The farm level impact of using Roundup Ready soybeans in Romania

Paper written by

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Executive summary

This paper examines the farm level impact of use of Roundup Ready soybeans in Romania.

Context of soybeans in Romania
Romania has the third highest soybean area in Europe (75,000 ha in 2003) behind Italy and Serbia/Montenegro, and roughly equal to the area in France. Within the country the main soybean growing regions can be found in the southern third of the country.

Roundup Ready (RR) soybeans have been grown commercially since 1999. The share of total soybeans planted to RR seed has increased to 55%-60% (inclusive of farm-saved seed) by 2003.

Weeds and conventional control measures
Weeds are a major problem in Romanian agriculture causing significant loss of yield and downgrading of harvest quality. The weed problems largely reflect a combination of climate/soils and limited use of herbicides since 1990. As a result of the limited use of herbicides (caused essentially by the breakdown of the old socialist economic system and transition to a market economy), there has been a significant build up in the weed seed bank. In addition, there are some problem weeds such as *Johnson grass* that, once established are extremely difficult to control with most herbicides. The full, recommended treatment for delivering reasonable weed control in soybeans is the use of 3 or 4 four spray runs with different herbicides. Only a limited number of farmers have adopted these practices (lack of financial resources and low levels of profitability being the main reasons for this).

RR soybean users
The average farm size growing soybeans is 400 ha and the average size of farm growing RR soybeans is about 500 ha (there is, however no link between size of farm and take up of the technology). Most farms growing RR soybeans grow either all RR soybeans or mostly RR soybeans – in other words conventional soybeans, if grown tend to have a small share of plantings and this largely reflects limited access to irrigation or RR seed (the latter is an issue in 2003).

Cost of the technology
RR soybeans are sold as a package with Roundup herbicide in Romania. The original cost in 1999 was equal to $160/ha but this has fallen to about $130/ha by 2003. The price paid by farmers does, however vary according to where purchased from and the ability to negotiate discounts (large users).

Since the launch of the technology, the general price level of herbicides has remained broadly stable, although in the last 2-3 years the price of Roundup has fallen by about a third (in line with the falling prices of generic glyphosate alternatives that have recently become available in Romania).

Impact on yield
The average impact on yield has been +31%, within a range of +16% to +50% (on a base yield of 2-2.5 tonnes/ha). This significant yield improvement is due to improved weed control, especially of 'difficult to control' established weeds like *Johnson grass*. This yield improvement compares with mostly yield neutral impact in countries like Argentina, the USA and Canada, where weeds are much less of a problem than in Romania.

Most farmers have also benefited from a 2%-3% improvement in the price received for their soybeans from improved harvest quality (less weed impurities).

Impact on costs and margins
Romanian farmers have, on average, made significant cost savings and improvements to gross margins. The average gross margin improvements have been +184%, +127% and +185% respectively for smaller farms using certified seed, larger farmers using certified seed and larger farms using farm saved seed (Figure 1). RR soybean user farmers indicated that this crop (RR soybeans) is now the most profitable arable crop grown in Romania). These gains derive from improved yields and improved quality of seed (see above) coupled with lower costs of production (savings on herbicide costs and application costs).

This average positive impact of the technology has been much higher than in other RR soybean using countries – this stems from the major improvements in weed control.

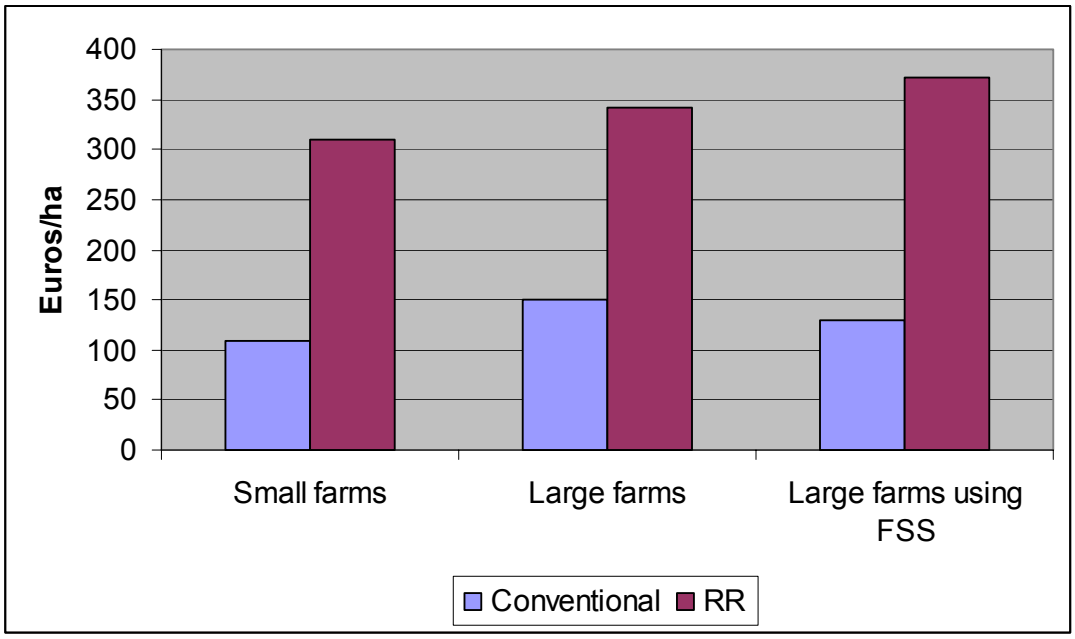


Figure 1: Impact of using RR soybeans on gross margins in Romania 2002-03

Notes: FFS = Farm saved seed, small farms = under 3,000 ha, large farms over 3,000 ha

Other impacts/issues relating to use of RR soybeans

a) Some farmers indicated that they benefited from increased convenience and management flexibility, most notably from having an increased time period for spraying.
b) Romanian farmers have, to date, not adopted or gained any benefits from minimum/low tillage systems, as has been one of the main impacts of adoption in countries like the USA and Argentina. This lack of adoption in Romania reflects a combination of limited financial resources with which to buy specialist equipment/machinery required and the common occurrence of clay soils which make minimum tillage systems difficult to operate.
c) Some farmers indicted that they derived small savings to harvest costs (less time spent harvesting).
d) Significant benefits were cited by many farmers for follow-on crops. In particular follow-on maize crops benefited from improved weed control and hence reduced use of herbicides
e) All RR soybeans were/are sold through normal marketing channels without segregation from non GM soybeans

Effect on the environment
It is difficult to show trends in herbicide use on soybeans and/or to draw conclusions about usage because of the impact of economic transition and re-structuring on the agricultural sector (fluctuating areas planted and inconsistent information). The only consistent finding has been the increased use of glyphosate and its replacement of herbicides which have higher toxicity profiles than glyphosate. This is consistent with findings in other countries like the USA and Argentina.

National level impact
Grossing up the farm level impact on soybean production and margins, the adoption of RR soybeans has increased the value of Romanian soybean production by about €8.23-€8.62 million in 2002-03. In production terms this is equal to about +14% to +19%.

1 Introduction

The commercial planting of genetically modified, herbicide tolerant (Roundup Ready) soybeans has been permitted in Romania since 1999.

This paper examines the farm level impact of use of Roundup Ready soybeans in Romania over the period 1999-2003 and draws comparisons with reported impact of the same technology in North and South America (USA, Canada and Argentina) where the main plantings of herbicide tolerant soybeans have been to date.

The research undertaken for this paper used a combination of desk research/analysis and field research in Romania. Interviews were undertaken with agricultural input distributors, scientists, academics and farmers. In particular, farmers in two of the main soybean growing counties of Romania were interviewed (Calarasi and Ialomita). In total, the farmers interviewed accounted for about 13% and 24% respectively of total soybean plantings and Roundup Ready (RR) soybean plantings in 2003[2]. The field research took place in May 2003.

The paper[3] is structured, after this introduction, as follows:

- Section 2: Romanian soybean production, GM soybean plantings, weed problems and conventional control methods;
- Section 3: the impact of RR soybeans at the farm level;
- Section 4: national level impact of adoption.

[2] This included farmers growing both Roundup Ready and conventional soybeans

[3] The author acknowledges funding for the research came from Monsanto Europe SA. The contents of the paper are, however the independent and objective views of the author and have not been influenced by Monsanto – this was a condition of undertaking the research

2 General: Romanian soybean production, weed problems and conventional control measures

2.1 Soybean production

In 2002/03, Romania harvested about 66,000 hectares[4] and produced about 106,000 tonnes of soybeans (Table 1). In the global context, Romania is a minor producer of soybeans relative to the three main producers of the USA, Brazil and Argentina, which respectively planted 29, 18 and 12.5 million hectares in 2002/03. In a European context, Romania is an important soybean producer, growing roughly the same area as France, but less than Italy and Serbia/Montenegro, the main European producers (Table 1).

Table 1: European soybean areas 2002/03: some of the main producing countries

	Area (hectares)
Romania	66,000 (75,000 forecast 2003)
France	76,000
Italy	129,000
Croatia	42,000
Turkey	20,000
Hungary	24,000
Serbia/Montenegro	100,000

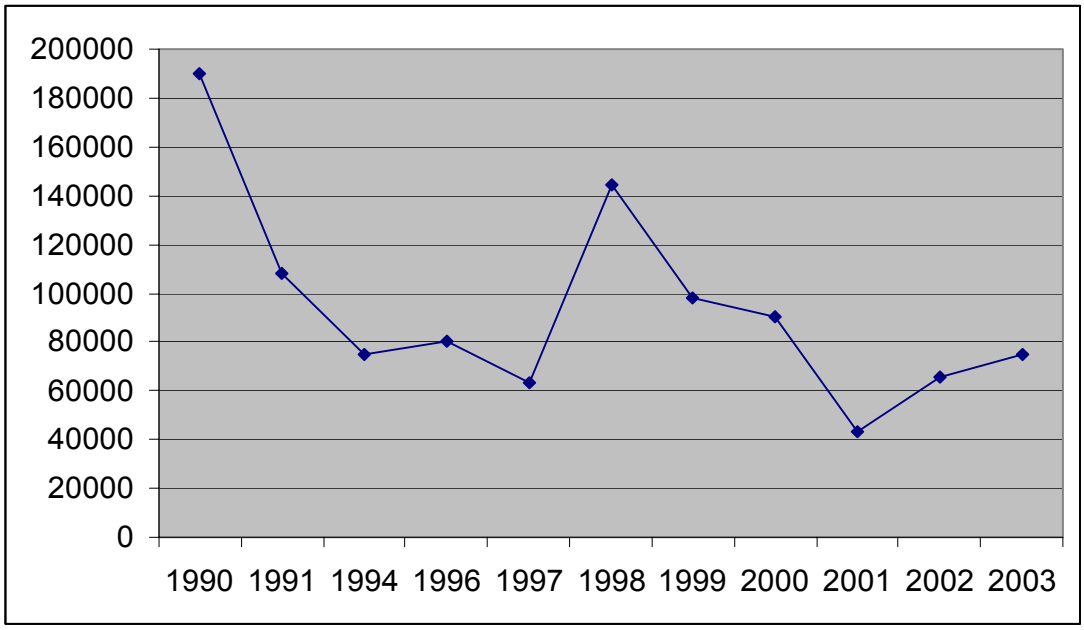
Sources: Coceral, FAO & various national statistical sources

In recent years the areas planted and harvested to soybeans in Romania has fluctuated considerably (Figure 2). At the beginning of the 1990s, and immediately after the collapse of the Communist system, soybean plantings were about 190,000 hectares. This area declined until the mid/late 1990s since when there has been significant annual fluctuation in plantings and harvested areas. This initial decline in plantings and subsequent fluctuation in plantings reflects a number of influences. Soybeans tend to be a crop grown more by commercial, rather than subsistence farmers and is highly reliant on reasonable levels of rainfall or access to irrigation water and equipment in order to obtain reasonable yields (relative to sunflower which is more tolerant of dry conditions). Consequently access to irrigation is currently considered to be one of the limiting factors affecting plantings. Prior to the breakdown in the communist regime, there were estimated to be about 2.5 million hectares of land in Romania that had access to irrigation. This area of potential irrigated land is now estimated to have fallen to about 0.5 million hectares in 2003 due to breakdowns, dis-repair and failure of some of the irrigation network. Coupled with years of drought (notably 2000), this has resulted in poor returns having been obtained on crops planted on land that does not have access to irrigation in some years and hence contributed to annual fluctuations in plantings (eg, the sharp decline in plantings and production in 2001 following drought in 2000).

Soybean yields have also varied in recent years. Average yields in 2001 and 2002 were reported to be about 1.6-1.7 tonnes/ha, although in the last five years the average yield has been within a range of 0.77 tonnes/ha (2000) and 1.92 tonnes/ha in 1997. Where irrigation is used average yields tend to be in the range of 2 to 3 tonnes/ha.

[4] Forecast plantings for 2003 are about 75,000 hectares

Figure 2: Soybean areas in Romania 1990-2003 (hectares)



Sources: FAO, MAFF Romania and trade estimates (2003)
Note: All years are harvested areas except 2003 which is estimated plantings

Within Romania, the main regions suitable for growing soybeans are in the southern third of the country (south and south east of the Carpathian mountains), and especially in the southern most counties of Ialomita, Calarasi, Constanta, Braila and Giurgiu.

2.2Roundup Ready soybeans in Romania

Herbicide tolerant soybeans (tolerant to the active ingredient glyphosate and in particular the Monsanto brand of Roundup), is currently the only genetically modified crop currently being commercially grown in Romania[5]. Five varieties of soybean containing the trait have been registered for commercial use, of which four are currently available. Two varieties are from group zero in terms of maturity (early maturity) and two are later (group two) maturing varieties.

Approval for commercial use in Romania was first given for crops planted in 1999. In the first year of adoption (1999), the area planted to Roundup Ready soybeans was about 15,500 (16% of the plantings). Since then the area planted to certified seed has increased to about 35-36,000 hectares (Figure 3). In terms of the share of total soybean plantings the share of Roundup Ready soybeans increased to about 40% in 2000 and has risen further to an estimated 48% in 2003[6]. Trade sources also indicated that for the 2003, demand for Roundup Ready soybeans has outstripped the supply of available seed and therefore the area planted in 2003 could have been higher if sufficient seed had been available. This increase in demand is attributed to a combination of factors, including the improved returns experienced by farmers (see section 3) and increased demand for spring sown crops to replace (harsh) winter damaged cereal crops. This share of Roundup Ready soybeans in Romania compares with shares of about 75% and 95% respectively

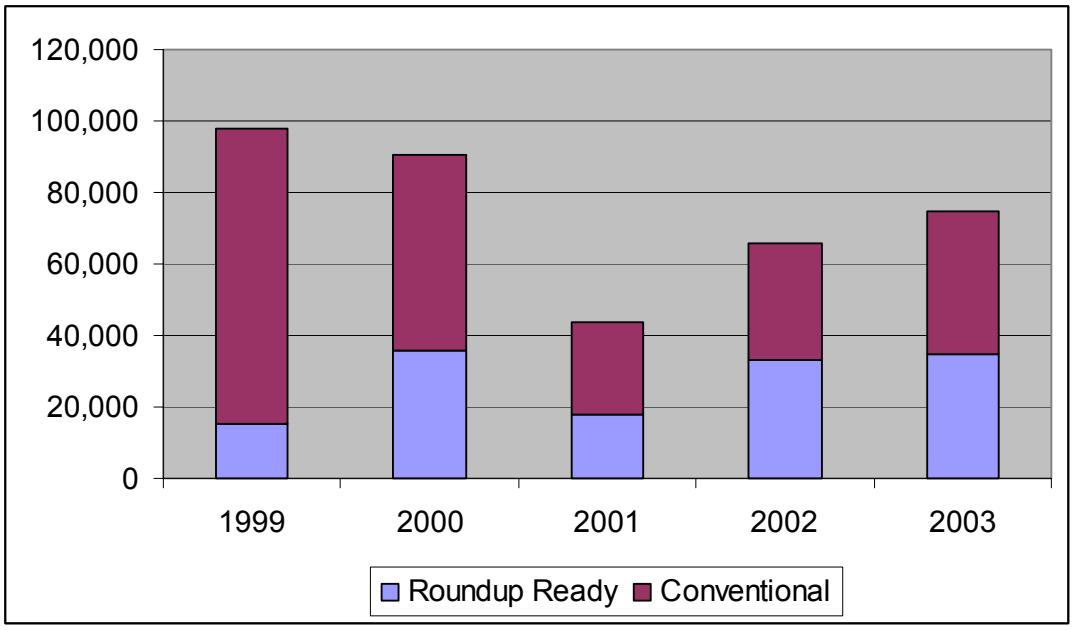
[5] Insect resistant potatoes are also approved for commercial planting and were available in 1999. However no GM potatoes are currently planted, as the trait is currently being crossed into local varieties most suited to growing in Romania

[6] Trade sources also suggest that anywhere between 15% and 20% of the total soybean area is to farm-saved seed, a significant proportion of which may be Roundup Ready varieties. Taking this into account, Roundup Ready soybeans may account for somewhere between 55% and 60% of the total crop area in 2003 (ie, 41-45,000 ha)

for Roundup Ready soybeans in the 2002 soybean crops in the USA and Argentina and is similar to the share (50%) in Canada.

Plantings of RR soybeans are concentrated in the south of Romania and, in particular in the counties of Calarasi and Ialomita.

Figure 3: Romania soybean area 1999-2003: Roundup Ready and conventional areas (hectares)



Sources: Trade, MAFF, AMIS Global

In terms of varieties of soybean planted, Monsanto's Roundup Ready, late maturing variety, SRR 2254 has been the largest selling variety since 2000 (Table 2), accounting for 30% of total certified seed sales in 2000 and 45% of total certified seed sales in 2002 (51% in 2001). Together with the newer, earlier maturing variety SR 0994, these two Monsanto varieties accounted for 60% of certified seed sales in 2002. In recent years, the main varieties planted, other than Roundup Ready varieties, have been Danubiana and Hodgson from the Romanian Fundulea Institute, Clamir from Pioneer and Avila from the Serbian breeder, Novi Sad. A comparison of the total estimated certified seed areas with the recorded harvested areas also suggests that since 2001, there may be a significant proportion (15%-20%) of the crop is derived from farm saved seed. The reader should also note that the area planted to soybeans is usually higher than the recorded harvested areas. There are, however no consistent data sources that record or estimate planted areas each year, although differences between planted and harvested areas can be significant because of factors such as access to irrigation and weather (ie, non irrigated crops are at risk of failure in years of drought).

Table 2: Certified soybean seed plantings in Romania 2000-2002 (hectares)

Variety	Breeder	2000	2001	2002
SRR 2254 (RR)	Monsanto	32,190	17,860	25,000
SR 0994	Monsanto	Not available	1,090	8,100
Clamir	Pioneer	7,210	2,200	1,500
Casimir	Pioneer	243	500	Under 100
Danubiana	Fundulea	16,270	3,000	3,200

Hodgson	Fundulea	10,300	1,700	1,900
Avial	Novi Sad	575	2,600	1,900
Condor	Novi Sad	466	1,600	Under 100
Others	Various	41,296	4,350	13,400
Total certified seed		108,550	34,900	55,000
Harvested area		90,708	43,471	66,000

Source: AMIS Global

2.3Weed pressure in Romania

Weeds are major problem faced by all arable crop farmers in Romania. They contribute significantly to reduced yields and to down-grading of crops sold because of the presence of weed material in deliveries to buyers and users. Whilst there is a lack of data relating to the estimated impact of weeds on soybean yields in Romania, it is probable that the level of average yield loss caused by weeds in the Romanian soybean crop is significantly higher than the estimated average loss recorded in other countries (eg, in the USA, despite the use of herbicides, weeds were estimated to cause a 7% yield loss in 1994). This weed problem in Romania, reflects the natural conditions (warm climate and fertile soils conducive for weed growth) coupled with the effect of ten years plus of very limited use of herbicides. Following the collapse of the Communist regime and the fundamental economic changes that have taken place as the Romanian economy moves to a more market oriented system, the agricultural sector has undergone major change. Farm profitability has been very low, production of most crops has fallen and subsistence farming has dominated. As a result few farmers could afford to buy in the latest high yielding certified seed varieties, to use fertilisers and to buy crop protection chemicals. Significant areas of land have been abandoned and on much of the cultivated land, the main form of weed control practiced has been hand weeding and hoeing. As a result the weed seed bank has expanded rapidly so that by the late 1990s, weeds have become the most important problem area for arable crop farmers, including soybean producers.

The main problem weeds faced by growers of soybeans in Romania include *abutilon (*velvet leaf), *Xanthium, Sorghum halepelise (*Johnson grass) and *Cirsium (*thistle).

2.4 Control of weeds in conventional soybeans

Weed control in Romanian arable crop production is, as indicated above, based on a combination of hand weeding/hoeing and use of herbicides. Hand weeding/hoeing dominates in the subsistence agriculture sector, with the use of herbicides being used mostly by commercial farmers. Nevertheless, even on commercial farms the use of herbicides has been and continues to be less than in most other soybean producing countries. Drawing on the limited data available on herbicide use on soybeans in Romania, the following key points have been identified:

- The commercial farmers interviewed in the course of the research cited active ingredients such as mesafen, fluazfop and imazetapyr as products commonly used (post emergent) to deal with weed problems. *Sorghum haleepelise,* in particular was cited as the most problematic weed that is difficult to control, with most herbicides not fully effective against it (except glyphosate – see below);
- Farm survey data for 2002 (Table 3) shows that the main herbicides used (apart from glyphosate) on soybeans are: pre-emergent – trifluralin, acetochlor, dimethenamid and metribuzin and post emergent; imazethapr, bentazone & acifluorfen, quzalofop, fluazifop and formesafan;
- The ‘full’ and recommended control practices for weeds in soybeans includes 3-5 spray runs, based on one pre-emergent spray, followed by 3 or 4 post emergent runs to deal with different weeds (and the different timing of germination of these weeds);

- Not all farmers operate to the full or recommended use of herbicides, mainly because of financial constraints. As a result, commercially grown soybean crops in Romania have been treated with a range of no herbicide spray runs at all, to upwards to 3 to 4 spray runs (ie, some spray only once or twice and only use the least expensive (usually broad-leaved) herbicides available). Drawing on herbicide usage data derived from farmer surveys, this limited use of herbicides is clearly shown (Table 3). In 2002, the total sprayed area of conventional soybeans was about 46,000 hectares. This relates to an estimated total crop area of about 23,000 hectares of conventional soybeans[7]. In other words the average number of spray runs on these crops (assuming all received at least one spray run) was about 1.98. About 15,000 hectares received one pre-emergent treatment, leaving a total post emergent spray area of about 31,000 hectares. This suggests that the average number of post emergent spray runs undertaken (assuming all of the conventional crop received some form of treatment) was about 1.34 (relative to the full or recommended number of 3-4). In reality, there are probably some areas of conventional crop receiving no herbicide treatments at one extreme and some others receiving full treatments (if all of the post emergent spray area was taken up only by farmers spraying their crop three times, this would imply that about 7,700 hectares were fully treated and 15,400 hectares received no treatment with post-emergent herbicides).

Table 3: Soybean herbicide use in Romania 2002 (hectares)

Active ingredients	Spray area	Base area	Average number of sprays
Imazethapr	12,930	12,930	1
Trifluralin	11,070	11,070	1
Bentazone	4,430	4,430	1
Acetochlor	5,840	5,840	1
Dimethenamid	3,510	3,510	1
Metribuzin	2,920	2,920	1
Acifluorfen	3,820	3,820	1
Quizalofop-P-ethyl	990	990	1
Fomesafan	180	180	1
Others			
Total use on conventional soybean crops	45,690	45,690	1
Glyphosate	61,920	40,430	1.52
Total all crops including RR soybeans	**107,610**	**86,120**	**1.25**

Source: AMIS Global
Notes: Spray area = total area sprayed, base area = base or crop area on which spraying occurred with each active ingredient

[7] Based on the total area of 66,000 hectares of which 33,000 hectares were to certified Roundup Ready varieties and an estimated further 15% (9,900 hectares) planted to farm-saved Roundup Ready seed

3 Impact of using Roundup Ready Soybeans in Romania

3.1 Nature of RR soy user

The typical profile for users of RR soybeans in Romania and features of use are as follows:

- Soybeans are grown almost entirely by commercial farmers (not subsistence farmers);
- The average size of farm growing soybeans is about 400 hectares, although this falls within a wide range (eg, 300 hectares to 20,000 hectares);
- The average size of farms growing RR soybeans is about 500 hectares. – again the range varies widely between 300 hectares and 20,000 hectares. There is however, no correlation or relationship between size of farm and adoption of the technology (none of the farmers interviewed referred to the cost of the technology as a factor affecting adoption, with some indicating that the availability of the technology on credit (until harvest) as an attraction for adoption)[8];
- A typical arable crop rotation includes maize, wheat, sunflower, soybeans and possibly lucerne, peas or oilseed rape. Soybeans are mostly grown as a break crop that precedes maize;
- The proportion of total arable land planted to soybeans each year varies by farm (see also recorded areas harvested in Figure 1). For the average farm growing RR soybeans (500 hectares), a typical area planted to soybeans is 20%-25% of the total arable area;
- Many farmers growing RR soybeans plant only RR varieties. Where farmers choose only RR varieties these are usually farmers who have used the technology in previous years. These farmers have experimented with RR soybeans in earlier years (perhaps 10%-30% of their total crop in year one) and then moved to total adoption in later years (following satisfactory experience with the technology);
- Some farmers plant a mix of RR and conventional varieties. In such cases, the RR varieties tend to account for 80%-90% of total plantings. The main reasons cited for growing some conventional varieties were limited access to irrigation water and/or equipment (ie, wanting to grow RR varieties on irrigated land only) or a shortage of RR seed relative to demand (as occurred in 2003).

3.2 Cost of the technology

RR soybeans have been commercially available to Romania farmers since 1999. This technology is sold as a package of the seed plus Roundup brand herbicide (four litres supplied for a recommended application of two litres/hectare in two spray runs).

The recommended price for sale of this package to farmers was originally set at about $160/hectare (seed supplied on the basis of four bags of 20 kgs seed, equal to 80 kgs/ha recommended seed rate) in 1999 and 2000. Since then the recommended price has fallen to $148/hectare in 2001, $135/hectare in 2002 and about $130/hectare in 2003[9]. The actual price paid by farmers for the package, however varies according to how the package is purchased, who from and the volume required. The range of prices paid by the farmers interviewed[10] was €135-€148/hectare when purchased from input distributors (applicable to most farmers) although large

[8] In contrast most other seeds and herbicides are not widely available on long term credit arrangements

[9] In Euro terms, the price has remained roughly the same 1999-2002 because of depreciation of the Euro against the Dollar (at about €145-€148/ha). In 2003, however appreciation of the Euro against the Dollar has resulted in a fall in the 'technical' price to about €120/ha – but because prices tend to be set in advance of the planting season, farmers are unlikely to have benefited from this appreciation of the Euro fully (where they buy seed in Euros)

[10] Who were mostly relating to purchases in the 2002 planting year but some also referred to current 2003 prices and others to 2001

farms (ie, over 5,000 hectares) were able to obtain substantial discounts and purchase at wholesale prices of about €110/ha.

An approximate breakdown of the component parts of the cost of the technology, as applicable for the first two years of commercialisation (1999 and 2000) in US Dollars is shown in Table 4

Table 4: Breakdown of RR soybean and herbicide package price 1999 and 2000 ($/hectare)

Seed cost	100.00
Comprising	
Technology fee	20.00
Seed cost	80.00
Herbicide cost	60.00
Total	160.00

Note: Herbicide (Roundup) = 4 litres

Farmers using RR soybean technology purchase the seed and herbicide package in the same way as they buy other inputs like seed and herbicides and are not required to sign any user licence agreement with Monsanto.

As a comparison with conventional soybean seed costs and the cost of glyphosate purchased independently (ie, not part of the package):

- Conventional, local soybean varieties from the Funduela Institute (eg, Danubiana) cost about $6-$8/bag of 20 kgs. This is equal to a seed cost of $24-$32/hectare at a seed rate of 80 kg/ha or $36-$48/ha at the more commonly applied seed rate of 120 kgs/ha (the largest farms able to obtain discounts for volume purchases access seed at about $30/ha);
- Conventional seed (non Romanian varieties that are multiplied up in Romania) supplied by companies such as Pioneer and Monsanto typically sell at $14-$16 per 20 kg bag, equal to a seed cost of $56-$64/ha at a seed rate of 80 kgs/ha, or $70-$80/ha at the more commonly applied seed rate of 100 kgs/ha;
- Roundup brand herbicide purchased independently to the RR seed (ie, for independent use on weeds) costs (in 2003) anywhere between $10/litre (recommended prices) and $7-$8/litre for large scale purchasers/users able to negotiate discounts. In the last 2-3 years, generic glyphosate products have also become registered and available to farmers in Romania. These generics trade at prices of $3-$5/litre;
- Since 1999, the price of herbicides in general, has remained broadly stable. However, with the recent availability of generic glyphosate in the market, the price of glyphosate has fallen. For example, the recommended price for Roundup brand is $10/litre compared to $15/litre in 1999;
- Prices of herbicides (other than glyphosate) commonly used on soybeans in Romania have not fallen significantly since the commercialisation of RR soybeans, as has been the case in Argentina and the USA (where prices fell in excess of one third between 1996 and 2001). This largely reflects the small size of the Romanian soybean crop relative to the significant size and importance of the soybean crops in Argentina and the USA and to the limited recent, historic use of herbicides in Romanian agriculture;
- A comparison of the cost of RR technology to farmers in Romania with the cost to farmers in the USA and Argentina (Table 5) shows some similarities and differences. In all three countries the price of the technology has fallen after initial introduction. This largely reflects increased availability of the technology in a wider range of varieties, competitive pricing of seed by different seed companies, competitive pricing of generic alternative glyphosate and, in the case of Argentina, the high use of farm-saved seed competing with certified seed. The price of the technology is currently highest in Romania mainly because of the limited availability of the technology in varieties (only in Monsanto varieties to

2003) and the limited availability of generic glyphosate alternatives in the first years of commercialisation (and the sale of the RR soybean product as a package). Given that other seed suppliers (eg, Pioneer) are expected to market RR varieties in 2004, generic glyphosate is now more freely available and the estimated quantity of farm-saved seed used is increasing rapidly, these competitive pressures are likely to result in further reductions in the price of the technology to Romanian farmers in 2004 and beyond (including the price of Roundup brand herbicide).

Table 5: Comparison of RR soybean costs to farmers in Romania, the USA and Argentina ($/hectare)

	Romania	USA	Argentina
Seed and herbicide package (2002-2003)	135	Not applicable	Not applicable
Seed premium in year one	20	17-20	25-30
Seed premium after 3-4 years of commercialisation	16.9	12-14	3.6
Approximate % seed premium (2002)	21	25-30	21
Cost of glyphosate per litre () = for generic	7-10 (3-5)	5-6	4-5

Notes:

1. Cost of seed technology estimated/derived from seed premium relative to the nearest performing conventional seed sold by the same seed supplier (company). Cost of seed in Romania after 3-4 years estimated on the basis of applying the % fall in the recommended package price to the original technology fee component
2. Farmers required to sign user licence agreements in the USA only

3.3 Impact on yield

The key finding of the farm level field research in Romania was that RR soybeans are and have been delivering a yield gain relative to conventional varieties. This gain falls within a range of +0.4 tonnes/ha and 1 tonne/ha and represents a yield increase of +16% to +50% (average +31%) relative to average base yields for the growers interviewed of 2 tonnes/ha to 2.5 tonnes/ha. The yield gain has therefore been a major benefit of adoption (see section 3.5 for impact on margins) and contrasts with findings in the USA, Argentina and Canada, where the evidence of average impact has shown to be yield neutral. The reasons why there has been a positive yield response in Romania includes the following:

- The yield gain is not due to any inherent improved vigour of the seed varieties with the RR event;
- Significantly improved weed control. As indicated earlier, conventionally grown soybeans in Romania suffer major weed infestation problems as a result of a combination of a build up in the weed seed bank (limited use of herbicides following the break down of the communist system and the subsequent economic difficulties associated with transition to a market economy), continued limited use of herbicides to date (ie, where herbicides are used the average level of use is usually well below requirements for effective control) and poor control of well established weeds like Johnson grass[11];
- Reduced soybean crop injury (eg, leave yellowing, burning, speckling, retarded growth) that may occur when some non-glyphosate based products are applied.

[11] Glyphosate has proved to be the only consistently effective control measures of well established Jonson grass weed

It should also be noted that most of the farmers interviewed indicated that their harvested yield quality was improved as a result of lower levels of weed impurities in the seed. This resulted in price premia being obtained from oilseed crushers (or reduced levels of price discount being applied), which averaged 2%-3% on the average price per tonne in previous years[12]. The impact of this premia on returns is examined further in section 3.5.

3.4 Impact on costs

The improved weed control has also enabled most growers using the technology to derive reduced costs of production. The precise impact on variable costs of production varies by user according to several factors such as the extent of weed problems suffered, effectiveness or otherwise of conventional control measures, the extent to which herbicides have been used relative to 'full' recommended levels and the type of conventional seed used (eg, local varieties from the Funduela Institute, more expensive varieties from international seed companies like Pioneer and Monsanto or farm-saved seed). Findings relating to costs of production drawn from the farm level research include the following (Table 6):

- Almost all farmers are deriving cost saving benefits from reduced herbicide use and fewer spray runs;
- For farms up to 5,000 hectares in size, the average cost saving has been €61.5/ha, within a range of €32/ha and €91/ha. This average cost saving is equal to a reduction of 29% of the variable costs referred to;
- For farms over 5,000 hectares, the average cost saving has been €44.4/ha, within a range of €11/ha and €78/ha. This average cost saving is equal to a reduction of 28% of the variable costs referred to.

The reader should note that the cost analysis presented relates to farmers that are applying the full conventional technology (ie, using 3-4 spray runs). Where farmers are not applying full conventional technology, the cost saving potential is lower (or could represent a cost increase). For example, for farms under 5,000 hectares, the breakeven point for use of the technology (in the absence of any yield gain) is between €135/ha and €148/ha and any farmer currently spending less than this range on seed and herbicides would not gain from lower production costs by using RR soybeans. There are probably some farmers who have lower costs of production than this and/or some who do not suffer significant yield loss from weed competition. For such farmers adoption of the RR soybean technology would deliver no significant cost saving and/or yield gain. Whilst it is probable that some farmers may fall within this categorisation, the evidence identified in the course of this research suggests that these are likely to be a small minority of soybean farmers.

A full comparison of cost savings with the use of RR soybeans in the USA, Argentina and Canada is not possible due to limited collection of comparable and detailed data in the USA/Canada and the wide range of performance experienced in all countries. Nevertheless, various studies have put the cost saving:

- in the US (herbicide cost savings net of any seed premium/technology fee) to be between zero(Duffy 2001) and $48/ha (Marra & Hubbell 1997) $14.8/ha (Moshini 2000);
- in Canada the cost savings from lower herbicide costs net of additional seed premium has been $Can 48/ha (Council for Biotechnology Information in Canada 2002); and
- in Argentina, the total variable cost saving, inclusive of changes in herbicide costs, seed costs, reduced number of spray runs (less fuel and use of hired labour) was about $21/ha – equal to a 10% saving on variable costs (Qaim & Traxler 2002).

[12] One farmer indicated a 10% improvement in the net price received from crushers. This farmer had previously suffered significant price discounts for having high levels of weed impurities in seed sent for crushing. The RR crop no longer suffered these discounts, being a cleaner crop

Table 6: Impact of using RR soybeans on key variable costs of production in Romania 2002-03 (€/ha)

	Farms up to 5,000 ha	**Farms up to 5,000 ha**	**Farms over 5,000 ha**	**Farms over 5,000 ha**
	Conventional	***RR***	***Conventional***	***RR***
Seed	45 (40-50)	Not applicable	40.5 (27-54)	Not applicable
Herbicide	152 (124-180)	Not applicable	109.5 (91-128)	Not applicable
Total cost of seed and herbicide	197 (164-230)	141.5 (135-148)	150 (118-182)	110
Cost of spraying	12 (9-15)	6	10.5 (9-12)	6
Total	209 (173-245)	147.5 (141-154)	160.5 (127-194)	116

Note: Values based on fewer estimates of impact applicable for 2003 and actual input in 2002. All farmers also indicated that these values are broadly representative of previous years (ie, the magnitude of changes has been similar in earlier years of adoption)
() figures = range

3.5 Impact on profitability

Analysis of the impact of using RR soybeans on the profitability of growing soybeans in Romania is presented in Tables 7-9[13]. Key impacts on profitability include the following:

Using certified seed

- average revenue gains for farmers, through an average 2% higher price associated with cleaner, harvested seed, coupled with average yield gains of 29% (smaller farms) - 33% (larger farms). This has resulted in average revenue gains of €139/ha (+32%) for farms under 5,000 ha and €147/ha (+35%) for farms over 5,000 ha (Table 7);
- average variable cost savings of between €44.5/ha and €61.5/ha (16.5%-19%: Table 7);
- average gross margin improvements of between €191.5/ha and €200.5/ha (+127% to + 184%);
- due to the variability in performance of different farms around these average figures, there are some farmers who will have derived greater increases in gross margins than the levels suggested in Table 7 and others who will have derived smaller increases in gross margins[14]. Further evidence on this range of performance is presented in appendix 1.

*Using farm-saved seed (*Table 8*)*

- revenue gains (+35%), cost savings (-43%) and gross margin improvements (+185%). These were higher than the gains for users of certified seed;
- these net gains to users of farm-saved seed move the use of farm-saved seed from delivering similar/marginally lower returns than certified seed users of conventional seed to a position where farm-saved seed of RR varieties delivers the highest level of returns (ie, higher than returns from use of certified seed). Given this it is not surprising that trade sources estimate that the level of farm-saved seed of RR varieties has increased significantly in the last two years.

[13] Additional detailed information about the impact on margins (range of performance) is presented in appendix 1
[14] For example one farmer, an above average performer, who was obtaining average yields of 3.8 tonnes/ha using conventional soybeans, indicated that when he switched to using RR soybeans the cost of the seed/herbicide package was roughly equal to the costs he had previously spent of conventional seed and herbicides. As such he did not derive any noticeable cost savings from the technology but did gain from higher yields (of about 0.4 tonnes/ha) and higher quality of the harvested seed. Overall, his variable costs remained at about €255/ha but his gross margin increased by about €88/ha (+20%)

Table 7: Impact of RR soybeans on average soybean gross margins in Romania 2002-2003 (€/ha)

	Farms under 5,000 ha	**Farms under 5,000 ha**	**Farms over 5,000 ha**	**Farms over 5,000 ha**
	Conventional	***RR***	***Conventional***	***RR***
Price	182.5	186	182.5	186
Yield	2.4	3.1	2.3	3.05
Revenue	*438*	*577*	*420*	*567*
Variable costs				
Seed	45	See herbicide	40.5	See herbicide
Fertiliser	10	10	52.5	52.5
Herbicide	152	141.5	109.5	110
Other crop protection	0	0	0	0
Cost of spraying	12	6	10.5	6
Irrigation	110	110	56.5	56.5
Total variable costs	*329*	*267.5*	*269.5*	*225*
Gross margin	**109**	**309.5**	**150.5**	**342**

Notes:

1. RR soybeans sold as a package with herbicide
2. Other crop protection – one or two farmers indicated that occasionally they spray for some pest problems (eg, spider mites) but this has been rare, hence no costs are cited

Table 8: Estimated impact of farm saved seed of RR soybeans on soybean gross margins in Romania 2002-2003 (€/ha)

	Conventional	**RR**
Price	182.5	186
Yield	2.07	2.75
Revenue	*378*	*512*
Variable costs		
Seed	19	8
Fertiliser	52.5	52.5
Herbicide	109.5	18
Other crop protection	0	0
Cost of spraying	10.5	6
Irrigation	56.5	56.5
Total variable costs	*248*	*141*
Gross margin	**130**	**371**

Notes:

1. Farm using farm-saved seed assumed to be a large farm (over 5,000 hectares) and planting 1,500-2,000 hectares of soybeans, all of which are farm-saved seed
2. Yield performance of farm-saved seed assumed to be 10% less than certified seed
3. Cost of farm-saved production (for 1,500-2,000 planted area) based on costs of conventional soybean production (see table 7) plus 40% for fixed costs
4. Farm-saved seed yield assumed to be 2.3 tonnes/ha for conventional seed of which 80% is usable as seed

Table 9: Summary of farm gross margin impact of RR soybeans in Romania 2002-03 (€/ha)

	Conventional gross margin	RR gross margin	Difference	% change
Smaller farms (under 5,000 ha)	109	309.5	200.5	+184
Larger farms (over 5,000 ha)	150.5	342	191.5	+127
Larger farms using farm-saved seed	130	371	241	+185

A comparison of the impact of RR soybean technology on gross margin profitability in Romania with other countries where the technology has been commercialised (notably the USA, Argentina and Canada shows mostly similarities but some differences. Of particular note are the following:

- In the USA, where a significant number of studies have been undertaken, there is conflicting evidence about impact on profitability. This however, is not surprising given the wide range of climatic and weed pressure differences faced by farmers and the different baseline information (eg, on base yields and costs) used in different studies. Some of the early studies that examined impact in the first 2-3 years of adoption suggested little or no increase in profitability (eg, USDA 1999[15], Duffy & Vontalage 1999), whilst others suggested positive increases in profitability (eg, of $14.83/ha-$23.71/ha (Furmen & Selz 1998) and $14.82/ha (Marra et al)). The reader should note that in the USA, none of the studies to date have examined impact over a number of years, many are based on trials data (not commercial farm experience) and in the first 2-3 years of adoption the RR technology was not available in all leading varieties (hence adoption by some farmers resulted in switching to a lower yielding variety). More recent studies conducted in other countries (see below) does suggest that, in general adoption of RR soybeans results in improvements in farm profitability for the majority of adopting farmers;
- the Council for Biotechnology Information in Canada (2002), based on farmer survey work found that, for growers in Ontario, GM soybeans produced higher returns in the two years 2000 and 2001. This mainly reflected the lower variable costs of production (yields were roughly the same), which more than offset the small price premia available for non GM soybeans[16];
- Qaim & Traxler (2002) found a clear gross margin profitability benefit of $21.71/hectare (+8%) in Argentina;
- These comparisons with Romania suggest that the improvements to farm profitability arising from adoption of RR soybeans have, on average been significantly higher in Romania than in other adopting countries. This mainly derives from the important yield improvements that Romanian farmers have obtained, via improved weed control.

3.6 Other impacts and issues

3.6.1 Convenience and increased management flexibility

Some of the farmers interviewed indicated that adoption of RR soybeans had increased management flexibility that comes from a combination of the ease of use associated with glyphosate and the increased/larger time window for spraying. In addition, treatment could be made when the crop is well established and less vulnerable to the herbicide (less risk of crop damage). Whilst this impact was cited by some farmers it appears to be less important to

[15] That looked at the 1997 harvest only

[16] In 2001 non GM soybeans had a 1.1% price premia relative to GM soybeans, whilst in 2000, the premia was 3.8%

Romanian farmers than their counterparts in the USA, Argentina and Canada – this probably reflects the more limited, historic use of herbicides in Romania.

3.6.2 Facilitation of low or no tillage husbandry

In North and South America this has been cited as an important reason for adoption by many farmers (providing cost savings from reduced labour and fuel costs associated with ploughing). In Romania, however adoption of RR soybeans has not led to or contributed to any increase in use of low or no tillage systems. None of the farmers interviewed cited this as a benefit of adoption. The main reasons why Romanian farmers have not adopted low/no tillage systems are a) the need for specialist equipment and machinery that few can afford and b) many farms being located on clay soils that are difficult to apply low/no tillage systems (without specialist equipment/machinery).

3.6.3 Reduced harvesting costs

Some of the farmers interviewed indicated that they had reduced their harvesting costs by a small amount as a result of using RR soybeans. This saving arose from having less weeds in the crop which facilitated quicker harvesting. None of the farmers were, however able to estimate a monetary value to this small saving.

3.6.4 Benefits to follow-on crops

Benefits to follow on crops were cited as a major benefit of using RR soybeans by most farmers. This essentially arises from the improvements in control of difficult weeds that would have otherwise adversely affected follow on crop establishment and yields. In particular, follow on crops of maize were benefiting from the adoption of RR soybeans because the fields were cleaner and required reduced levels of herbicide application on the maize crops. Against the baseline of average herbicide expenditure per hectare on maize (by commercial maize growers) of about €70/ha, the perceived savings were anywhere between €10/ha and €70/ha[17] .

In addition, most farmers are using RR soybeans as a general 'cleaning' crop for their farms, rotating the area planted to soybeans around the farm over a number of years as an effective way of improving whole farm weed control.

3.6.5 Marketing of the crop

All of the farmers interviewed indicated that their RR soybean crops were sold via normal marketing channels, without any requirement to segregate GM from non GM crops. There is no apparent market differentiation between GM and non GM soybean crops in Romania and hence no price differentials between the two crops. Whilst it is probable that there is some demand for non GM and/or organic soybeans in Romania (including possible demand for export markets), the evidence gathered in the course of this research suggests that such a market is currently small.

3.6.6 Possible incidence of weeds and volunteers resistant to glyphosate and weed bio-diversity issues

The development of weeds resistant to herbicides is not a new development in agriculture. It occurs mostly when the same herbicide(s), with the same mode of action have been applied on a continuous basis over a number of years.

As glyphosate is the primary herbicide used in GM (herbicide tolerant) soybeans, it is possible that glyphosate use could lead to the emergence of weeds resistant to glyphosate and to weed shifts towards those weed species that not well controlled by glyphosate. In addition, it is possible that

[17] One farmer estimated that the use of RR soybeans resulted in a saving of about €70/hectare in herbicide costs on maize because the fields were cleaner – this implies that he either did not need to spray his subsequent maize crop or he was using more than the average level of expenditure

herbicide tolerant soybean plants could become volunteers in a subsequent crop which cannot be controlled by using glyphosate. Evidence to date on these issues suggests:

- There are no reported instances of glyphosate resistance in weeds in Romania. This is not surprising given the recent historic pattern of limited herbicide use *per se* and of glyphosate in particular. Elsewhere in the world (where glyphosate use has been greater than in Romania) there are only limited reports of weed resistance to glyphosate (eg, in Australia with ryegrass and in the USA with ryegrass, horseweed, marestail and water hemp (Van Gessel 2001, Heap 2000 and Harzler 1999). In all cases these examples of resistance build up were in conventional crops;
- None of the farmers interviewed reported any incidence of RR soybean volunteers occurring or being problems in subsequent crops. This finding is similar to the reports from the USA (Hin et al 2001). In all cases, farmers indicated that if they were to find RR soybean volunteers in subsequent crops these would be easily controlled through the current, normal herbicide-based, weed control measures taken in following crops (that are not based on glyphosate[18]);
- Weed bio-diversity is 'not an issue' to the farmers interviewed in Romania. Weed problems (ie, the abundance of weeds) is one of the main issues facing Romanian agriculture.

Looking forward many years it is possible weed resistance to glyphosate and weed shifts may occur[19] and therefore farmers may eventually have to supplement their glyphosate treatments with other herbicides to give adequate weed control. To the extent to which these problems might occur, this will add cost to farmers who are required to use additional levels of glyphosate or include low dose applications of other herbicides in their weed control programmes[20]. For example in Australia, where instances of glyphosate resistant weeds have been found, farmers increasingly use other herbicides like trifluralin as a pre-sowing treatment instead of glyphosate. This may therefore reduce, marginally, the average level of cost saving and profit gains cited earlier.

3.6.7 Environmental impact: use of herbicides

Examination of the impact of RR soybeans on the use of herbicides on arable crops like soybeans in Romania is difficult because of the limited availability of consistent data on herbicide use and the impact of recent/continued economic transition to a market economy on the structure and practices in agriculture. In particular, over the last 12-13 years, there has been limited use of conventional weed control practices (ie, use of herbicides) because of low levels of profitability, limited access to financial resources, re-structuring in the input supply and distribution chain and the break-up of state farms which has resulted in an increase in land being either left idle or farmed on a subsistence basis. In addition, the area planted to soybeans has fluctuated significantly over the last five years which means that data relating to areas sprayed and kilo-grammes of herbicide product used has also varied (Table 10). The available information on soybean herbicide use in Romania since 1996 (Table 10) shows few clear trends apart from the increase in the use of glyphosate from zero use in 1996 to being the main product used on soybean crops in 2002. Thus, some positive environmental benefit may have accrued through the displacement of some herbicides that are more persistent and residual in the soil than glyphosate (see also the comparisons with the impact of using RR soybeans in the USA and Argentina below).

[18] Some of the farmers also indicated that if RR maize was planted, RR soybean volunteers would also not be problem because they would simply have to add a non glyphosate based product to their herbicide tank mix in order to obtain adequate control

[19] Given the limited use of glyphosate to date in Romania and drawing on evidence of the limited incidence of glyphosate-resistant weeds having developed globally, any possible development of glyphosate-resistant weeds in Romania may take 15-20 years to materialise

[20] Farmers could also revert to conventional cropping and crop protection practices

No conclusions should be drawn from the data relating to the average volume of product sprayed per hectare or on the average number of treatments per ha because of disparities between the sources used (their methodologies), the lack of information relating to the proportion of the total crop that receives no herbicide treatments at all and a lack of information on areas planted (as distinct to areas harvested). No firm conclusions should also be drawn from examining trends in herbicide usage since 1996[21] because of the effect of 'economic shock adjustments' in the Romanian economy and agricultural sector. Specifically, the base years presented for the pre-RR soybean usage (1996 and 1998) were years in which herbicide use was probably significantly below the 'norm' that might otherwise have been used if the agricultural sector had not been undergoing fundamental structural change and it is not possible to assess what level of herbicides might otherwise have been used in 2002, if RR soybeans had not been introduced in 1999.

Table 10: Herbicide usage on soybeans in Romania 1996-2002

	1996	**1998**	**2000**	**2002**
Area treated (sprayed area: hectares)				
Glyphosate	0	15,000	45,590	61,920
Other herbicides	169,100	219,400	164,150	47,360
Total area treated	169,100	234,400	209,740	109,280
Area harvested	80,180	144,300	90,708	66,000
Kgs of product used				
Glyphosate	0	16,200	37,260	54,140
Other herbicides	67,660	100,850	119,280	34,340
Total	67,660	117,050	156,540	88,480
Average volume of product (kgs)/ha sprayed	0.4	0.5	0.75	0.81
Average number of sprays per hectare harvested	2.11	1.62	2.31	1.66

Sources: 1996 and 1998 Sigma (Produce Studies), 2000 and 2002 (AMIS Global)
Notes:

1. Average number of sprays per hectare is probably overstated because the area planted is usually higher than the area harvested. However, the difference between the area planted and harvested varies each year according to weather factors (eg, drought) and access to irrigation. There is no consistent data available on areas planted
2. It has not been possible to derive herbicide use per base area of crop planted because there is no information on what proportion of the total crop is treated with herbicides. Inevitably some of the crop area probably receives no herbicide treatments at all, some one treatment per year and others higher numbers of treatments
3. The two sources of data used are not consistent. AMIS Global is based on farmer surveys, which, since they began in 2000, cover about 60-65% of the total soybean crop area in the country. Sigma data is estimated on the basis of herbicide product sales information obtained from input suppliers

A comparison of studies that have included environmental impact of using RR soybeans in other countries shows the following:

[21] As might reasonably be undertaken in some of the other RR soybean adopting countries like the USA and Argentina which have not undergone fundamental economic transition during this period

USA
The Economic Research Service of the USDA[22] identified the following key findings:

- Average pesticide use (in terms of area sprayed) of adopters was 2.5% and 4.4% less than non adopter use in 1997 and 1998 respectively (referring to adopters/non adopters of GM maize, soybeans and cotton). Within this, herbicide tolerant soybean adopters accounted for over half of the total difference in 1998;
- In terms of active ingredient applied, there was a net decrease in usage of 0.798 million kgs on US soybeans in 1998 compared to 1997. This derived from an increase in use of glyphosate (2.45 million kgs), which was substituted for 3.26 million kgs of other herbicides (eg, imazethapyr, pendimethalin, trifluralin). As glyphosate has a half-life in the environment of 47 days, compared to 60-90 days for the herbicides it commonly replaces, this suggests that glyphosate is replacing herbicides that are between 3.4 and 16.8 times more toxic than glyphosate[23]. This means that the adoption of herbicide tolerant soybeans is resulting in the replacement of other synthetic herbicides that are three times as toxic and that persist in the environment nearly twice as long as glyphosate;
- The average annual rate of glyphosate application on soybeans increased from 0.19 kgs/hectare in 1996 to 0.48 kgs/hectare in 1998, whilst the average application rate for all other herbicides fell from about 1.12 kgs/hectare to 0.64 kgs/hectare over the same period, This equates to a 10% net decrease in herbicide use on soybeans during this period.

Similar findings were identified by Carpenter and Gianessi (2001) based on examination of USDA herbicide usage data. This analysis found that the use of glyphosate has increased from being used on about 20% of the area planted in 1995 (mainly as a burn out or spot treatment), to being used on 62% of the total area planted in 1999. The use of other herbicides decreased. Imazethapyr use (the most widely used herbicide in 1995) fell from being used on 44% of the total area planted in 1995 to 16% in 1999 and the use of Pendimethlin (the second most used herbicide in 1995) fell from being used on 26% of the total crop in 1995 to 14% in 1999. In terms of herbicide application rates these fell by 12% between 1995 and 1999 even though the area planted to soybeans increased by 18% over the same period. This, therefore highlighted the significant decrease in herbicide applications and use of active ingredients.

Argentina
Qaim & Traxler (2002) found that whilst the average number of herbicide applications[24] and the volume of active ingredient applied to crops rose using GM soybeans (eg, the average number of applications rose to 2.3 relative to 1.97 for conventional soybeans), there was a significant reduction on the use of herbicides with a relatively higher toxicity rating (classes II (-83%) & III (-200%)). The main reason for the increase in the number of herbicide applications was associated with increased use of no tillage practices and the need for a pre-seeding weed treatment.

[22] Genetically engineered crops: has adoption reduced pesticide use? (2000)
[23] According to the US Environmental Protection Agency chronic risk indicators for human exposure
[24] In contrast to the US experience, where decreased numbers of applications were reported (Carpenter 2001), Fernandez-Cornejo & McBride (2000)

4 National level impact of using RR soybeans

Building on the evidence presented in section 3, this section briefly examines the probable aggregated impact of using RR soybeans in Romania.

4.1 Production

The estimated impact on Romanian soybean production is summarized in (Table 11). Assuming a base area of 75,000 hectares (the 2003 forecast area) is planted to soybeans and 57% of this crop is RR soybeans (based on estimated certified seed sale and farm-saved seed use in 2003) and the estimated benefit of the technology is between +29% and +33% on yield, the net impact is likely to result in additional production of about 29,000 to 33,500 tonnes (a 16% - 19% increase). In value terms (at the farm level), this is equal to an additional €54.39 to €62.4 million.

Table 11: Aggregated impact on Romanian soybean production of using RR soybeans in 2003

	Yield effect +29%	**Yield effect +33%**
Area of RR soybeans (hectares)	43,000	43,000
Average yield conventional soybeans (tonnes/ha)	2.35	2.35
Yield impact of RR soybeans (tonnes/ha)	+0.68	+0.78
Impact on production (tonnes)	+29,240	33,540
% change in total production (2003 crop area and average conventional yield = baseline)	+16.6%	+19%

Notes:

1. Average yield = based on farmer interviews

4.2 Farm level income

Drawing on the analysis presented in section 3.5 for the impact of the technology on adopting farmers gross margins, the positive contribution to farm gross margins is between €191.5/ha and €200.5/ha[25]. If these levels of benefit are applied to the estimated area planted to RR soybeans in 2003, this produces a positive contribution to farm income of RR soybeans of €8.23-€8.62 million for the year.

4.3 Impact on the economy

On the basis of the additional production of soybeans generated from using RR soybeans shown in Table 11, the additional, annual production of soybeans (+29,240 to +33,540 tonnes) is equal to about 14%-19% of total soybean use in 2001-02[26] (Table 12). This additional production is therefore contributing to reducing the import requirement for the domestic crushing and user sectors. Using the average European import price for soybeans in 2001-2[27] of about €200/tonne as a benchmark price, this equates to an annual import substitution value of €5.8-€6.7 million.

[25] Assuming certified seed is used
[26] Based on an average yield of 2.35 tonnes/ha
[27] Cif Rotterdam

Table 12: Romania soybean and key derivative use 2001-02 ('000 tonnes)

Opening stocks	11
Domestic production	75
Imports	150
Exports	15
Supply availability	221
Crushed	195
Whole bean uses	12
Closing stocks	14
Soy oil: domestic use	30
Soy oil: derived from domestic crushing	33.5
Soybean meal: domestic use	335
Soybean meal derived from domestic crushing	156

Source: Oil World

Appendix 1: Gross margin impact (range) of using RR soybeans

Euros/ha	**Farms under 5,000 ha**	**Farms under 5,000 ha**	**Farms over 5,000 ha**	**Farms over 5,000 ha**
	Conventional	***RR***	***Conventional***	***RR***
Price	182.5	186	182.5	186
Yield	2.0-3.2	3.0-3.6	2-2.5	3-3.3
Revenue	*365-584*	*558-670*	*365-456*	*550-614*
Variable costs				
Seed	40-50	See herbicide	27-54	See herbicide
Fertiliser	0-20	0-20	32-73	32-73
Herbicide	124-180	135-148	91-128	110
Other crop protection	0	0	0	0
Cost of spraying	9-15	6	9-12	6
Irrigation	110	110	40-73	40-73
Total variable costs	*283-375*	*251-284*	*199-340*	*188-262*
Gross margin	**-10 to +301**	**+274 to +419**	**+25 to +257**	**+288 to +426**

Bibliography

AMIS Global (2000-2002) Herbicide usage on soybeans in Romania data, personal communication
Carpenter J & Gianessi L (1999) Herbicide tolerant soybeans: Why growers are adopting Roundup ready varieties, Ag Bioforum, Vol 2 1999, 65-72
Carpenter J & Gianessi L (2001) Agricultural biotechnology: updated benefit estimates, National Centre for Food & Agriculture Policy, Washington
Carpenter J (2001) Comparing Roundup ready and conventional soybean yields 1999, National Centre for Food & Agriculture Policy, Washington
Carpenter et al (2002) Comparative environmental impacts of biotech-derived and traditional soybeans, corn and cotton crops, Council for Agricultural Science and Technology (CAST), USA
Carpenter J & Gianessi L (2002) Agricultural Biotechnology: updated benefit estimates, National Centre for Food and Agricultural Policy (NCFAP), Washington, USA
Coceral (2002) Crop Forecasts various from 2001 and 2002, Brussels
Council for Biotechnology Information Canada (2002) Agronomic, economic and environmental impacts of the commercial cultivation of glyphosate tolerant soybeans in Ontario
Duffy M (1999) Does planting GMO seed boost farmers profits?
Duffy M & Vontalge A (1999) Estimated costs of crop production in Iowa 1999, Iowa State University Extension, Fm 1712
Duffy M (2001) Who benefits from biotechnology ?, Presentation to the American Seed Trade Association, Chicago, Dec 2001
Fernandez-Cornejo J & Klotz-Ingram C (1998) Economic, environmental and policy impacts of using GE crops for pest management. Presented to 1998 NE Agricultural & Resource Economics Association, Itthaca, USA. Cited in Fernandez-Cornejo J & McBride W (2000)
Fernandez-Cornejo J & McBride W (2000) Genetically engineered crops for pest management in US agriculture: farm level benefits, USDA, ERS Agricultural Economics Report No 786
Fernandez-Cornejo J & McBride W (2002) Adoption of bio-engineered crops, USDA, ERS Agricultural Economics Report No 810
Fernandez-Cornejo J, Heimlich R & McBride W (2000) Genetically engineered crops: has adoption reduced pesticide use, USDA Outlook August 2000
Fernandez-Cornejo J & McBride W (2000) Genetically engineered crops for pest management in US agriculture, USDA Economic Research Service report 786
Food and Agriculture Organisation (2003) Agricultural production statistical database, www.fao.org
Furmen M & Selz L (1998) Farmer Economics for biotech seeds, consultant report cited in OECD (2000) Modern biotechnology & agricultural markets: a discussion of selected issues, AGR/CA/APM/2000/5 Final
Gianessi L & Carpenter J (2000) Agricultural biotechnology: benefits of transgenic soybeans, National Centre for Food & Agricultural Policy, Washington
Hartzler B (1999) Are Roundup Ready weeds in your future, Dept of Agronomy, Iowa State University Extension Service. Cited in Hin C, Schenkelaars P, Pak G (2001) Agronomic & environmental effects of commercial cultivation of glyphosate tolerant soybeans in the USA, Dutch Centre for Agriculture & Environment, Utrecht
Heap I (2000) The occurrence of herbicide resistance weeds worldwide. Pesticide science, vol 51, 235-243. Cited in Hin C, Schenkelaars P, Pak G (2001) Agronomic & environmental effects of commercial cultivation of glyphosate tolerant soybeans in the USA, Dutch Centre for Agriculture & Environment, Utrecht
Hin C, Schenkelaars P, Pak G (2001) Agronomic & environmental effects of commercial cultivation of glyphosate tolerant soybeans in the USA, Dutch Centre for Agriculture & Environment, Utrecht
Ionescude la Brid I et al (2003) Fitotehnie, Editura 2003
Lin W et al (2001) Farm level effects of adopting herbicide tolerant soybeans in Oil Crops Situation and Outlook, USDA OCS 2001
Marra M, Carlson G & Hubbell B (1997) Economic impacts of the first crop biotechnologies, North Carolina Agricultural Research Service – in see below reference by the same author
Marra M, Pardey P & Alston J (2002) The pay-offs of agricultural biotechnology: an assessment of the evidence, International Food Policy Research Institute, Washington, USA
Moschini G, Lapan H & Sobolevsky A (2000) Roundup ready soybeans and welfare effects in the soybean complex, Iowa State University, Agribusiness vol 16: 33-55
OilWorld (2002) Oil World Annual 2002, Oil World, Hamburg, Germany

Produce Studies Research (2003) Sigma database on herbicide usage on soybeans in Romania 1996 and 1998, personal communication, UK
Qaim M & Traxler G (2002) Roundup Ready soybeans in Argentina: farm level, environmental and welfare effects, 6th ICABR conference, Ravello, Italy
USDA (1999) Farm level effects of adopting genetically engineered crops, preliminary evidence from the US experience, Economic Issues in Agricultural Biotechnology