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The Farm-Level Impact of Herbicide-Tolerant Soybeans in Romania

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This paper examines the farm-level impact of use of genetically modified herbicide-tolerant (GM HT) soybeans in Romania. It covers the context of soybeans in Romania, weeds, conventional control measures, and the impact of using herbicide-tolerant technology. Impact on yields, costs of production, and profitability are examined; GM HT technology is shown to have had a significant positive impact on yields and profitability. Estimates of the production impact at a national level and the environment are also made. The adoption of the technology has delivered major improvements in farm income, mostly from yield enhancements associated with improved weed control.

Key words: cost, environment, gross margin, herbicides, herbicide tolerant, weeds, yield.

Introduction

The commercial planting of genetically modified herbicide-tolerant (GM HT) soybeans has been permitted in Romania since 1999. This paper examines the farm-level impact over the period 1999–2003. The research used a combination of desk research/analysis and field work 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 (Calarasi and Ialomita) were interviewed. In total, the farmers interviewed accounted for about 13% and 24%, respectively, of total soybean plantings and Roundup Ready (RR) soybean plantings in 2003.[1] The field research took place in May 2003.

Soybean Plantings

In recent years, the area planted to soybeans in Romania has fluctuated considerably. At the beginning of the 1990s and immediately after the collapse of the Communist system, soybean plantings were about 190,000 ha. This area declined until the middle to late 1990s; since then, there has been significant annual fluctuation in plantings and harvested areas. In 2003, the area planted was 120,000 ha. Genetically modified HT soybeans were first grown commercially in 1999 (15,500 ha). Since then, the area planted has increased to about 70,000 ha in 2004.

1. *This included farmers growing both Roundup Ready and conventional soybeans.*

Weed Pressure in Romania

Weeds are a major problem faced by all arable crop farmers in Romania. Weeds contribute significantly to reduced yields and to downgrading of crops sold because of the presence of weed material in deliveries to buyers and users. Although 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 (e.g., in the United States, despite the use of herbicides, weeds were estimated to cause a 7% yield loss in 1994; Gianessi & Carpenter, 2000). This weed problem in Romania reflects the natural conditions (warm climate and fertile soils conducive to weed growth) coupled with the effect of 10-plus years of very limited herbicide use.

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 changes. Farm profitability has been very low, production of most crops has fallen, and subsistence farming has dominated. As a result, few farmers can afford to buy the latest high-yielding certified seed varieties, use fertilizers, or buy crop protection chemicals. Significant areas of land have been abandoned, and on much of the cultivated land, the main form of weed control has been hand weeding and hoeing. The weed seed bank has expanded so rapidly that by the late 1990s, weeds had become the most important problem for arable crop farmers, including soybean producers. The main problem weeds faced by growers of soybeans in Romania include *Abutilon* (velvetleaf), *Xanthium,* *Sorghum halepense* (Johnsongrass), and *Cirsium* (thistle).

Control of Weeds in Conventional Soybeans

Hand weeding and hoeing dominates in the subsistence agriculture sector, with the use of herbicides being limited mostly to 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 (Table 1), several key points have been identified.

The commercial farmers interviewed cited active ingredients such as mesafen, fluazfop, and imazetapyr as postemergent products commonly used to deal with weed problems. Johnsongrass, in particular, was cited as the most problematic and difficult-to-control weed, with most herbicides (except glyphosate) not fully effective against it. Farm survey data for 2002 (Table 1) shows that the main herbicides used (apart from glyphosate) on soybeans are trifluralin, acetochlor, dimethenamid, and metribuzin (preemergent) and imazethapyr, bentazon + acifluorfen, quizalofop, fluazifop, and fomesafen (postemergent).

The full and recommended control practices for weeds in soybeans includes three to five spray runs, based on one preemergent spray, followed by three or four postemergent 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 of three to four spray runs (i.e., some farmers spray only once or twice and use only the least expensive—usually broad-leaved—herbicides available).

Impact of Using Genetically Modified Herbicide-Tolerant Soybeans in Romania

Nature of GM HT Soybean Users and Farms

Soybeans in Romania are grown almost entirely by commercial farmers, not subsistence farmers; the average size of all soybean-growing farms is about 400 ha. The average size of farms growing RR soybeans is about 500 ha; the range varies widely between 300 and 20,000 ha. 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, although some indicated that the availability of the technology on credit (until harvest) was an incentive for adoption.[2]

Table 1. Soybean herbicide use in Romania, 2002.

Active ingredients	Spray area[a] (ha)	Base area[b] (ha)	Average # of sprays
Imazethapyr	12,930	12,930	1
Trifluralin	11,070	11,070	1
Bentazon	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
Fomesafen	180	180	1
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

Note. Data from AMIS Global (personal communications, 2000–2002).
[a] Spray area = total area sprayed.
[b] Base area = base or crop area on which spraying occurred with each active ingredient.

The proportion of total arable land planted to soybeans each year varies by farm. For the average farm growing GM HT soybeans, a typical area planted to soybeans is 20–25% of the total arable area. Many farmers growing GM HT soybeans plant only GM HT varieties. These farmers experimented with GM HT 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.

A typical arable crop rotation in Romania includes maize, wheat, sunflower, soybeans, and possibly lucerne, peas, or oilseed rape. Soybeans are mostly grown as a break crop before maize.

Cost of the Technology

Genetically modified HT soybean technology is sold as a package of seed plus Roundup herbicide (4 L supplied

2. *By contrast, most other seeds and herbicides are not widely available on long-term credit arrangements.*

for a recommended application of 2 L/ha in two spray runs). The recommended price of this package to farmers was originally set at about \$160/ha in 1999 and 2000.[3] Since then, the recommended price fell to \$148/ha in 2001, \$135/ha in 2002, and about \$130/ha in 2003. The actual price paid by farmers for the package, however, varies according to how the package is purchased, who it is purchased from, and the volume required. The range of prices paid by the farmers interviewed was €135–148/ha when purchased from input distributors (applicable to most farmers), although large farms (i.e., over 5,000 ha) were able to obtain substantial discounts and purchase at wholesale prices of about €110/ha.

These prices compare with conventional soybean seed costs as follows: Conventional local soybean varieties from the Funduela Institute (e.g., Danubiana) cost about \$6–8 per 20-kg bag. This is equal to a seed cost of \$24–32/ha at a seed rate of 80 kg/ha or \$36–48/ha at the more commonly applied seed rate of 120 kg/ha. The largest farms (which are able to obtain discounts for volume purchases) access conventional local seed at about \$30/ha. Conventional non-Romanian seed 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 kg/ha or \$70–80/ha at the more commonly applied seed rate of 100 kg/ha.

Roundup herbicide purchased independently from GM HT seed (i.e., for independent use on weeds and not part of the package described above) cost between \$10/L (recommended prices) and \$7–8/L in 2003 for large-scale purchasers able to negotiate discounts. In the last two to three years, generic glyphosate products have also become registered and available to farmers in Romania. These generics trade at prices of \$3–5/liter. 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 was \$10/L in 2003, compared to \$15/L in 1999.

Impact on Yield

The key finding of this research was that GM HT soybeans are and have been delivering a yield gain relative to conventional varieties. This gain falls within a range of 0.4–1 t/ha and represents a yield increase of 16–50% (average 31%) relative to average base yields for the growers interviewed of 2–2.5 t/ha. The yield gain has therefore been a major benefit of adoption and contrasts with findings in the United States, Argentina, and Canada (Brethour, Mussell, Mayer, & Martin, 2002; Carpenter & Gianessi, 2001, 2002; Fernandez-Cornejo & McBride, 2000; Marra, Pardey, & Alston, 2002; Qaim & Traxler, 2002), where the evidence of average impact has shown to be yield neutral.

The positive yield response in Romania has occurred for several reasons. First, weed control is significantly improved. As indicated earlier, conventionally grown soybeans in Romania suffer major weed infestation problems as a result of a combination of a buildup in the weed seed bank (due to the limited use of herbicides following the breakdown of the communist system and the subsequent economic difficulties associated with transition to a market economy), continued limited use of herbicides to date (i.e., where herbicides are used, the average level of use is usually well below requirements for effective control), and poor control of well-established weeds such as Johnsongrass.[4] Second, GM HT technology results in reduced soybean crop injury (e.g., leaf yellowing, burning, speckling, retarded growth) that may occur when some non-glyphosate-based products are applied. 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 per-tonne price in previous years.

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, including the extent of weed problems suffered, the 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 (e.g., local varieties from the Funduela Institute, more expensive varieties from international seed companies like Pioneer and Monsanto, or farm-saved seed).

3. *Seed supplied on the basis of four 20-kg bags of seed, equal to 80 kg/ha recommended seed rate.*

4. *Glyphosate has proven to be the only consistently effective control measure for well-established Johnsongrass.*

Table 2. Impact of using GM HT soybeans on key variable costs of production in Romania, 2002–2003 (€/ha).

	Farms smaller than 5,000 ha		Farms larger than 5,000 ha	
	Conventional	GM HT	Conventional	GM HT
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 are 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 (i.e., the magnitude of changes has been similar in earlier years of adoption). Ranges are shown in parentheses.

Table 3. Impact of GM HT soybeans on average soybean gross margins in Romania, 2002–2003 (€/ha).

	Farms smaller than 5,000 ha		Farms larger than 5,000 ha	
	Conventional	GM HT	Conventional	GM HT
Price	182.5	186.0	182.5	186.0
Yield	2.4	3.1	2.3	3.1
Revenue	438.0	577.0	420.0	567.0
Variable costs				
Seed	45.0	See herbicide	40.5	See herbicide
Fertilizer	10.0	10.0	52.5	52.5
Herbicide	152.0	141.5	109.5	110.0
Other crop protection[a]	0.0	0.0	0.0	0.0
Cost of spraying	12.0	6.0	10.5	6.0
Irrigation	110.0	110.0	56.5	56.5
Total variable costs	329.0	267.5	269.5	225.0
Gross margin	109.0	309.5	150.5	342.0

Note. RR soybeans sold as a package with herbicide.
[a] One or two farmers indicated that occasionally they spray for some pest problems (e.g., spider mites) but this has been rare, hence no costs are cited for other crop protection.

Findings relating to farm-level costs of production (Table 2) show that almost all farmers are deriving cost-saving benefits from reduced herbicide use and fewer spray runs. For farms up to 5,000 ha in size, the average cost saving has been €61.5/ha with a range of €32–91/ha. This average cost saving is equal to a reduction of 29% of the variable costs referred to. For farms larger than 5,000 ha, the average cost saving has been €44.4/ha with a range of €11–78/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 (i.e., using three or four 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 smaller than 5,000 ha, the breakeven point for use of the technology (in the absence of any yield gain) is between €135/ha and €148/ha; any farmer currently spending less than this 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. Although it is probable that some farmers may fall within this categorization, the evidence identified in the course of this research suggests that these are likely to be a small minority of soybean farmers.

Impact on Profitability

Analysis of the impact of using GM HT soybeans on the profitability of growing soybeans in Romania is presented in Tables 3 and 4. For farms using certified seed, an average 2% higher price associated with cleaner harvested seed, coupled with average yield gains of 29%

Table 4. Estimated impact of farm-saved seed of GM HT soybeans on soybean gross margins in Romania, 2002–2003 (€/ha).

	Conventional	RR
Price	182.5	186.0
Yield	2.1	2.8
Revenue	378.0	512.0
Variable costs		
Seed	19.0	8.0
Fertilizer	52.5	52.5
Herbicide	109.5	18.0
Other crop protection	0.0	0.0
Cost of spraying	10.5	6.0
Irrigation	56.5	56.5
Total variable costs	248.0	141.0
Gross margin	130.0	371.0

Note. Farms using farm-saved seed are assumed to be large farms (larger than 5,000 ha) planting 1,500–2,000 ha of soybeans, all of which are farm-saved seed. Yield performance of farm-saved seed is assumed to be 10% less than certified seed. Costs of farm-saved production (for 1,500–2,000 ha planted area) are based on costs of conventional soybean production plus 40% for fixed costs. Farm-saved seed yield is assumed to be 2.3 t/ha for conventional seed, of which 80% is usable as seed.

(farms smaller than 5,000 ha) to 33% (farms larger than 5,000 ha), resulted in average revenue gains of €139/ha (32%) for smaller farms and €147/ha (35%) for larger farms. Table 3 indicates average variable cost savings of €44.5–61.5/ha (16.5–19%) and average gross margin improvements of €191.5–200.5/ha (+127–184%). 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 3 and others who will have derived smaller increases in gross margins.

Farms using farm-saved seed experienced revenue gains of 35%, cost savings of 43%, and gross margin improvements of 185% (Table 4). These gains—higher than those of certified seed users—move the use of farm-saved seed from delivering similar (or marginally lower) returns than certified seed users of conventional seed to a position where farm-saved seed of GM HT varieties delivers the highest level of returns (i.e., 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 GM HT varieties has increased significantly in the last two years.

Other Impacts and Issues

Convenience and Increased Management Flexibility

Some of the farmers interviewed indicated that adoption of GM HT soybeans had increased management flexibility through a combination of the ease of use associated with glyphosate and the larger time window for spraying. In addition, treatment can be made with less risk of crop damage when the crop is well established and less vulnerable to the herbicide. Although this impact was cited by some farmers, it appears to be less important to Romanian farmers than their counterparts in the United States, Argentina, and Canada (Brethour et al., 2002; Carpenter & Gianessi, 2002; Qaim & Traxler, 2002; United States Department of Agriculture, 1999)—this probably reflects the more limited historic use of herbicides in Romania.

Facilitation of Low/No-Tillage Husbandry

In North and South America, low- or no-tillage husbandry has been cited as an important reason for adoption by many farmers—it provides cost savings through reduced labor and fuel costs associated with plowing. In Romania, however, adoption of GM HT soybeans has not contributed to any increase in the use of low/no-tillage systems. None of the farmers interviewed cited this as a benefit of adoption. Romanian farmers have not adopted low/no-tillage systems because few can afford the specialized equipment and machinery required. Furthermore, many farms are located on clay soils that are difficult to apply low/no-tillage systems to without additional specialized equipment or machinery.

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 GM HT 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.

Benefits to Follow-On Crops

Benefits to follow-on crops were cited as a major benefit of using GM HT soybeans by most farmers. These benefits essentially arise from 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 GM HT soybeans, because the fields were cleaner and required reduced levels of herbicide application on the maize crops. Against the baseline of average per-hectare herbicide expenditure on maize by commercial maize growers of about €70/ha, the perceived savings were anywhere between €10/ha and €70/ha. In addition, most farmers are using GM HT 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.

Marketing of the Crop

All of the farmers interviewed indicated that their GM HT 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. Although 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.

Environmental Impact: Use of Herbicides

Examination of the impact of GM HT soybeans on the use of herbicides on arable crops in Romania is difficult because of the limited availability of consistent data on herbicide use and the impact of recent and continued economic transition to a market economy on the structure and practices of agriculture. In particular, over the last 12–13 years there has been limited use of conventional weed control practices (i.e., herbicides) because of low levels of profitability, limited access to financial resources, restructuring in the input supply and distribution chain, and the breakup 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 kilograms of herbicide product used has also varied (Table 5). The available information on soybean herbicide use in Romania since 1996 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.

Table 5. 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
Product used (kilograms)				
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 sprayed (kg/ha)	0.40	0.50	0.75	0.81
Average number of sprays per hectare harvested[a]	2.11	1.62	2.31	1.66

Note. Data from AMIS Global (personal communications, 2000, 2002); Produce Studies Research (personal communication, 2003). 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. Produce Studies Research (Sigma) data is estimated on the basis of herbicide product sales information obtained from input suppliers. 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 receives one treatment per year, and others receive higher numbers of treatments.

[a] 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 (e.g., drought) and access to irrigation. There is no consistent data available on areas planted.

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 hectare 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 from areas harvested). Nor should firm conclusions be drawn from examining trends in herbicide usage since 1996 because of the effect of economic shock adjustments in the Romanian economy and agricultural sector. Specifically, the base years presented for the pre-GM HT 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; it is not possible to assess what level of herbicides might otherwise have been used in 2002 if GM HT soybeans had not been introduced in 1999.

National-Level Impact of Using GM HT Soybeans

Production

The estimated impact on Romanian soybean production is summarized in Table 6. Assuming a base area of 120,500 ha is planted to soybeans, of which 70,000 ha are GM HT soybeans (the 2004 plantings) and the estimated benefit of the technology is +29–33% of yield, the net impact is likely to result in additional production of about 47,600–54,600 t, or a 17–19% increase. In value terms (at the farm level), this is equal to an additional €87.1–99.9 million.

Farm-Level Income

The positive contribution of the technology to adopting farmers' gross margins is €191.5–200.5/ha. If these benefit levels are applied to the estimated area planted to GM HT soybeans in 2004, this produces a positive contribution to farm income of GM HT soybeans of €13.4–14 million for the year.

Impact on the Economy

On the basis of the additional production of soybeans generated from using GM HT soybeans shown in Table 6, the additional annual production of soybeans is equal to about 14–17% of total soybean use in 2004–2005. 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 2005[5] of about €225/t as a benchmark price, this equates to an annual import substitution value of €10.7–12.3 million.

Table 6. Aggregated impact on Romanian soybean production of using GM HT soybeans, 2004.

	Yield effect +29%	Yield effect +33%
Area of GM HT soybeans (ha)	70,000	70,000
Average yield conventional soybeans[a] (t/ha)	2.35	2.35
Yield impact of GM HT soybeans (t/ha)	+0.68	+0.78
Impact on production (t)	+47,600	+54,600
% change in total production (2003 crop area and average conventional yield = baseline)	+16.8%	+19.3%

[a] *Average yield is based on farmer interviews.*

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