

Oilseed rape grain yield productivity increases with hybrid varietal types: a first balance sheet with post registration tests in France and in Europe

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Summary: Since 1994 several oilseed rape hybrid types were proposed to farmers. Following registration experiments, Cetiom and different equivalent institutions in European Union have tested them in different post registration national networks. Grain yield productivity increases were demonstrated and a first synthesis could be done to check advantages and difficulties which had occurred. For winter types, Hybrid Composites were widely used, mainly in France and in the United Kingdom. Grain yield increases were important in the South and West part of France where their market shares increased up to 50-80%. Nevertheless, many fecondation problems occurred in several places all over Europe. Reasons of such problems were difficult to identify. Several factors, as cold temperatures, nutritionnal competitions, pollen availability may be involved to explain low seed sets. Restored Hybrids made with the NPZ hybridization system were successfully tested widely, and has reached significative market shares during 1999-2000 season. Less experiments were carried out with others hybrid types (Ogu-INRA Restored Hybrids, Mixed Hybrids). Ogu-INRA Restored Hybrids reached the highest grain yield levels but users are waiting for lower glucosinolates seed content hybrids which would come in the next future. Performances comparisons among countries have to be done carefully. Productivity increases with hybrid types could have been over estimated depending of pollinic environments or plot size and possible neighbouring effects. For France, results from field trials networks are coherent with results coming from postal surveys. For spring varieties, Polima restored hybrids and varietal associations have demonstrated a significative advantage compared to classical lines.

Keywords: oilseed rape, hybrid, hybridization system, grain yield productivity.

ARTICLE

Introduction

The European Union is an important producer of oilseed rape with more than 3 million hectares in 1998 and 27% of the world grain production. Oilseed rape is known as a good agronomic head of rotation, able to cover the soil and catch nitrate over nearly a year. Faced to the international competition, and with the new Commun Agricultural Policy, winter oilseed rape has to increase its competitiveness and its grain yield productivity. Hybrids were announced as a good mean to increase grain yields and promizing heterosis effects were demonstrated [1, 2]. Actually, Varietal Associations and Restored Hybrids together reached between 20 and 25% of market shares in the main countries (*table 1*). Several hybridization systems were in competition. In 1994, the first winter Hybrid-Line Composite (Synergy) and the first spring Polima Restored Hybrid (Hybridol) were registered in

France, followed by NPZ Restored Hybrids in Germany in 1996 (Pronto and Joker), and the first Ogu-INRA Restored Hybrid in Denmark in 1998 (Elite). From 1994 to 1999, Cetiom has tested, in its varietal evaluation networks, several types of hybrids: Varietal Associations, Mixed Hybrids, and Restored Hybrids produced with different hybridization systems. The same was done in the different European countries. After six years of a large scale evaluation of different hybrid types, it would be interesting to draw up a first balance-sheet of hybrids results, especially focussed on grain yield productivity. The aim of this paper is to present the main results of field evaluations of different types of winter oilseed rape hybrids in France and in different European countries in post registration trials. For France, we also try to evaluate the benefit at the farmers level through postal surveys.

Materials and methods

In most of the European countries new registered varieties are tested in post registration networks. Several varietal types were used in the field experiments.

* Varietal Associations are associations between a male sterile Ogu-INRA hybrid and one or two pollinating varieties. The pollinating varieties could be restored hybrids (Hybrid-Hybrid Composites) or homozygous classical lines (Hybrid-Line Composites). In the association, 70 to 80% of the plants are male sterile hybrids.

* Mixed Hybrids are three ways hybrids coming from a cross between an Ogu-INRA Restored Hybrid and a male sterile line. The restoration of the male fertility is in segregation after the second cross. Half of the cropping plants are male sterile.

* Restored Hybrids are simple hybrids fully male fertile produced with several Hybridization systems: NPZ and Ogu-INRA CMS restoration system.

The national post registration winter oilseed rape variety testing network carried out each year by Cetiom and its usual partner had the following structure.

* From 1993-1994 to 1995-1996, we had only a limited number of Hybrid-Line Composites to evaluate (one Synergy - INRA-Serasem - in 1993-1994 and two, Synergy and Cocktail - Cargill -, the two following years). There was a unique serie including Hybrid-Line Composites among classical lines.

* For the following years, taking into account seed set problems occurred in production fields and in trials during spring 1995, and to avoid undesirable neighbouring effects due to height differences among varieties or pollen transfers from classical lines to Varietal Association, the national variety testing network was split:

- in the North, East and Central parts of the country, we introduced two different series in separate designs, one with the non fully male fertile materials, isolated from classical line fields, and with only one line as control, and a second serie with the classical lines and the restored hybrids;

- in the South and West parts of the country there were much less risks of pollination accidents with Varietal Associations. The different varietal types were kept together with non harvested rows to avoid undesirable neighbouring effects. Two series were done in 1997-1998 faced to the larger number of varieties to be tested.

Grain yield data were coming from different post registration networks through Europe. The trials were carried out by Cetiom and its usual partners in France, and by different equivalent institutions in the others countries: UFOP for Germany, NIAB and ADAS for UK, The Swiss Federal Research Stations for agronomy, BFL in Austria and the LR center in Denmark. Number of trials for each country are different. *Table 7* indicates the number of trails, the control taken, and the experimental years taken into account for each country.

Trials were generally done with 4 replications in randomized bloc designs or with lattice designs. Plot sizes could be different among countries. Border rows were not always left. Each trial has been validate according to national agronomic and statistical procedures. Results were expressed as a ratio between a given variety and the control for each trial. The regional or national average scores are arithmetic mean values of the ratios. For global national scores, average value for each varietal type for each year were first calculated, followed by a mean of the different years. Percentage of dry and clean seeds is established for each site on an average sample per treatment following the normalized methods of each country. Glucosinolates content were measured by HPLC normalized method.

Each year, a postal questionnaire was sent to several thousand farmers all over France by Cetiom. The objective was to follow evolutions in how the farmers are cropping oilseed rape and to know if recommended technical practicies, considered as good for environment protection, are taken into account and applied at the farmer's level. Among the questions, it was asked for data on grain yield productivity and the variety used for each fields. We considered that answers to these questionnaires could be an interesting way to estimate productivity results of Varietal Associations compared to leading lines at the farmer's level if answers were numerous enough for each area. Data from 1996 to 1999 were used for regions where there was a significative market share for Varietal Associations and a large number of answers to avoid hiden effects which could occurred in such approaches. The considered Varietal Associations were Synergy and Cocktail which were the only one cropped at a large scale. They were compared to Bristol and/or Goeland, and to Capitol and Navajo.

Results

Results in France

Varietal Associations in trials from 1993-1994 to 1995-1996

During the first three years of experimentation, results of Varietal Associations compared to classical lines were always very good in the South and West parts of the country (*table 2*). The yield increases, compared to the average values of the classical lines tested at the same time, were from + 6 to + 16%, except in 1994-1995, in the North-East area. As at the farmers scale, pod seed set accidents on Hybrid-Line Composites happened often in the East and North parts of the country during spring 1995 [3], with sometimes dramatic decreases of grain yields. Nevertheless the impact was probably less important due to a more favourable pollinic environment coming from the neighbouring male fertile lines of the trial. 1994-1995 experimentation underlined risks which could have heavy consequences on grain yield with non fully fertile materials like Varietal Associations.

Varietal Associations in trials from 1996-1997 to 1998-1999

In 1997, 1998 and 1999, pod seed set accidents on Hybrid-Line Composites occurred again and explained the lower results for this type of variety in some areas. This could be seen on results shown in *table 3* for the northern areas in 1997 and 1998. During 1997-1998 cropping season, Emblème reached a 6% more grain yield than the control line Capitol. This demonstrated that Ogu-INRA Mixed Hybrid could lowered risks of seed set accident compared to Varietal Association, with a high productivity and a lower glucosinolates content than a Ogu-INRA Restored Hybrid. On the other hand, grain yield increases with Varietal Associations were measured in 1999 all over the country: from + 6% to + 9% (*table 3*).

For the three years, results of Varietal Associations were very high in the South and the West regions, with a higher increase in the South (+ 8 to + 14%) than in the West-Atlantic (+ 4 to + 10%), compared to the more recent registered lines (*table 4*). Similar results were reached with the Mixed Hybrid.

Utilization of Varietal Associations: results from postal surveys

Estimations of grain yield advantages reached with Varietal Associations compared to well known leading classical lines were done through postal surveys when the number of answers for a same variety and the same region was high enough. This estimation was possible where Varietal Associations were cropped at a large scale. This is the reason why the North-East areas were excluded. The comparisons were done between the average grain yields of the Varietal Associations Synergy and Cocktail, and the leader lines Navajo, Capitol, Goeland and Bristol

The results, presented in *table 5*, demonstrated that there was a general advantage for Varietal Associations. Nevertheless, this advantage was higher for southern areas where the differences were closed to those found in trial designs. In the northern areas the difference with Goeland and Bristol were less important. Compared to the new leading lines Navajo and Capitol, Varietal Associations were very closed to lines, and sometime lower (in Normandy and Brittany). Results were very similar from one year to each other, except when seed set accidents occurred (see Pays-de-Loire and Poitou-Charentes in 1999). We also notice that ratio of number of fields registered in these sample surveys could give market share estimations for the different varieties taken into account. This underlined the large market share of Varietal Associations in the south of the country and in Rhône-Alpes.

Restored Hybrids in trials

In the Central, North and East parts of the country, grain yield advantages for Restored Hybrids were smaller than in the southern areas (*table 6*). Recent lines were very competitive and NPZ Restored Hybrid had only a slight advantage. In the South and West areas, the advantage could be higher in some years. The Ogu-INRA Restored Hybrid tested in 1997-1998 reached, every where, especially in the South, very important grain yield increases. Results registered with Elite in 1998-1999 were not so good, but were not representative of the variety grain yield potential. This hybrid looked very

sensitive to lodge and to blackleg stem canker. Nevertheless, both Ogu-INRA Restored Hybrids were not registered in France (Elite was registered in Denmark and Italy) because of a too high glucosinolates content in the harvested seeds (around 24 μM instead of less than 18 μM per gram).

Results in post registration networks in Europe

From post registration networks, considering grain yield productivity, hybrid materials have shown an advantage compared to classical lines. This advantage ranged from 4 to 18% compared to the average result for classical lines, and from 0 to 12% in front of the leading lines. Varietal Associations performed better in South of France, in UK, in Switzerland and in Austria. There were less advantages in North of France, Germany and Denmark. Results with Restored Hybrids were closed to those with Varietal Associations, except in Germany and in Denmark where they were better (*table 7*).

There were less results with Ogu-INRA Restored or Mixed Hybrids. They were mainly French results for the moment (*see tables 3, 4, 6*). Nevertheless the Restored Hybrid Elite reached a 118 score in Denmark in 1997 compared to Express, and the Mixed Hybrid CHM02 a 102 score in UK with Falcon, Apex, Alpine, Pronto (RH) and Synergy (VA) as controls. RPC605 was successfully tested in Switzerland in 1997 and 1998 with an average score of 105.6 compared to Express.

Discussion

Generally speaking, there is a significative increase of grain yield productivity using hybrids types. Compared to classical controls which were often leading lines, widely cropped, the average benefit can be estimated around 5 to 15% more, with variations among regions and environments. The benefit with Varietal Associations was closed to the benefit reached with Restored Hybrids, except in areas where seed set accidents were more frequent.

Among the different hybridization systems available to produce hybrids, the two leading systems are the Ogu-INRA system and the NPZ system.

The Ogu-INRA system is the more widely used, mainly with its CMS (cytoplasmic male sterility) for Varietal Associations. This system has a very safe and convenient CMS, but its restoration induces interferences with the glucosinolates metabolisms. The consequence is that Restored Hybrids produced with this hybridization system reached a 5 to 10 μM higher glucosinolates content in the seeds, compared to parental lines. This trait of higher glucosinolates content for Ogu-INRA hybrids is linked to the restoration trait. Progress on this point is expected very soon [4-6, 11]. Waiting for a solution to this problem, and considering that probably higher grain productivity levels could be reached, plant breeders have imagine to develop Varietal Associations. Compared to parental lines, Hybrid Composites demonstrated quickly a 20% increase for grain yield productivity [7]. They also demonstrated a wide branching ability and high compensation ability through the weight of thousand seeds [8]. Nevertheless, such materials introduced an important specificity for oilseed rape with an obligatory cross pollination among components of the association. Unsuccessfull seed set accidents occurred, first in spring 1995, and during the following years, more or less, in different areas of Europe. European results from *table 7* were average values of several trials among which there was variability. Especially for Varietal Associations we may underlined that probably there was some of the sites with seed set accidents, more frequent in cold northern areas like Germany and

Denmark. This may influence the average results and can explain that, in these countries, even with a favourable pollinic environment, results of Varietal Associations were not as good as results with Restored Hybrids. In France, as summarized in *table 8*, seed set problems were seen in trials as well as in farmers fields. Reasons of such problems were difficult to identify. Several factors, as cold temperatures, nutritional competitions, ratio light/temperature, pollen availability may be involved to explain low seed sets [9, 10].

As an alternative varietal type, Mixed Hybrids were developed later. In environmental conditions, where there was no external pollen provided by male fertile varieties around (except the control line), the Mixed Hybrids with 50% of fertile plants were much more successful than the Hybrid-Line Composites which have only 20 or 30% of pollinating plants.

Nevertheless, Restored Hybrids came up rapidly with a similar grain yield productivity. Restored Hybrids with the Polima hybridization system were first registered in 1994 for spring types. But for winter oilseed rape, Restored Hybrids mainly used the second hybridization system: the NPZ system. NPZ Restored Hybrids reached significant market shares during the last two years: 5% in France, more than 10% in Germany and in UK for 1998-1999 season. Nevertheless this system has to be improved for seeds production. Pollinating lines in the females could sometimes occur and has to be identified and switched off. For 1999-2000 cropping season, NPZ Restored Hybrids are widely used and represent around 90% of the Restored Hybrids cropped. Several private breeding companies or public institutes have recently announced that they succeeded to reduce the radish introgression necessary for male fertility restoration, and would be very soon able to register Ogu-INRA restored hybrids with seed glucosinolates content lower than 18 μM per gram [5, 6, 11]. The first Restored Hybrid was registered in France in summer 1999. It was the Ogu-INRA semi dwarf hybrid Lutin, early maturing, lodging resistant and with low glucosinolates content (16 $\mu\text{M}/\text{gr}$).

In trials, results with Varietal Associations and Restored Hybrids were very good, especially in countries like Denmark, Austria, or Switzerland. Nevertheless, we may pay attention to two important methodological questions. The first question is specific to Varietal Associations and Mixed Hybrids. These not fully male fertile varietal types are working with allofecondation. Pollen from the pollinating plants has to be provided in enough quantities. In classical variety testing designs, compared to classical autogamous materials, Varietal Associations could take a benefit from the higher pollen concentration in such designs compared to isolated condition in production fields. This allows us to assume that grain yield productivity of Varietal Associations in trials could be over-estimated compared to isolated environments. This over-estimation of a Varietal Association grain yield neighbored by fully fertile varieties was quantified by Schott [12] from + 0.9% to + 5% depending on environmental conditions, on fully fertile neighbours on one or two sides, on the presence or absence of non harvested border rows, and on the plots width. That is the reason why Varietal Associations and Mixed Hybrids were tested in special series, isolated from classical lines, since 1995-1996 season, in France in areas where seed set accidents had already happened. Especially results from 1998 experimentation in France demonstrated that, in such conditions, this methodological disposition was successful and put in evidence that Varietal Associations could be less productive than the control line and that Mixed Hybrids could bring more safety with a larger percentage of pollinating plants.

The second methodological question is the risks of over-estimations of grain yield productivity of hybrid types through neighbouring effects. The heterosis effect can also be measured on others variables than grain yield. Plant height was often higher with Varietal Associations or with Restored Hybrids. Neighbouring effects linked to plant height were already demonstrated in registration trials and in special experimentations in France [13, 14]. This has led to special recommendations to experimentators, inviting them to have large enough plots and to introduce non harvested border rows. The French experience in the pre- and post-registration networks has shown, with the introduction of larger plots and non harvested border rows, significative decreases of residual standard errors and variation coefficients. The estimation of productivity benefit in the South and West parts of France through field trials networks seems good and coherent, compared to estimations through farmers questionnaires (*table 5*). In some of the european countries differences between classical lines and hybrids (Restored and Varietal Associations) were very high. This probably means that it would be necessary to be carefull about this methodological aspect which over-estimated the differences. This was probably true for Switzerland, Austria and Denmark.

Results, especially in France, demonstrated a higher benefit with hybrids, in the southern areas. In the South of the country this increase seems higher, arround 10%, and sometimes more. Results from the farmers postal surveys indicate a particulary high benefit with Varietal Associations compared to the Classical Line Bristol. In the northern areas Varietal Associations were much more risky and yield increases with Restored Hybrids were limited to few percents. There is no clear demonstration of the reasons why such results were observed. We may suppose that in southern areas where the water avaibility could be limited, hybrids with stronger root systems, could have a better water and nutritional uptake efficiency. For the moment, there is no clear evidence of a better mineral and water uptake by hybrids root system compared to Classical Lines. Nevertheless, further deeper studies are probably needed to check advantages of hybrid materials in stressed environments and its possible ability to get more regular productivity.

All the results we got through different networks carried out in France or in Europe demonstrated a significative increase of grain yield productivity linked to hydrids utilization. Hybrids and Varietal Associations utilization has increased and reached between 15 to 25% of seeds market shares in the main countries (*table 1*) These results obtained with a first generation of commercial hybrids are very encouraging for two reasons: (i) these results were obtained comparing lines registered from 1994 to 1998, leading lines like Bristol and Goeland registered in 1993, with hybrid materials made with parental lines belonging to the previous generation (Eurol, Samourai, Falcon); (ii) we may supposed that the combination ability of the parental lines has not been fully exploited. Progress are expected. Work on combination abilities of the parental lines has started recently with the avaibility of hybridation systems. Probably a higher benefit will be found from deeper studies looking for parental lines expressing high combination abilities. This would provide larger heterosis effects to promote new grain yield increases with oilseed rape varieties and to keep competitiveness in front of others crops.

CONCLUSION

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REFERENCES

1. LEFORT BUSON M, DATTEE Y (1982). Genetic study of some agronomic characters in winter oilseed rape (*Brassica napus* L.). I: Heterosis. *Agronomie*, 2: 315-22.
2. MCVETTY PB (1995). Review of performance and seed production of hybrid brassicas. *Proceedings 9th International rapeseed congress*, Cambridge, UK, 4-7 july 1995: 98-103.
3. PINOCHET X (1995). Comportement au champ des composites hybrides lignées. *Les Rencontres Annuelles du CETIOM*. Paris, France : 39-43.
4. DELOURME R, EBER F, RENARD M (1995). Breeding double low restorer lines in radish cytoplasmic male sterility of rapeseed (*Brassica napus*). *Proceedings 9th International rapeseed congress*, Cambridge, UK, 4-7 july 1995: 73-8.
5. BARTKOWIAK I, POPLAWSKA W (1999). Characteristics of double low winter rapeseed lines with introduced restore gene for CMS Ogu-INRA. *Proceedings 10th International rapeseed congress*, Canberra, Australia.
6. PRUVOT JC, KRALING K, CHARNE D, TULSIERAM L (1999). Development of low glucosinolate restorer and Ogu CMS Winter rape hybrids. *Proceedings 10th International rapeseed congress*, Canberra, Australia.
7. DELBECQ E, SCHOTT JJ, BLOUET F (1998). Les variétés de colza oléagineux du catalogue officiel français - édition 1997-1998. Guyancourt, GEVES Édition : 24-5.
8. PINOCHET X, COLSON J (1994). Colza : Les composites hybride-lignées. Un potentiel de production élevé et des questions spécifiques. *Oléoscope* 17 (numéro spécial) : 10-24.
9. PINOCHET X (1998). Méthode d'expérimentation des CHL : identification des milieux à risques d'accidents. Conséquences pour la structuration des réseaux d'évaluation variétale. CR Final DPE CHL DOMN 9608 : 11 p. + annexes.
10. PINOCHET X, DARROZES G, MARGALÉ E, GIGANDON C (1999). Flowering dynamics of different winter oilseed rape varietal types: Consequences on seed sets. *Proceedings 10th International rapeseed congress*, Canberra, Australia.

11. DELOURME R, HORVAIS R, VALLÉE P, RENARD M (1999). Double low restored F1 hybrids can be produced with the Ogu INRA CMS in rapeseed. *Proceedings 10th International rapeseed congress*, Canberra, Australia.
12. SCHOTT JJ (1999). Neighbour effect of pollen density on yield evaluation of non 100% fertile genotypes of oilseed rape (*Brassica napus*). *Proceedings 10th International rapeseed congress*, Canberra, Australia.
13. PINOCHET X, BERTRAND R, VANDEPUTTE B, PERRET D (1997). Les plans équilibrés pour les effets de voisinages sont-ils intéressants pour la comparaison de variétés de colza. *Proceedings Coll. INRA-ITCF Paris « Effets de compétition dans les essais variétaux de plein champ »* : 89-96.
14. PINOCHET X, SCHOTT JJ (1998). Les effets de compétition en colza d'hiver. Comment les neutraliser? *Perspectives Agricoles*, 236 : 80-4.
15. NIAB (1998). Oilseeds variety handbook. NIAB-HGCA.
16. NIAB (1999). UK recommended lists for oilseeds 1999. HGCA-NIAB-SAC.
17. Swiss Federal Research stations for agronomy, Changins (RAC) and Zurich-Reckenholz (FAL) (Févr. 1999). Résultats des essais variétaux de colza d'automne 1998.
18. UFOP-Schriften: Sortenversuche mit Winterraps, Futtererbsen, und Sonnenblumen 1995-1996-1997.
19. SAUERMAN W, GRONOW J (1999). Bundes- und EU-sortenversuch Winterraps 1998. *Raps* 17: 89-93.
20. HALDRUP C, HANSEN MS (1997). Fro-og industriafgroder. In: *Oversigt over Landsforsogene* : 136-59.
21. LUFTENSTEINER HW, PUTZ G, HENDLER M (1995). Ölsaaten-sortenversuche 1995. Bundesamt und Forschungszentrum für Landwirtschaft.
22. LUFTENSTEINER HW, HENDLER M (1996). Winterkörner-Raps: Herbstanbau 96 in Österreich. *Raps*, 14: 127-9.

Pictures

	Area (Ha)	RH (%)	VA (%)	Total (%)
France	1,200,000	7	17	24
Germany	1,000,000	6	0	16
United Kingdom	380,000	3	8	21
Denmark	100,000	21	5	26

Table 1. Estimation of areas of winter oilseed rape cropped with Restored Hybrids (RH) and Varietal Associations (VA) in the main countries of the European Union during 1999-2000 season.

		South	West-Atlantic	Center	Central-East	North-East	France
Trials with lines and 1 or 2 Varietal Associations							
1993-1994	Varietal Associations	116	116	110	113	113	114
	Trials numb.	7	11	8	10	10	46
1994-1995	Varietal Associations	111	116	112	106	99	108
	Trials numb.	17	11	11	19	13	71
1995-1996	Varietal Associations	109	106	106	106	108	108
	Trials numb.	15	13	13	16	13	70

Table 2. Average grain yield results of Lines (12-15) and Varietal Associations (Synergy and Cocktail) from Cetiom post registration networks 1993-1994, 1994-1995, 1995-1996. (100 = Average grain yield results of Lines.)

		Center	Central-East	North-East
Trials with Varietal Associations + Mixed Hybrids + 1 control-line (Capitol or Goeland)				
1997	Varietal Associations	120	113	101
100 = Goeland	Trials numb.	5	7	5
1998	Varietal Associations	97	97	97
100 = Capitol	MH (Emblème)	106	106	106
	Trials numb.	10	10	10
1999	Varietal Associations	109	109	109
100 = Capitol	MH (Emblème + CHM07)	103	103	103
	Trials numb.	9	9	9

Table 3. Average grain yield results of Varietal Associations, and Mixed Hybrids from Cetiom post registration networks 1996-1997, 1997-1998, and 1998-1999 for Central, North and East areas. Not fully male fertile materials were experimented in separate trials. (MH = mixed hybrid. 100 = Goeland in 1996-1997 and Capitol in 1997-1998 and 1998-1999.)

		South	West-Atlantic
Trials with all types of materials together			
1997	Varietal Associations	114	109
	Trials numb.	14	9
1998 (trials with list 1)	Varietal Associations	110	104
	Trials numb.	18	10
1998 (trials with list 2)	Varietal Associations	113	110
	MH (Emblème)	110	107
	Trials numb.	8	5
1999	Varietal Associations	108	106
	Trials numb.	16	13

Table 4. Average grain yield results of Varietal Associations, and Mixed Hybrids from Cetiom post registration networks 1996-1997, 1997-1998, and 1998-1999 for South and West-Atlantic areas. (100 = Average grain yield results of Lines. MH = Mixed Hybrid.)

		1996			1997			1999		
		Number of farmers fields	Grain yield (ton/Ha)	Ratio VA/line (%)	Number of farmers fields	Grain yield (ton/Ha)	Ratio VA/line (%)	Number of farmers fields	Grain yield (ton/Ha)	Ratio VA/line (%)
Picardie, Nord, Pas-de-Calais	Capitol + Navajo	437	3.92	+ 1.8%	770	4.08	+ 1.2%	197	3.84	+ 8.3%
	Bristol + Goeland	916	3.71	+ 7.5%	339	3.94	+ 4.8%			
	Var. Ass.	239	3.99		166	4.13		30	4.17	
Centre	Capitol + Navajo	226	3.72	+ 1.3%	460	3.88	+ 4.1%			
	Bristol + Goeland	486	3.45	+ 9.3%	197	3.62	+ 11.6%			
	Var. Ass.	31	3.77		40	4.04				
Bretagne-Normandie	Capitol	50	3.71	- 1.3%	91	4.07	- 6.3%			
	Goeland	137	3.52	+ 4%	108	3.87	- 1.5%			
	Var. Ass.	62	3.66		103	3.81				
Pays-de-Loire, Poitou-Charentes	Bristol + Goeland	194	3.51	+ 7.1%	51	3.14	+ 8.0%			
	Capitol							27	3.37	- 1.0%
	Var. Ass.	341	3.76		324	3.39		89	3.35	
Aquitaine, Midi-Pyrénées	Goeland	24	2.88	+ 8.0%	45	2,53	+ 11.5%			
	Lines									
	Var. Ass.	87	3.11		186	2.82				
Languedoc, Provence	Bristol	42	2.25	+ 12.9%	50	1.67	+ 29.9%	31	2.37	+ 7.6%
	Var. Ass.	34	2.54		48	2.17		72	2.55	
Rhône-Alpes	Bristol	85	3.06	+ 12.4%	59	3.01	+ 9.6%	27	2.85	+ 24.2%
	Navajo				29	3.17	+ 4.1%	34	3.00	+ 18%
	Var. Ass.	166	3.44		159	3.3		39	3.54	

Table 5. Average Grain Yield data for the leading varieties coming from Charte Environnement postal surveys for the main regions where Varietal Associations were cropped. For each answer, the variety name and the grain yield harvested were farmer's declaration.

		South	West-Atlantic	Center	Central-East	North-East
1997	Goeland (Line)		96	98	100	103
	RH NPZ (Pronto)		113	105	101	102
	Trials numb.		9	13	9	12
1998	Capitol (Line)		105	101	105	97
	RH NPZ (Pronto)	108 (serie 1)	104 (serie 1)	103	102	101
	RH OguINRA (ccwh001)	121 (serie 2)	111 (serie 2)	111	113	105
	Trials numb.	18 (S1) - 8 (S2)	10 (S1) - 5 (S2)	13	15	11
1999	Capitol (Line)		99	101	101	103
	Colosse (Va r. Ass.)	112	108			
	RH NPZ (Pronto)	99	103	105	104	103
	RH OguINRA (Elite)	101	103	97	101	95
	Trials numb.	16	13	13	12	13

Table 6. Average grain yield results of Lines, and Restored Hybrids from Cetiom post registration networks 1996-1997, 1997-1998, and 1998-1999 for different areas. (RH = Restored Hybrid. 100 = Average grain yield results of Lines.)

	France North	France South	United Kingdom [15, 16]	Switzerland [17]	Germany [18, 19]	Denmark [20]	Austria [21, 22]
Varietal Associations	105.8	109.5	106	113.6	103.9	103.6	114.8
Restored Hybrids (NPZ)	105.2	111.2	106	115.1	107.7	118	
Lines	100.4	98.2	98.5	100.7	97.9	99.6	99
VA/L (%)	+ 5	+ 11	+ 8	+ 13	+ 6	+ 4	+ 16
RH/L (%)	+ 5	+ 13	+ 8	+ 14	+ 10	+ 18	
Apex/Goeland/Lady	102	102	97			96	103
Express	96.5	98.5		100	98.3	100	101
Capitol	103.8	100	98	106.5		106	
Mohican	104.5	98		100	104		107
Control 100 =	Bristol + Goeland	Bristol + Goeland	Average of 5 cv	Express	Average of 4 cv	Express	Honk
Nber trials/year	28-43	18-28	20-25	7-9	8-14	8-13	6-8
Years taken into account	94-95-96-97-98	94-95-96-97-98	95-96-97-98	95-96-97-98	96-97-98	95-96-97	95-96

Table 7. Average grain yield results of Lines, Varietal Associations, and Mixed or Restored Hybrids from European post registration networks.

	Seed set accidents in trials	Seed set accidents in farmers fields
North-East	1995, 1997, 1998	1995 (non cropped after)
Center-East	1995, 1998	1995 (non cropped after)
Center	1998	1995, 1998
West-Atlantic	no pb	1996 (Vienne), 1998, 1999
South	no pb	1997 (north Dordogne)

Table 8. *Seed set accidents seen in trails or in production farmers fields cropped with Varietal Associations during the last years in different regions of France.*
