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Seed quality recommendations

Joost van Der Burg, Silvio Pino, Hans-Jakob Schärer, Estelle Serpolay, Veronique Chable

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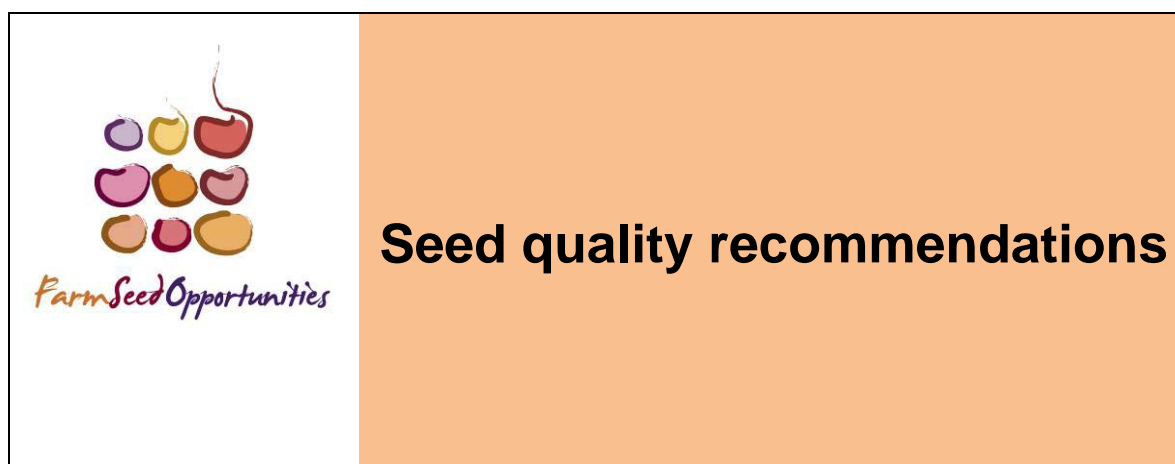
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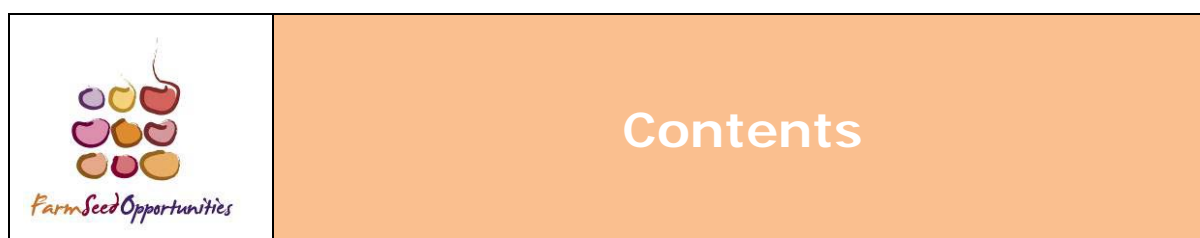




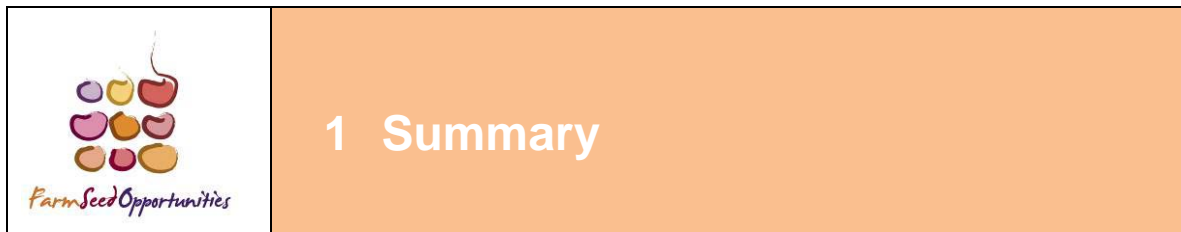
WP3 Leader: Joost van der Burg, PRI

Partners: FiBL, INRA, PRI, IGSA

Authors: Joost van der Burg, Silvio Pino, Hans-Jakob Schärer, Estelle Serpolay, Véronique Chable



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This document describes the results of interviews with farmer-seed producers and seed testing experiments in relation to farmer seed production. The most important seed quality parameters are highlighted and discussed, conclusions are drawn, and recommendations are given for 1. how to achieve quality of seed at farm level and 2. how to be able to comply with the current and forthcoming EU seed regulations. These regulations comprise regulations for ‘conventional seeds’ as well as for ‘conservation varieties’ and varieties of vegetables ‘developed for growing under particular situations’ (Commission Directive 2009/145/EC of 26 November 2009, i.e. amateur varieties).

It can be concluded that farmers in general can produce seed of reasonable to good quality fit for sowing, certainly for wheat, maize and spinach. Due to the nature of beans, which are notorious for their vulnerability to diseases, good seed can only be produced if farmers specialise on disease detection and use agronomic approaches to minimize the impact on quality.

It is recommended to maintain the same standards for conservation varieties and farmers’ own seeds (by whatever definition or using whatever production method) regarding purity, germination, presence of other seed, and seed health as for conventional seeds. In years when a shortage of a particular variety is at risk, the national seed authorities should be able to derogate and allow lower qualities if no seed of that variety is (anymore) available that meets the standard.



2 Introduction

The present document describes the first deliverable of Work Package 3 ‘Improving seed production and marketing’ of the FarmSeedOpportunities (FSO) project. The activities ran from January 2007 to February 2010. This is a little over half a year behind the agreed deadline (M30, *viz.* June 2009), but it allowed seed testing of the seeds harvested during summer and late summer 2009, as well as some additional testing of farmer’s bean samples in early 2010. These last tests were done to see if the seeds that are exchanged between farmers are indeed of better quality than the seeds produced during the trials (see discussion).

Seed quality in the framework of this document comprises the physical and physiological quality of seeds. Genetic quality, *viz.* aspects of varietal identity, purity, stability, etc are being dealt with in Work Packages 1 and 2.

The seeds for testing were obtained directly from farmers’ production or from the FSO project trials. In the first case, the data obtained concerned a snapshot. In the last case, the quality development of this material could be observed over three seasons. However, this latter category of seeds, which comprise the vast majority of the samples, was produced in the framework of the tests of WP2, which aimed at assessing the adaptation process of varieties when they are moved from one environment. This means that these seeds were not always produced in the same way as farmers would do when they would produce seed for themselves or for exchange with colleagues. In some cases there was not enough time to process the seeds and more or less raw material was provided to be tested. In other cases, varieties were not adapted to the climatic conditions of their new environment, which led to strong maturity discrepancy or disease problems. This in part explains the somewhat high incidence of disease and presence of weed seeds that could be observed.

Two crops were well-represented in the trials: wheat and maize, but seeds of beans and spinach were less available. Generally, the work was seriously hampered by the lack of seeds. Especially in the first year, no seeds of bean and spinach were available from the trials, meaning that the starting quality of the samples could not be established. The non-availability was largely due to the fact that the starting material originated from seed stores of farmers, participating institutes and gene banks, so not from commercial suppliers, and all seed material was needed for the sowing of the trial fields at the various locations and to be kept in stock for comparison in the WP2 trials of the last year.

Sufficient material was available for wheat and maize. In the case of wheat this resulted in data from three harvests for purity, germination and seed health. In maize extensive data on seed health (fungal pathogens) were obtained from the harvest of year 2, the funds not allowing testing it more frequently for this aspect. In beans extensive tests were carried out on germination and viral and bacterial diseases, but the sample size was small in many cases, resulting in less reliable results. For spinach we only have results of the material of the trial fields for germination and seed health for the harvest of year two.





3 Important seed quality parameters

The most important quality characteristics/parameters for seed quality are: analytical purity (hereafter referred to as ‘purity’ or ‘mechanical purity’), the content of foreign seeds (‘other seed by number’), percentage normal seedlings (‘germination’ or ‘germination capacity’), and the absence of pathogens (‘seed health’). Furthermore the moisture content is important for maintaining the quality during storage. The aspects of speed of germination (‘germination energy’) and vigour are further elements of quality that will not be discussed here because they are less relevant and are not subject to regulation.

Purity

Mechanical purity is the composition by weight of the sample being tested and by inference the composition of the seed lot (ISTA 2009)^[2]. The identity of the various species of seed and inert particles is determined.

Seed purity is subject to regulations because it determines, together with germination capacity, the field planting value. The test consists of separating all foreign material, not being seeds of the crop in question, and determining its identity. This is then separated into two fractions: other seeds, consisting of seed of other crops and/or weeds; and inert mater, containing all material not being seeds and pieces of seed smaller than half their original size. The other seeds fraction may be subsequently separated into ‘other crop seeds’ and ‘weed seeds’ upon request of the owner of the lot. The definition of ‘weed’ differs between countries however.

The results are expressed as weight percentage and therefore give only a general impression of the weed content.

Germination

The object of the germination test is to determine the maximum germination potential of a seed lot, which can then be used to compare the quality of different lots and also to estimate the field planting value (ISTA 2009)^[2].

The germination test is the best estimator for seedling establishment: lots with a higher germination capacity normally perform better than ones with a lower value. The test is based on laboratory germination using optimum condition for germination, to generate the maximum possible number of ‘normal seedlings’. Normal seedlings are seedlings showing no or only minor defects, as defined by ISTA (2009)^[2]. They show the potential for continued development into satisfactory plants when grown in good quality soil and under favourable conditions of moisture, temperature and light.

Seed health

The object of the seed health test is to determine the health status of a seed sample, and by inference that of the seed lot (ISTA 2009)^[2]. This is done by estimating the presence of inoculum of seed-borne pathogens.

These pathogens may or may not give rise to disease development in the field, very much depending on the genetic background of the seed (tolerance or resistance), the environmental conditions during crop establishment and growth, and the crop management used.

Disease management is an important aspect of low-input and organic agriculture, since in most cases conventional crop protectants will not be used. This makes it extra important to use seeds with as few as possible contaminants. The test results may indicate the necessity to take extra measures, such as specific seed treatments like the hot water treatment to remove or neutralise the inoculums. In addition to careful seed management, different agronomic practices have proved useful in organic agriculture. While pesticides are used in most conventional crops, plant population diversity and innovating cultural practices may enhance the soil biodiversity and the plant health for organic crops.

Moisture content

The object of the moisture test is to determine the moisture content of seeds by determining the loss in weight during a certain drying period in a heated oven, expressed as a percentage of the weight of the original sample (ISTA 2009)^[2].

Sufficiently low moisture content (MC) is essential for maintaining the seed quality after harvest, allowing processing without damage and storage and packaging without decline in germination capacity between harvest and sowing in the next season.





Seed testing methods are internationally formulated by the International Seed Testing Association, ISTA, in the so-called ISTA Rules^[2]. Based on this, a Working Document has been prepared to describe the general requirements and procedures, while at the same time referring to the ISTA Rules^[2]. This document was the basis for our analyses.



FSO Working Document 2

Protocol for testing seeds in the framework of EU FarmSeedOpportunities

Introduction

Samples are to be representative of the seed lot (use FSO Working Document 1 Sampling); testing has to be done according international standard methods. These methods are described in the International Rules for Seed Testing (ISTA Rules)^[1] and we follow these as much as possible. It is strongly advised to ask an accredited ISTA laboratory to investigate the seeds. In case partners have their own experience in seed testing, the following may serve as guidance.

Procedure

PURITY TEST and COUNT OF OTHER SPECIES TEST

Tests are carried out on standardised sample weights (table). This means that for all species except spinach (250 g), samples for seed testing ('submitted samples') should weight at least 1 kg (ISTA Rules, Chapter 2).

In the Purity analysis the samples are split into: Pure Seed, Inert Matter, and Other Seeds. (ISTA Rules, Chapter 3). The nature of the inert matter and the scientific name of all other seeds have to be reported. The three components are weighed and percentages by weight are calculated.

In the Count of other species test (Number count test) all other seeds are named and counted (ISTA Rules, Chapter 4)

Sample sizes (g)	Submitted sample	Purity analysis	Count of other species
<i>Phaseolus vulgaris</i>	1000	700	1000
<i>Spinacia oleracea</i>	250	25	250
<i>Triticum aestivum</i> & <i>T.durum</i>	1000	120	1000
<i>Triticum dicoccum</i> & <i>T.spelta</i>	1000	270	1000
<i>Zea mays</i>	1000	900	1000

GERMINATION TEST

Tests are carried out with standardised methods using 400 Pure Seeds (from the Purity Test) in replicates of 50 or 100 seeds each. At first count all Normal Seedlings (ISTA Rules, Chapter 5) are removed; at second count all further Normal Seedlings are removed and the remaining seedlings classified as: Abnormal Seedlings, Fresh Ungerminated Seed, Hard seed (only *Phaseolus*), Dead Seed.

Germination methods	Substrate	Temperature °C	1 st count	Final count	Breaking dormancy
<i>Phaseolus vulgaris</i>	BP, S	20-30; 25; 20	5	9	-
<i>Spinacia oleracea</i>	TP; BP	15; 10	7	21	Prechill
<i>Triticum aestivum</i> & <i>T.durum</i>	TP; BP; S	20	4	8	Preheat (30-35 °C); prechill; GA ₃
<i>Triticum dicoccum</i> & <i>T.spelta</i>	BP; S	20	4	8	Preheat (30-35 °C); prechill; GA ₃
<i>Zea mays</i>	BP; S	20-30; 25; 20	4	7	-

MOISTURE TEST

Tests are carried out on moisture-proof packed seeds, like in tightly closed plastic bags of a solid type of plastic or in completely filled-up bottles. Preferably the seeds need to be tested directly after harvest, but if well moisture-proof, then it can also be done a few days later.

Tests are typically carried out by the Air Oven Method, but can also be performed with certain rapid moisture meters (ISTA Rules, Chapter 9). The seeds are briefly mixed and two replicates of 5 g each are taken, weighed, dried and weighed again. Any loss or attracting of moisture between the separate handlings must be avoided.

All species except spinach need to be ground with a special mill before drying.

Moisture methods	Grinding	Drying temperature °C	Drying time h
<i>Phaseolus vulgaris</i>	Coarse	130	1
<i>Spinacia oleracea</i>	-	130	1
<i>Triticum aestivum</i> & <i>T.durum</i>	Fine	130	1
<i>Triticum dicoccum</i> & <i>T.spelta</i>	Fine	130	1
<i>Zea mays</i>	Fine	130	1

SEED HEALTH TEST

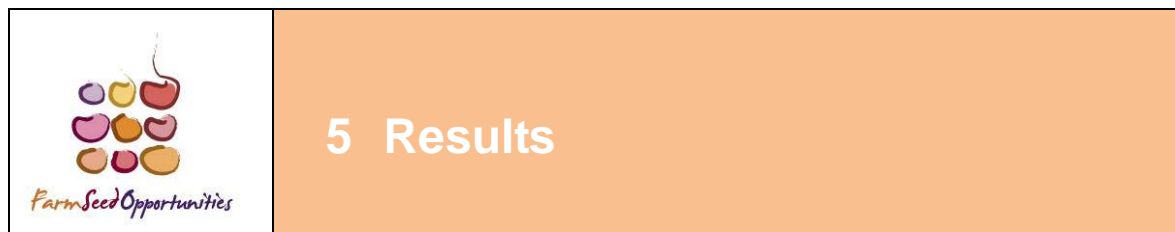
These test are so specialised, that they can only performed by seed pathologists. (ISTA Rules, Chapter 7 and Annexe to Chapter 7) ^{[1] & [2]}.

References

^[1] ISTA 2007. International Rules for Seed Testing. International Seed Testing Association. Bassersdorf, Switzerland.

^[2] ISTA 2007. Annexe to Chapter 7: Seed Health Testing Methods. ISTA, Bassersdorf, Switzerland.





5 Results

Results have been obtained for the four species of the project: wheat, maize, beans, and spinach. For wheat results are available for harvest 2007, 2008 and 2009, for maize only the harvest of 2007 was investigated due to the high costs of testing by GEVES, for beans we have results of 2007 and 2009 and for spinach we have results of 2008.

The seed production of spinach and beans under WP2 was problematic due to a number of reasons (climate, lack of local experience, large isolation distance required) and did not produce enough seed for all standard quality tests. Most of these reasons also apply to bean: the starting material originated in part from genebanks and in part of farmer's samples. Several of these proved infected with CBMV and several other pathogens from the start. Moreover, some of the farmers who participated in the trials accepted to observe the adaptation of the plants for all the characters, in particular the disease susceptibility. This resulted in below minimum performance in some cases. This has especially been true for beans in which several farmers recognised the presence of diseased plants but left them in the field in order to observe the evolution of the next generation.

Despite these drawbacks, the test results reveal interesting results which are presented below.

Purity

Wheat

The purity of wheat samples of 2007, 2008 and 2009 harvests have been investigated and the results are in general fair. 23 out of the 102 investigated are below standard. A remarkable improvement occurred in 2008 (samples 37 onwards), when only 5 samples were below standard; the same is true for 2009. An explanation could be that 2007 was a dramatic season with a lot of rain during harvesting time, especially in Western France, causing lodging which normally results in higher incidences of soil particles, fungi and weed seeds. It was also the first year of 'adaptation' for a number of these varieties to the new conditions.

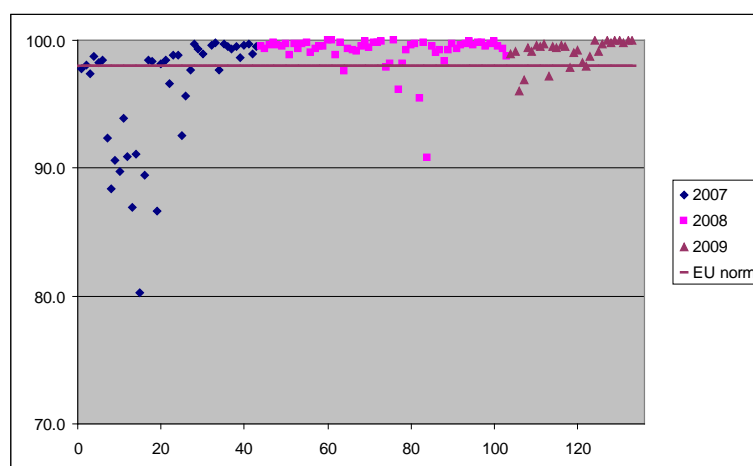


Figure 1. Purity percentages of all wheat samples tested. The line indicates the EU minimum standard of 98%.

On average the purity is 86.0% in 2007, and 99.1% both in 2008 and 2009. With 0.1% other crop seeds and 0.2% weed seeds as contaminants.

The most frequently found species are given in Table 1. It presents the number of samples in which the weed has been found (n=133). It has to be noted that the figures are higher than one would normally expect: the reason being that these samples were taken from the farmers in the framework of the experiments, and not as exchange seed between farmers. For the latter case the farmers usually take greater care in order not to spread weeds to their fellow farmers.

Table 1. Weed presence in wheat samples tested.

<i>Polygonum</i>	28
<i>Vicia</i>	24
<i>Galium</i>	21
<i>Atriplex</i>	9
<i>Sinapis</i>	8
<i>Avena fatua</i>	6
<i>Chenopodium</i>	4
<i>Echium</i>	4
<i>Papaver</i>	4
<i>Taraxacum</i>	4
<i>Veronica</i>	4

Inert matter was 1.6% on average. 87 Samples (65%) contained chaff, 74 (56%) contained broken seeds, and 36 (27%) contained sand. This lowered the purity in several cases considerably (to below 95% and as low as 80%). This sand, as mentioned before, is normally due to lodging of the crop under rainy conditions and occurred especially in year 2007 when conditions were quite unfavourable.

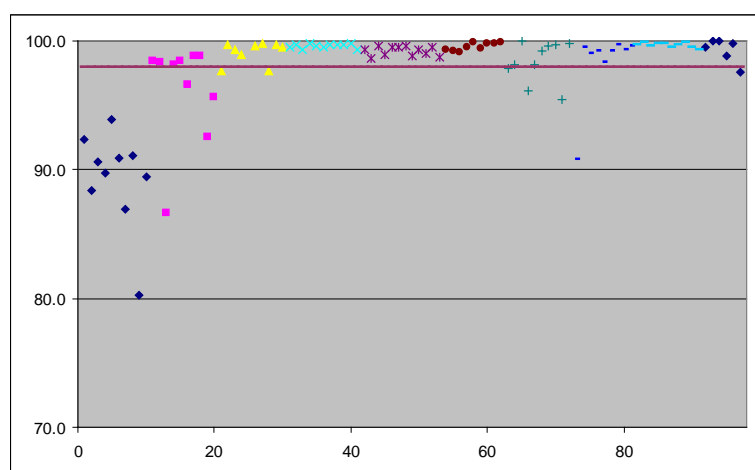


Figure 2. Purity percentages of wheat arranged by farmer. Different symbols represent different farmers. The line indicates the EU minimum standard of 98%.

As shown in Figure 2 the quality of production is quite different between individual farmers. Three farmers performing below minimal performance while 7 others demonstrate that

meeting purity standards does not pose any problem to farmers who apply the basic principles for seed production.

Maize

Analytical purity is usually no issue for maize, since all lots are normally 100% pure. Therefore it was decided not to determine purity in maize.

Beans

Analytical purity is usually no issue for beans, since all lots are normally 100% pure. Therefore it was decided not to determine purity in beans.

Spinach

The samples which we received were not cleaned or processed in any way, so the seeds were hand-picked from the uncleaned sample and tested for germination and diseases only.

Germination

Wheat

Clearly germination poses a greater problem. Many samples, 41%, are below EU standards. In practice, commercial wheat seed seldom comes below 90%. Using that criterion, 62% of the seed lots were below standard and would have been rejected for sowing seed. During discussions of the relatively meagre results, the farmers stressed that they had not considered the harvested material as seed for sowing. At least it was not handled and treated in the same way as seed that they would exchange between themselves. This certainly explains in part why so many lots are below standard. However, many lots are of acceptable quality, and also all farmers were able to produce at least some lots of good quality (figure 4), so that the conclusion may be that the present standard of 90% can be met without great difficulty (75% of the cases, Table 2) and shall also be maintained for conservation varieties and the like.

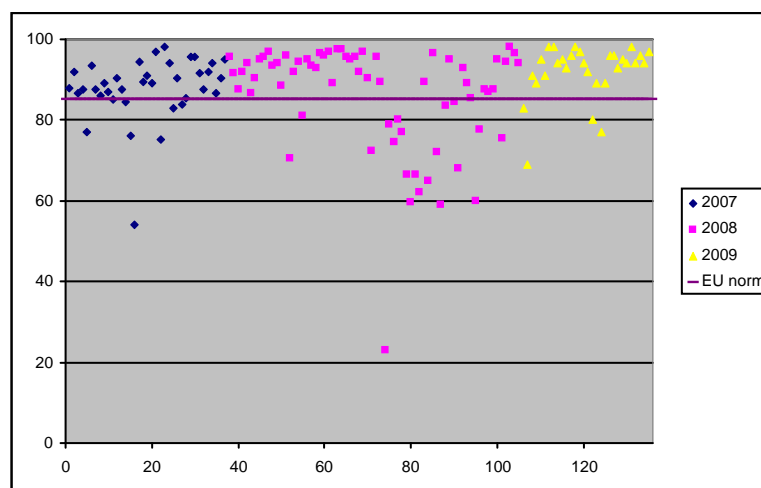


Figure 3. Germination percentages of wheat. The line indicates the EU minimum standard of 85%.

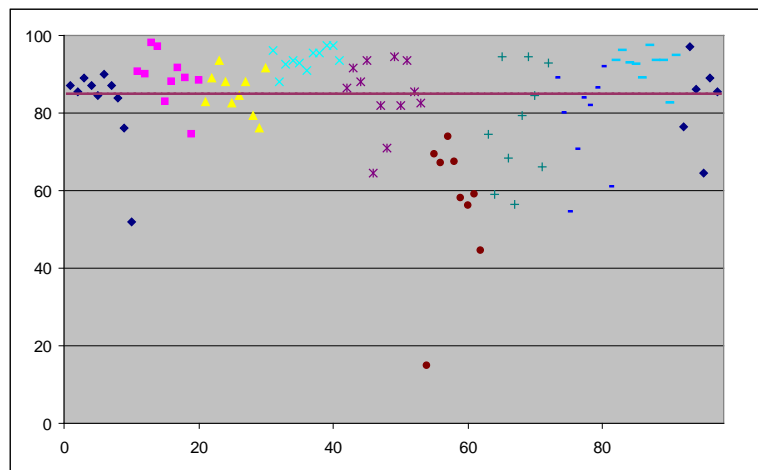


Figure 4. Germination percentages of wheat arranged by farmer. Different symbols represent different farmers. The line indicates the EU minimum standard of 85%.

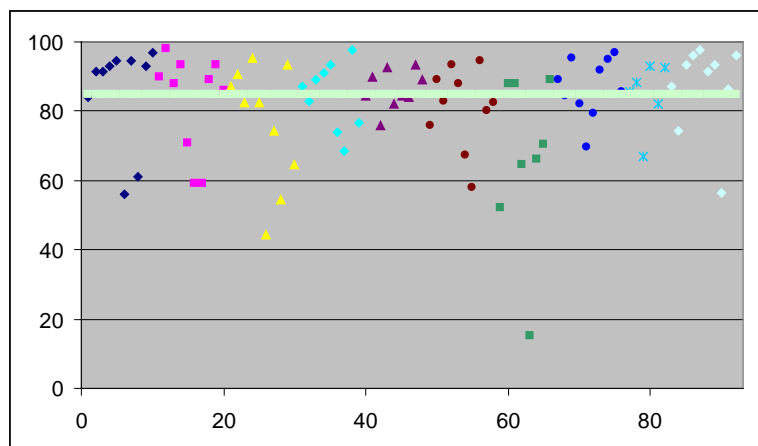


Figure 5. Germination results of wheat, arranged by variety. Different symbols represent different varieties.

Although 2 varieties show a higher than average number of seed lots above the EU standard, there seems to be no big difference between varieties in ease of production. All could produce lots above the minimum standard.

Table 2. Percentages of samples meeting a certain standard: consequences of lowering the standard (85% is the EU minimum standard).

standard	percentage of samples
≥ 90	55
≥ 85	75
≥ 80	81
≥ 70	88

Maize

In 2008 the lab of GEVES, Angers, was asked to investigate the germination capacity of the maize harvest in that year. The results are presented in Figure 6. It shows that producing seed with sufficient germination has not always succeeded. However, the lots that farmers produced for themselves or for exchange were all above the minimum standard of 90%, indicating that the samples from the trials are not representative for the normal quality of seed lots exchanged between farmers.

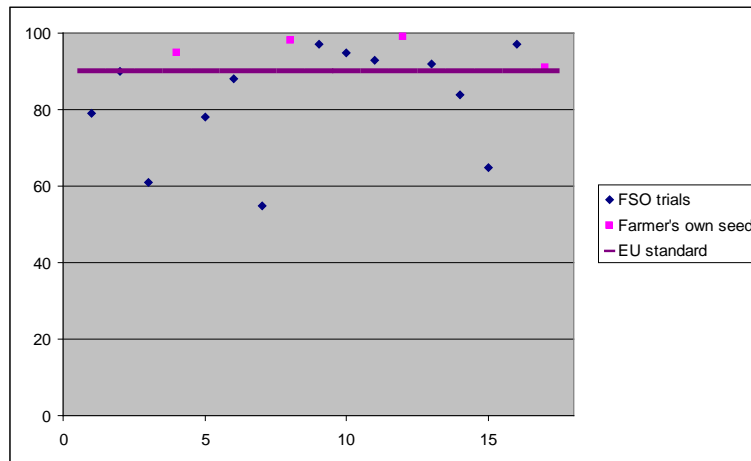


Figure 6. Germination results of maize seed harvest 2008. The line indicates the EU minimum standard of 90%.

Beans

Germination in beans proved more variable (Figure 7). In 2007 only 14 out of 36 lots were above the EU minimum standard of 75%.

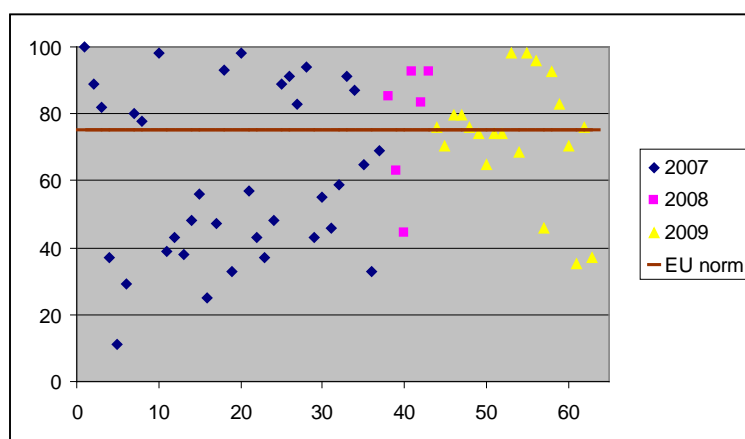


Figure 7. Germination results of beans arranged by production year.

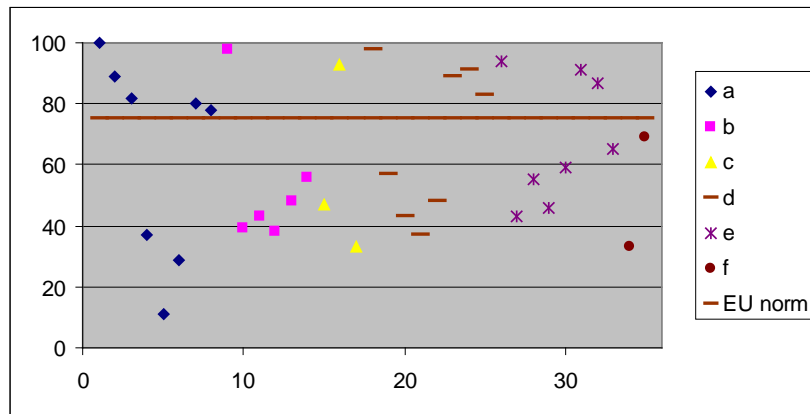


Figure 8. Germination results of beans of harvest 2007, arranged by farmer (a-f). Different symbols represent different farmers.

Figure 8 shows that almost all farmers are able to produce good seed lots. There seemed to be a dependence on variety. In one variety, ‘Coco du Cheylard’, all 4 lots were up to standard. In ‘Walcherse Witte’ (extreme right) 2 out of 3 lots tested were above minimum standard. This indicates that the quality of the seeds provided to the farmers varied and that some of the inferior results are due to the bad starting material (see below).

Here we have to make some observations. Producing well-germinating bean seeds is more difficult than for most other vegetable species. This is due to the nature of the seed, having high oil and protein content, their size, their vulnerability, their natural enemies, etc. So therefore the EU norm was put at 75% in order not to have shortages of seed. This is also the reason why many (amateur) farmers normally plant 3 or 4 seeds in one hole, to compensate for non-germinating seeds.

Spinach

Although spinach seed production is problematic in terms of land requirement and organisation, seed quality does not seem to pose any problem (Figure 9). All but 2 lots are high above the EU minimum standard of 75% germination. It must be remarked that this observation is based on a low number of samples grown by a few farmers only. These were farmers that have shown interest in the crop and who wished to join the experiment.

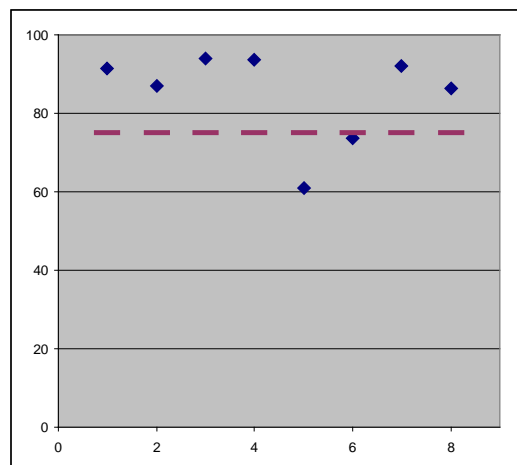


Figure 9. Germination results of spinach of harvest 2008. Each dot represents a different lot and variety. Dashed line represents the EU minimum standard of 75% germination.

Seed health

Results are available for wheat, maize and bean seeds. Tests on *Fusarium* in wheat were performed in all three seasons. In maize extensive analysis of all seed-borne fungi was done on the harvest of 2008. In beans the most important seed-borne viruses and bacteria were investigated on harvests 2008 and 2009.

Wheat

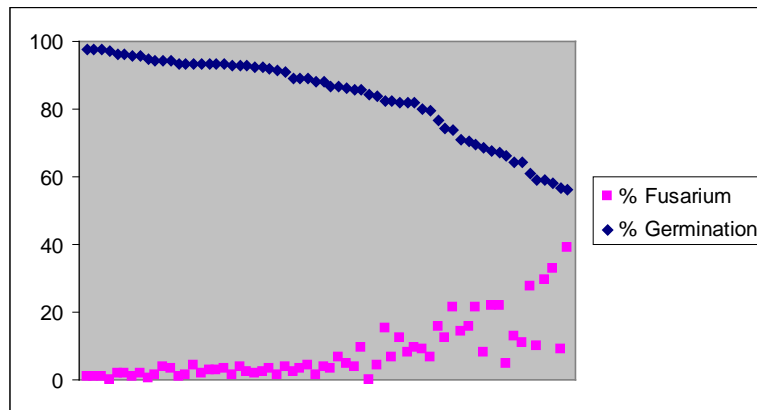


Figure 10. Contamination with *Fusarium* spp. All lots, arranged by germination percentage.

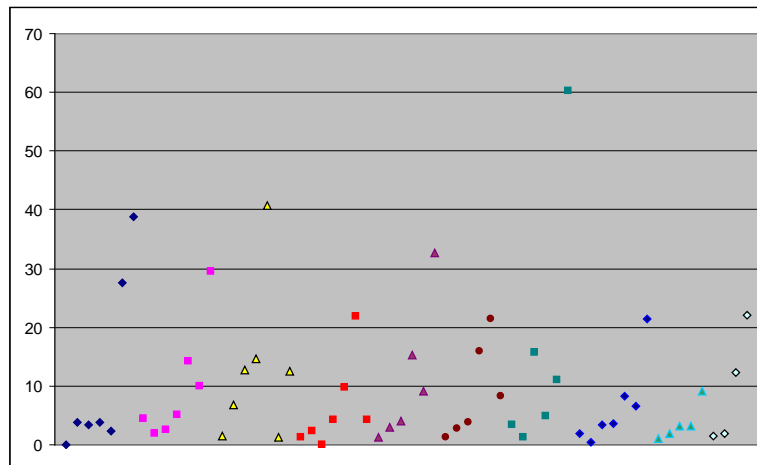


Figure 11. Contamination of wheat seeds with *Fusarium* spp. All lots, arranged by variety. Each different symbol represents a different variety.

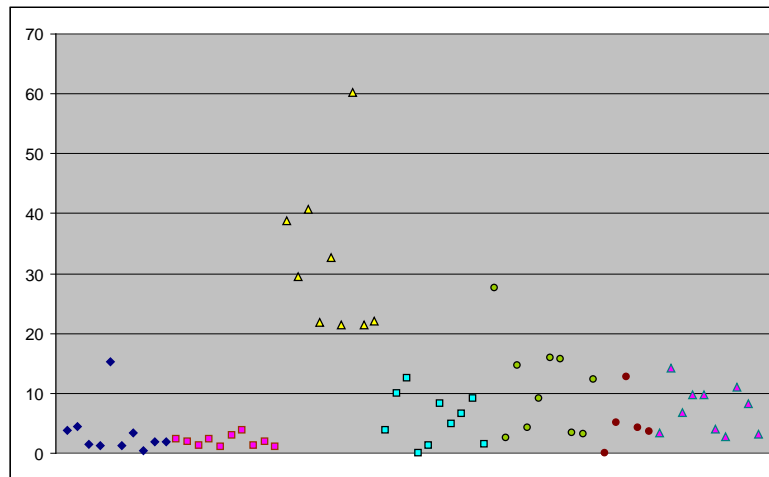


Figure 12. Contamination of wheat seeds with *Fusarium* spp. All lots, arranged by farmer. Each different symbol represents a different farmer.

The presence of *Fusarium* is problematic because of toxic effects on consumers of the seeds and their products due to their mycotoxins. It is important that farmers are aware of this problem, especially when they are also using the grain for producing flour and bread which they sell directly to consumers.



Figure 13. Wheat kernels, healthy (left) and infected with *Fusarium* sp., possibly *F. roseum* on the right.

Copyright <http://scarab.msu.montana.edu/Disease/DiseaseGuidehtml/webFunghead.htm>

Grain kernels affected with *Fusarium* are shrivelled, often slightly pinkish, much lighter and produce weak seedlings, if ever. They can largely be removed from the seed lot mechanically by screening and airlifting. This can for instance be done with a hand-operated or motor-driven winnower.

Maize

The seed testing station of GEVES in Angers tested the maize seed of the FSO trials of harvest 2008 for the presence of all kinds of fungi. All results are summarised in Table 3.

Fusarium species are amongst the most important fungal diseases of maize. *F. roseum* is known to affect germination of seeds and seedling development, as is confirmed in Figure 14. *F. moniliforme* on the other hand, affects the plants in a later stage and clearly does not correlate negatively with germination.

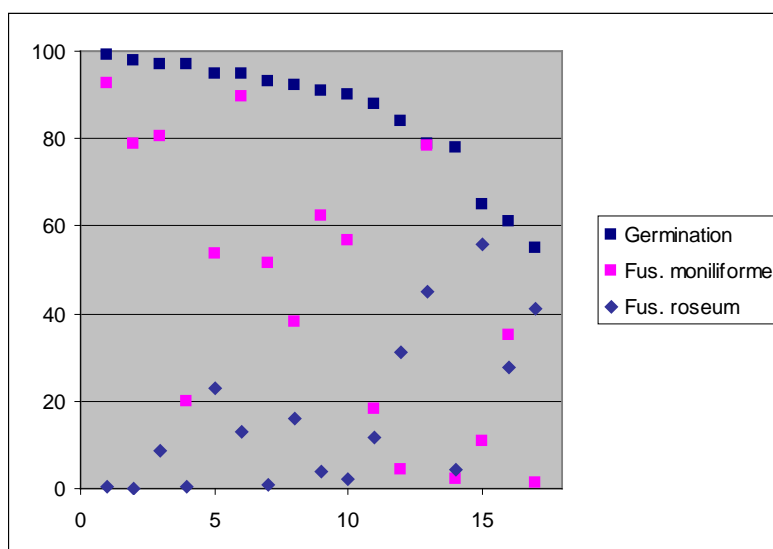


Figure 14. Seed health results for maize. *Fusarium moniliforme* and *F. roseum* contamination, arranged by germination percentage.

Table 3. Presence of fungal pathogens on maize seeds. Yellow shading indicates seed produced for further production (true ‘Farmer’s seed’).

	Germination (%)	<i>Botrytis sp.</i>		<i>Fusarium moniliforme</i>		<i>Fusarium roseum</i>		<i>Fusarium sp.</i>		<i>Helminthosporium carbonum</i>		<i>Nigrospora sp.</i>	
		N	T	N	T	N	T	N	T	N	T	N	T
Amalia	79	0	1	79	4	45	50	1	3	3	2	6	15
Amarillo	90	2	0.5	57	19	2	2	0	1	1	0	3	7
Atlas	61	8	6.5	35	2	28	20	10	10	0	0	9	11
Bangold	95			54	1	23	21	0	0	0	0		
BDA	78	2	1	2	1	5	5	1	1	0	0	56	33
Beha Nafaroa	88	11	1.5	18	6	12	20	2	1	0	0	19	13
Bénastone	55			2	5	41	28	1	1	0	0	18	10
Biancoperla De Tacchi	98			79	21	0	1	0	0	0	0	1	0
Biancoperla Feltre	97			81	19	9	10	5	2	0	0	1	4
Blanc de Monein	95	3.5	0	90	9	13	13	0	0	0	0	2	6
GRB	93	0.5	0.5	52	7	1	9	1	2	0	0	5	14
Marano	99	0.5	0	93	12	1	0	1	0	0	0	2	0
Nabaté	92	5.5	0	38	9	16	13	6	1	1	0	1	8
Poromb	84			5	4	31	36	1	2	0	0	5	17
Portugais	65	0.5	0	11	2	56	45	11	5	2	1	6	3
Sponcio Feltre	97			20	8	1	1	0	0	0	0		

N= Normal, untreated seed; T= treated with 1% Sodium Hypochlorite for 10 minutes.

Empty cells indicate not investigated. Yellow lines indicate that these represent farmer’s own seed production (not from FSO trials)

The presence of *Fusarium*, but especially of *Nigrospora* is problematic because of toxic effects on consumers of the seeds and their products due to their mycotoxins. It is important



that farmers are aware of this problem, especially when they are also using the grain for producing bread which they sell directly to consumers.



It is important to recognise these diseases in the field and on the harvested product. Therefore we include some illustrations.

Figure 15. *Nigrospora oryzae* on maize cobs

Picture © 2003-2009 Project «Interactive Agricultural Ecological Atlas of Russia and Neighboring Countries. Economic Plants and their Diseases, Pests and Weeds»

http://www.agroatlas.ru/en/content/diseases/Zae/Zae_Nigrospora_oryzae/

Figure 16. Harvested maize kernels showing variable incidence and severity of silk cut and colonization by *Fusarium moniliforme*.

Photograph courtesy G. N. Odvody, et. al.
from Plant Disease, Volume 81, Number 5.

www.apsnet.org/online/archive/silkcut.jpg



Beans

Variété	Provenance	BCMNV	BCMV	Xanth	Pseudo
Coco du Cheylard	CV	+	+	+	-
Haricot Cerise	CV	-	-	+	-
Flageolet Chevrier	CV	-	-	-	-
Gialet	CV	-	+	+	-
Princesse de Chambord	CV	+	-	+	-
Rouge Suisse	CV	+	-	-	-
Scalda	CV	+	-	+	-
Waldbeantsje	CV	-	-	-	-
Coco du Cheylard	GB	-	+	-	-
Haricot Cerise	GB	-	-	-	+
Gialet	GB	-	-	-	+
Princesse de Chambord	GB	+	-	-	+
Rouge Suisse	GB	+	-	+	-
Scalda	GB	-	-	-	+
Flageolet Chevrier	JJM	+	+	-	+
Flageolet Chevrier	JLB	-	-	-	+
Gialet	JLB	-	+	-	-
Princesse de Chambord	JLB	+	-	-	+
Coco du Cheylard	JM	+	+	-	-
Flageolet Chevrier	JM	-	-	-	-
Gialet	JM	-	+	-	-
Princesse de Chambord	JM	+	-	+	-
Rouge Suisse	JM	-	-	-	-
Scalda	JM	+	-	-	-
Waldbeantsje	JM	+	-	+	-
Walcherse Witte	JM	+	+	-	-
Coco du Cheylard	SS	-	-	-	-
Flageolet Chevrier	SS	-	+	+	+
Gialet	SS	-	+	-	-
Princesse de Chambord	SS	+	-	+	-
Rouge Suisse	SS	+	-	-	-
Scalda	SS	+	-	-	-
Waldbeantsje	SS	+	-	-	+
Walcherse Witte	SS	-	-	-	-
Waldbeantsje	X	-	-	nt	nt
Walcherse Witte	X	-	-	nt	nt

Table 4. Seed health test results for beans harvest 2007. BCMNV stands for Bean Common Mosaic Necrosis Virus; BCMV for Bean Common Mosaic Virus; Xant for Xanthomonas spp; and Pseudo for Pseudomonas spp.

The present results have been obtained from the trials and it must be acknowledged that many farmers are actually specialised in wheat growing, not in bean seed production. Moreover, the initial material given to these farmers apparently contained diseases already, making it almost impossible to produce good seeds. Surprisingly, and maybe due to selection by the farmers, the crops in years 2 and 3 looked much healthier. This is in part corroborated by the virus and bacteria analyses of later years. Finally, the analyses were based on too small amounts of seeds. Very often only 50 seeds or even less were available for germination tests, while 400 seeds are considered the minimum. The same applies to the virus and bacteria tests.

In the last year we tested four samples from a professional organic seed producer, and all seeds proved free from BCMNV and BCMV viruses. Nevertheless one sample germinated below standard, 46%, while the others all germinated above 80% and in one instance even way above 90%. In another set of samples one of two samples obtained from seeds produced in a controlled multiplication in another project aimed at improving quality of "farm seed", respectively of "old varieties", contained BCMV.

This demonstrates the difficulties encountered in bean production. Farmers are aware of this, and some specialise in bean production, while others stay away from it. Beans are recognised as a species that requires special skills and attention^[1].

Spinach

lot	% Fusarium	% Phoma	% Botrytis	% Colletotrichum
114	1.5	0	0	0
115	1	0	0	0
116	0	0	0	0
117	3	0	0	0
118	5.5	0	0	8
119	7	0	0	0.5
120	0.5	0	0	0
121	0.5	0	0	0

Table 5. Seed health test results for spinach.

From the few samples that we were able to obtain, it follows that the seed health status is quite acceptable.

Moisture content

This parameter was not tested because most seed lots were treated in the same way by the participating institutes, and did not represent the situation in practice. Moreover, the samples that originated from farmers own production, could not be tested immediately, which is a prerequisite, because they were not packed moisture-proof and were dispatched over long periods of time, and hence such tests had no value.

The impression that we have however, is that most samples would easily meet the normal requirements used for conventional seeds.





Council Directives 66/402 and 2002/55 describe the quality standards that have to be applied within the EU for cereals and vegetables respectively. The most essential elements are mechanical purity and germination capacity. Next to this, norms have been formulated for the maximum tolerated content of a number of weeds and other crop seeds, as well as the presence of fungal bodies (sclerotia, ergot).

Certified seed	Minimum purity (%)	Minimum germination (%)
Wheat	98	85
Maize	98	90
Beans	98	75
Spinach	97	75

Furthermore, standards have been formulated for the maximum presence of fungal diseases on cereal seeds. Generally, a maximum of 25% infected seeds is acceptable, of which not more than 10% is heavily infected (inside the kernel), then seed treatment is highly recommended. If either of these margins is surpassed, seed must be compulsorily treated.



7 Conclusions and recommendations

Conclusion 1: Current EU purity standards can normally be met for wheat, maize, beans. For spinach no conclusion can be drawn, because no cleaned seed lots were available.

Recommendation 1: Farmers shall use cleaning equipment whenever possible to remove foreign material and weed seeds

Conclusion 2: Current EU germination standards can generally be met for wheat, maize, spinach; not for beans.

Recommendation 2: New or unexperienced farmers producing bean seeds should follow a training course on disease management for seed production.

Conclusion 3: Seed health (esp. *Fusarium*) is poor.

Recommendation 3: Farmers should pay extra attention to this problem and fungal infections in general. The danger of consumers being exposed to seed-borne mycotoxins needs attention.

Additional Recommendation:

Training: To help farmers who are not experienced in seed producing to improve their practices, special training courses for small seed producers should be organized with special emphasis on recognizing seed-borne diseases in the field and their management, on developing knowledge of processing and best storage practices. A document describing small-scale seed processing and its equipment should be produced and made available.

Examples can be found in France, where ITAB (Institut technique pour l'Agriculture Biologique) has developed and disseminated a technical document on bunt (*Tilletia caries*) on wheat¹ and the RSP published a technical booklet on on-farm breeding and seed production². Seed associations dedicated on on-farm breeding and seed production organize farm days and period of training on methods to prevent seed born disease by cultural practices and organic treatment³.

Organisation for sharing cleaning equipment and knowledge dissemination: This can be possibly achieved by the organisation of dedicated associations⁴ to get common means to clean and prepare seed samples for the farmers' use. These initiatives are currently spreading in Europe. Seed associations and organizations involved in participatory plant breeding such as "Farm seed houses" should be encouraged because they provide support to individual farmers for the management and conservation of diversity on farm, being meeting points where farmers will share specific equipment for seed processing and methods for seed conservation. Another possibility for the farmers is to get some help by handcraft breeders

¹ http://www.itab.asso.fr/downloads/fiches-techniques_cultures/fiche%20Carie%20mini.pdf

² « Variétés paysanne de maïs et tournesol pour une agriculture écologique et autonome », Cahier Technique, Réseau Semences Paysannes, Agrobio Périgord, Bio d'Aquitaine, 2009

³ Episème (2009), bulletin d'été n°9 – Association Triptolème

⁴ Véronique Chable, François Le Lagadec, Nicolas Supiot, René Léa (2009) Participatory research for plant breeding in Brittany, the Western region of France: its actors and organisation. Proceedings of the 1st IFOAM Conference on Plant breeding, Breeding Diversity, August 25-28, 2009 - Santa Fe, New Mexico, USA, 363-370.



and organic seed producers who are often involved in participatory breeding with public research.

Funding aspects: from the context of legislative status of on farm breeding, seed production and dynamic management of on farm cultivated biodiversity has to be supported. These activities would therefore be eligible to public funds for :

- small specific equipments for the seed process and treatments, on farm or collectively
- editing training documents on the sanitary quality of seeds in the framework of the farm from participatory researches.

Complementary discussion on the conclusions and recommendations:

Discussion in relation to Conclusion 2 :

Studies on beans diseases can bring some light on the relation between seed health and crop health. For example, no significant correlation was observed between the percentage of plants with anthracnose symptoms in the field and the percentage on seed infection with *C. lindemuthianum* (anthracnose) in a Brazilian study⁵. Concerning bacterial infection of the bean, i.e. common bacterial blight caused by *Xanthomonas axonopodis* pv. *phaseoli* and its variant *fuscans*, the production of seeds is recommended in arid climates with the use of pathogen-free seeds. However, contamination of seeds still occurs in these seed production areas⁶. The few available data on the inoculum threshold of seedborne bacteria sufficient for epidemic development indicate that these thresholds are dependent on plant-pathogen-environment interactions⁷.

Interview of a French small scale breeder on seed production of beans:

Philippe Catinaud has performed the beans trials in the framework of WP2. He belongs to a small scale breeding company involved, among others, in beans seed production and marketing. He summarized some reflections based on his contribution to the FSO consortium and on his experience of the management of bean seed production according to the French legislative framework :

“ Our organization is followed by the French service of plant protection (“Protection des Végétaux”) and is submitted through an agreement, to the examination of parasites inside seed batches and to the visit of the fields in which the beans are multiplied. We usually have very few problems with the viruses. Exceptionally, on susceptible varieties and under some climatic conditions, we may observe some mosaic type symptoms.

More generally, we are confronted to an endemic disease, the common bacterial blight caused by one kind of *Xanthomonas* bacteria which has become a quarantine parasite for some years, at the European level. It can be noted that some ancient varieties are very susceptible to the bacteria. And in some cases, this susceptibility is also part of their “typical” traits. For example, an expert of the GEVES (Groupe d’Etudes des Variétés et Semences), in charge in France of the registration test for the varieties, declared that the flageolet ‘Rognon du coq’, without the bacterial blight, is not a ‘Rognon du coq’ !

In 2008, our seed company, developed an area to produce beans without bacterial blight. In this area, no beans has been cultivated for 10 years and we will follow several kinds of cares and management practices such as those realised by other seed companies, according to an official protocol (established by the FNAMS in France).

⁵ Vechiato, M. H.; Lasca, C. C.; Kohara, E. Y.; Chiba, S (2001) Bean anthracnose: seed treatment and correlation between disease incidence in plants and seed infection. Arquivos do Instituto Biologico (Sao Paulo) 68 (1):83-87

⁶ Darrasse1 A., Bureau C, Samson R, Morris CE and Jacques MA (2007) Contamination of bean seeds by *Xanthomonas axonopodis* pv. *phaseoli* associated with low bacterial densities in the phyllosphere under field and greenhouse conditions EUROPEAN JOURNAL OF PLANT PATHOLOGY,119 (2): 203-215

⁷ Schaad, N. W. (1988). Inoculum thresholds of seedborne pathogens: Bacteria. Phytopathology, 78, 872–875



To be sure not to introduce the bacteria, we have bought new seed from seed companies which provide sanitary passport for these seed sample used as “base seed”. To check for the absence of bacteria, we asked for a control analysis by an official French laboratory: 3 of 8 samples were positive. From our own samples, the results were also inconsistent with regards to our observations.

Based on our experience, we concluded that it is very difficult to get reliable tests of the disease presence and to produce healthy seed without bacteria, even for seed companies that have taken all the specific means to protect the crop. Hand-craft and industrial seed producers have to live with the bacteria.

Nowadays, to my knowledge, we have no classic means to fight against the bacteria. With several organic seed producers, we are improving the thermotherapy, which allows a complete treatment and which respects the standards of organic agriculture, but may alter the germination rate. Nevertheless, by this way, we are able to diminish the presence of the bacteria even to suppress it when the charge is light.

We wish to underline that, in the past, before the systematic controls, we were used to live with the bacteria. During many years, even under a hard bacteria incidence, we used to select the healthiest plants for seed yielding. Our customers did never complain about the sanitary quality of our seed. The common blight is endemic in France, and except very unfavorable climatic conditions, the presence of the bacteria did not prevent from very good yields. To my opinion, the eradication of the bacteria is not the good strategy general, the dynamic equilibrium of common parasites which, most often, are only slightly virulent, may be more profitable to the whole agro-ecosystem.”

Discussion in relation to Conclusion 3:

In a study on wheat *Fusarium*⁸, they investigated the effects of various wheat cropping systems on *Fusarium* head blight severity and mycotoxin (deoxynivalenol, nivalenol, zearalenone) levels. They were unable to rank the organic and conventional systems, because neither was consistently more contaminated than the other. Moreover, no clear relationship was found between disease severity and levels of contamination with deoxynivalenol, nivalenol or zearalenone under conditions of natural contamination. Another study⁹ on peer-reviewed publications indicate that organic foods are not more hazardous sources of mycotoxins than conventional foods. On the contrary, according to this study, organic foods tend to be less contaminated, and may provide protection from the toxins.

As soon Howard, a pioneer for organic agriculture, the link between the soil fertility and plant health was an evidence. Today, a very recent publication claims the same reality : “Soil microbial biomass (MB-C) plays important roles in nutrient cycling, plant-pathogen suppression, decomposition of residues and degradation of pollutants; therefore, it is often regarded as a good indicator of soil quality. However, direct relationships between MB-C and nutrient-cycling dynamics, microbial diversity and functionality are still unclear. Further studies are needed to develop strategies to maximize beneficial effects of microbial communities on soil fertility and crop productivity”¹⁰. Thus, seed borne diseases could not have the same consequences whether the seeds are sown in a “conventional” soil or an “organic living” soil. Further analysis are to be encouraged to evaluate the interaction between microorganisms and to get means to better evaluate the risks of disease and to stimulate synergy in the soil in order to prevent diseases.

⁸ Champeil, A.; Fourbet, J. F.; Dore, T.; Rossignol, L. (2004) Influence of cropping system on *Fusarium* head blight and mycotoxin levels in winter wheat. *Crop Protection* 23 (6): 531-537

⁹ Joe Cummins (23/11/2004) - Increased Mycotoxins in Organic Produce? (retrieved on April 7th 2010) <http://www.i-sis.org.uk/IMIOF.php>

¹⁰ Kaschuk G, Alberton O, Hungria M (2010) Three decades of soil microbial biomass studies in Brazilian ecosystems: Lessons learned about soil quality and indications for improving sustainability. *Soil Biology & Biochemistry* 42 (1): 1-13





8 Practical guidelines for quality seed production

Some practical guidelines and recommended procedures will be given for the production of quality seed.

Seed selection

The selection of seeds or plants for the next generation is an important aspect of seed production. The aims of selection are (Almekinders & Louwaars 1999):

- improve the vigour of the seed by selecting well-developed plants and plump seeds only
- reduce disease incidence by discarding obviously diseased plants or seeds
- maintain genetic quality of the variety
- adapt the variety continually to changing growing conditions
- obtain better varieties

A number of different approaches can be distinguished, each with a different aim and used at different stages of seed production. These include:

1. Select the best seeds from bulk before sowing, such as is often done with bean seeds. Only the healthy-looking seeds of the right type will then be sown. This reduces the incidence of diseases in the next crop.
2. Select the best seeds after harvesting, but before threshing and storage. This is commonly done in maize, where the best-looking cobs are selected for seed. These can then be treated separately and given more care during storage.
3. Select a good-looking portion of a field to be harvested separately for seed. This is done because one can expect these plants to produce healthier and more vigorous seeds.
4. Select individual plants from over the entire field. In this way one can, in addition to the better seed quality, also enhance the genetic composition of the variety.
5. In crops where the characteristics are no longer visible at the time of harvest, one can mark individual plants as seed plant during the vegetative stage. These will then be left in the field to produce seeds. This is often the case in crops like many vegetables in which the plant and not the seed is the commercial product. In this way one can still select on for instance susceptibility for leaf diseases.

These are the methods that can be used by farmers when producing seed for themselves only or for very limited distribution to others. If however, more seed needs to be produced and irrespective of whether it is going to be officially inspected or not, the production should become more sophisticated and planned. Then the following methods of selection are available:

6. Prepare a field especially for seed production, separate from the crop production field, and taking precautions for undesired cross-pollination. During the season, one will then remove plants of undesired type ('off-types') and diseased plants.

7. Use special selection procedures to maintain or purify the variety (see below), like for instance ear-to-row systems. In land races this has to be done with great care: one should only remove the plants that clearly not belong to the variety, in order to maintain the varieties' identity and normal heterogeneity.

Isolation distance and crop rotation

In cross-pollinating crops like for example spinach and maize, considerable distance should be observed between varieties if these are to be used for seed production. For spinach this distance is at least 200 m up to 1 km, for maize this is 400 m. If this is not respected, the next generation will have a totally mixed genetic background. For wheat and beans, both outcrossing to only a very small extent, a much smaller distance can be used to avoid the physical mixing of varieties.

On the other hand, some farmers use this phenomenon to combine properties of different OP (Open Pollinated, *i.e.* non-hybrid) varieties. A variation on this theme is the sowing of a mix of varieties and to harvest them for seed.

To avoid varietal contamination in the field, isolation in space is not sufficient: also isolation in time should be observed for crops that are able to survive winter and produce seedlings in the next season. This depends on the crop/climate combination. If the seeds or plants survive, this will result in 'volunteer plants' which may be of a different variety. So either move to another field or use the same variety.

Crop rotation may also be useful for other well-known reasons, if not for improving the soil structure and composition, then indeed for managing soil-borne diseases or disease vectors. Rotations of at least 3 years are recommended with crops from different crop groups to minimise the risk of survival of diseases.

Variety maintenance

Maintenance is an activity to keep the variety true to its identity. If this is a formal variety, special maintenance breeders are officially recognised, others are not allowed to do this. In these cases the variety is cleaned from off-types carefully to keep it true to its original description.

For landraces and other varieties with inherent heterogeneity (like conservation varieties and many amateur varieties) the situation is different. Farmers multiply the seeds themselves and will normally not do something extra to keep the variety in shape; nothing other than perhaps making sure he selects a good representation of the different types in his field, excluding only real off-types or strange varieties. Farmers can in this way continually adapt the variety to changing environmental conditions, the variety evolves with them.

Harvesting

Timing of the harvest is crucial in obtaining high quality seed. It has been observed that many farmers produce cereal seed next to other activities (vegetable growing, cattle raising), which are getting priority for obvious reasons. But if this goes to the detriment of seed quality one is in the danger zone: next year's crop establishment may become problematic.

Some guidelines:

1. Harvest as soon as the seed has reached full maturity; when too long in the field, and especially under humid conditions, fungi will develop on the seed, which may result in bad storage behaviour and low seedling quality;
2. Harvest when the crop has not yet lodged. Weed seed may be collected with the crop seed, sand and clay particles will become admixed, and the more humid condition will result in seed deterioration (see next);



3. When in swath, leave it only for a few days maximum there, for if rain comes, the seed may start to germinate. Pre-harvest sprouting is one of the major factors of inferior seed quality;
4. Harvest in one operation: so no quality differences occur in the lot (they will result in bags with good and bad seed, even if one tries to mix). If a combine is used, be very sure it is clean or was used for the same variety before;
5. Preclean when possible: separate the seeds from the inflorescence material (except with maize, that can remain on the cob, but these need to be peeled from the husks for more efficient drying);
6. Dry as soon as possible. If the material is too wet, artificial drying may be necessary and should start immediately after harvest. Each day lost will result in an ever increasing decline in seed quality;
7. Store the seed dry in airy conditions, free from the floor (in woven bags on pallets or shelves);
8. To avoid varietal admixture, harvested products should be kept separate and not used on the same machinery without thorough cleaning;
9. Combat rodents and insect as best as you can;
10. Make sure you have intact floors without crevices and wipe or vacuum clean these regularly;
11. Have a good look at your seed stock every week: it is your treasure.

Post harvest technologies

Drying

To be on the safe side, always dry or ventilate the seed for a few days before further processing. Artificial drying in kilns is the preferred method. This consists in its simplest form of a mesh table placed on a box in which warm dry air is blown. The air is produced by a simple heater and a ventilator. Temperatures should not go beyond 30°C.

If sun drying is applied, then the seed should be put in a shallow layer of a few cm maximum, regularly raked and mixed to avoid excessive heat and moisture accumulation in the seed layer, and it should immediately be covered with sheets or otherwise to protect it from rain.

Cleaning

If you use mechanical equipment for harvesting, threshing and/or cleaning, then cleanliness of the machines is of foremost importance. The following shall be observed:

1. The machines should be thoroughly cleaned before parking them during winter: leftover seed will result in a lot of insects (and rodents);
2. The bags if reused should be turned inside out to remove all remaining seeds and debris. It may sometimes be necessary to wash the bags. They should be discarded for seed purposes if there were fungus-infected seeds in them before.
3. Use sieves (hand sieves or sieving machines) to remove all undersized kernels, which are usually immature and/or diseased seed, and other debris including ergot.
4. Threshing and cleaning machines can be used if properly cleaned and operated. They are usually very efficient in removing all kinds of non-seed material and other seeds. They provide the only realistic way to meet the standards that are set for certified seed, unless one has the whole winter for hand selection.

If hand-cleaning your seed: try to clean it as soon as possible, use hand sieves, and put them in bags if clean. Observe most points raised for mechanical harvesting above.



Sanitation

Apart from the sanitation measures dealt with in the previous paragraph ('Cleaning') the term sanitation is also used for seed cleansing methods: methods to remove, inactivate or neutralise pathogens on the seeds.

Most well-known is the hot water treatment, usually performed at 70°C during a few minutes. This temperature is dangerous for the seed and the immersion should not take too long, so careful experimentation is needed before one can decide on the optimum method.

Other methods include the dressing of seeds with 'green' compounds such as ash, vinegar, neem seed oil, thyme seed oil, powdered leaves of certain plants, etc. Some of these compounds are detrimental to the seed too, so they should be used with care.

Other environmentally acceptable treatments include treatment with hot water vapour (ThermoSeed procedure, Incotec International BV, Holland) and electrification (e-ventus, Schmidt-Seeger AG, Germany). These methods are both very efficient in the almost complete removal of pathogens.

Seed storage

Never store potatoes or seed potatoes that have been treated with potato sprout inhibitor in the same hall with seeds: the seeds will inevitably refuse to germinate afterwards.

Seeds should be stored dry, and if possible cool. Temperatures ranging from 15-25 are adequate if the seeds are sufficiently dry (10-12% MC) for storage until next season. For intermediate term storage more careful observation of the conditions must be observed. For real long-term storage the conditions must be like in gene banks: dry (in closed water-proof bags or containers) and cool (5°C or lower).





^[1] Almekinders, C.J.M. & Louwaars, N.P. 1999. Farmers' seed production – New approaches and practices. Intermediate Technology Publications, London.

^[2] ISTA 2009. International Rules for Seed Testing. International Seed Testing Association, Bassersdorf, Switzerland.