maize fields means that cross contamination must occur frequently. If a large part of these fields consists of the same local cultivar Guagal, cross contamination is not really a problem; it helps to keep the variability of the local cultivar at a high level. Cross contamination, however, is a major problem when a farmer wants to grow an improved maize cultivar because that cultivar will rapidly loose its beneficial properties unless proper maintenance selection is carried out (Parlevliet this issue).

The seeds for sowing appeared of a poor quality (Table 7). However, this quality may have been poorer than at the time of sowing, since these samples were tested some 6–8 months after sowing. Nevertheless the quite consistent low quality measured across the 32 samples indicates that the way the farmers store their seed for sowing is far from optimal. This low seed quality is just one of several important limiting factors in maize production and should be approached simultaneously as discussed at the end of this chapter.

The usual seed rate is about 50 kg/ha. For maize grown in combination with beans, on average just over 40 kg/ha of seed is sown. This means that the yearly demand to plant the total area of maize in this region, about 30,000 ha, is some 1,300–1,400 tons. Of this only a very small proportion, a few per cent, consists of improved material produced by INIAP or Bolívar University. In order to increase the availability of quality seed at a lower price than that of the certified seed from INIAP, INIAP-Bolívar and Bolívar University produced seed of 'INIAP-111' on 5 ha, spread over six farms. This link between the informal and formal sector is called UVTT-C-B (unity of validation, transference of technology and capacity in Bolívar). Still, this does not meet the demand. A main problem is that the formal sector too often is unaware of the actual demand of maize seed and that, especially in the sowing period (time of the highest demand), the availability of quality seed is too low.

Based on the yield data obtained from 121 of the 212 farmers interviewed, the price farmers get for their maize and the proportion of the crop they could sell (their surpluses) the financial revenue per ha would be in de order of 170 US$. This leaves little room for investments such as high-quality seed, fertilizers and pesticides.

Many farmers, about 55%, appeared willing to buy restricted amounts of good seed of a new cultivar to observe it at a small plot of their field provided the costs are not too high (not more than US$ 0.40/kg). The costs of certified seed of cultivars from formal breeding programmes (INIAP, Bolívar University) are too high, well over 1 US$ per kg. This might partially explain the relatively small acreage planted with INIAP cultivars. However, the costs of that seed could be reduced considerably if the improved cultivars are multiplied under supervision in the region at a few selected farms, which in fact is already done to a very limited extent. According to several technicians, the costs of such seed could be about US$ 0.60 per kg (Table 6). The gap in price between the costs of good seed and what the farmer can pay can be bridged provided the informal system is adapted.

The situation described here for the Andean region of Bolívar is very similar to the one shortly described by Chavez (2003) for the province of

Table 7 Quality aspects of 32 maize seed samples from four districts in Bolívar and the standard requirements for certified seed set by INIAP

Quality aspect	Chillanes $N = 2$	Chimbo $N = 9$	Guaranda $N = 16$	San Miguel $N = 5$	Weighted average	Standard INIAP
Purity (%)	99.9	99.0	98.5	99.1	98.8	100.0
Moisture content (%)	13.5	13.6	12.7	13.3	13.3	13.0
Germination (%)	97.8	90.2	91.3	93.3	91.8	98.0
Vigorous seedlings (%)	34.5	44.7	44.1	42.6	43.4	92.0
Seeds without fungal infestation (%)	31.3	23.9	11.6	31.0	19.7	98.0

Chota in Peru (see introduction). Basically the maize grown in these areas and probably in many areas of the Andean region is grown from seed maintained from the last crop, either the farmers' own crop or that of a neighbour. The seed used for sowing comes predominantly from the larger ears and is usually selected for kernel type. Plant selection does not seem to play a significant role. The selection for large ears is indirectly a selection for late maturity as Chavez (2003) rightly noticed and indeed local cultivars are usually late maturing. There are indications that farmers do not really want this late maturity. This informal seed system is probably as old as the crop and resulted in so called landraces or local cultivars (Parlevliet 2003). Introduction of new, more productive cultivars without adapting this informal system will result in a rapid decline of the new cultivars to the level of the existing local cultivars due to cross contamination and incidental mixing or interchanging. Maintenance of the improved cultivars and the production of good quality seed is better feasible when the informal system is adapted to prevent or reduce the declining factors (Parlevliet 2003). One such an adaptation could be the production of the seed for sowing at a group (community) level (Cordeiro 1993). As maize is a cross-pollinator contamination by other maize material grown in the neighbourhood is difficult to avoid especially if the maize is grown in many small plots. Contamination decreases when the plot size increases. When the seed for sowing for the whole group of farmers is produced on a separate field, of which the border rows are not used as they will be cross contaminated most, the cross contamination can be reduced strongly, while at the same time the maintenance selection becomes considerably easier. Another advantage of this group activity is that it may bridge the gap between the formal and the informal seed sector. A few groups could increase the certified seed of the improved cultivar under the supervision of the breeder. The seed could be produced at a reasonable price to other groups in the surroundings, who can multiply it further with some supervision of the breeder. Together with the production of the seed of this improved cultivar the surrounding farmers may acquire some knowledge about how to maintain and even improve the material (kernel quality for instance) through the maintenance selection (Parlevliet 2003, this issue). The initiative of INIAP-Bolívar and Bolívar University, mentioned above, could be a first step in this direction.

The productivity of their maize crop (and of other crops) will be improved most if a range of factors affecting the productivity is improved, by preference simultaneously. Using the right cultivar, applying proper maintenance selection, improved storage conditions of the seed, improved land preparation, including some fertilizers and improved weeding would increase the productivity and quality of the crop considerably.

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