Coexistence of Conventional and Roundup Ready Soybean in Parana State, Brazil

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Abstract

In the State of Parana in Brazil, the survey we conducted revealed that 21%, 34% and 45% of producers were respectively having no, total and partial adoption of RoundUp Ready soybean (RRS). Coexistence within the same farm holding pertains to various levels of RRS adoption ratio. It indicates a management approach, at least on the part of the producers involved, in using RRS according to weed infestation levels in soybean plots. Continuation of the balanced coexistence depends on various factors, namely the purity of Conventional soybean (CS) seeds with regard to GMO content, Monsanto's strategy on royalties, and increase of the market premium to CS producers.

1. Introduction

The commercial release of transgenic varieties immediately raises the issue of coexistence with conventional varieties; it has induced many authors to determine distances to separate transgenic and conventional plots (Messean, 2005, Messean et al., 2006). The balance between the two types of crops is a matter of debate. Opponents of GMOs anticipate the hegemony of transgenic crops as an inescapable outcome (Les Amis de la Terre, 2007). This position is somehow sustained by figures in countries where transgenic crops are commonly grown. In the USA, the proportions of transgenic crops are 92%, 80% and 86% for soybean, corn and cotton respectively (GMO Compass, 2009). The proportion of Bt-cotton in China is estimated to be 70% nationally and close to 95% in some provinces (Fok and Xu, 2009) while in India estimates are 80-90% (Anon., 2009). For some observers, these adoption rates confirm the effectiveness of transgenic varieties (Toenniessen et al., 2003, de Grassi, 2003, Shankar and Thirtle, 2005), while others see these figures as an illustration of the power of multinational Biotech Companies to impose their products on farmers (Robin, 2008). Both positions nevertheless overlook the issue of managing the use of transgenic varieties, so that any positive effects they have might last. The intensive use of glyphosate-tolerant varieties has already led to the emergence of glyphosate resistant weeds (VanGessel, 2001, Powles, 2008) or weed complex shifts (Tuesca et al., 2001, Owen, 2008). In the case of Bt-cotton varieties, more damage is reported in China from pests which were previously considered only secondary before the commercial release of Bt varieties (Wang et al., 2008, Fok et al., 2005). These types of phenomena illustrate the need to address the issue of managing transgenic crop use by preserving the effective share of conventional crops (Fok, 2006, Mueller et al., 2005, Liebman and Dick, 1993, Shaner, 2000). In this sense, the issue of coexistence proves to be technically relevant, beyond economic and/or ideological considerations.

This paper addresses the technical and economic factors of the coexistence of RoundUp Ready Soybean (RRS) and Conventional Soybean (CS) in the State of Parana, Brazil. In spite of political opposition to the commercial release of RRS in Parana until 2005 (Castellanet et al., 2006), a *de facto* but poorly understood coexistence is operating (Lubello, 2006). This article is based on data collected during the 2006/07 and 2007/08 cropping seasons and considers the factors that enable coexistence.

2. Materials and methods

Many stakeholders are involved in the soybean sector in Brazil and they can be divided into four groups. At the production stage, producers grow soybean on farms of variable sizes and they may be institutionally represented by cooperatives or professional associations, on either local or national levels. Downstream of production, elevators, traders (either national or multinational entities) and oilseed processors are involved in storing or buying what the farmers produce. In between, there is a layer of players providing various services, such as credit or inputs, technical advice on a contractual basis ("consultants"), but also soybean breeding organizations of varying legal status (public, cooperative, national private and multinational companies). Some players overlap the three identified groups, e.g. some traders or cooperatives may also provide production inputs and credit, and manage warehouses. Finally, the fourth group pertains to public organisations, in

particular on a state level, which are involved for instance in seed production control as well as checking the transgenic nature of soybeans. Each of these groups has a unique view on the commercialization and use of RRS.

The research work undertaken was based on a combination of qualitative and quantitative approaches. Individuals from each of the stakeholder groups were interviewed to ascertain their perceptions of soybean production and RRS use. The interviews started in April 2007 and continued to July 2007. They provided an overall understanding of the perceptions of the advantages and limitations of RRS use. These interviews were not sufficient to get a clear idea of farmers' perceptions on RRS and so a larger farmer survey was also conducted.

Conducting surveys among producers in Brazil is not very common. Indeed, long distances between producers in a huge country make surveys costly and time-consuming. It is more common to convene a panel of a dozen producers to gain an idea of producers' average practices. Although convenient, the panel method does not necessarily fully represent producer practices and opinions.

Implementation of the survey had to comply with the impossibility of gaining access to a complete register of producers. Producer registers managed by credit or input suppliers are not complete and it was not possible to access them. However, the cooperative process is very active in Parana State (about 70 distinct agricultural cooperatives in the whole State), but there is no consolidated register. This situation meant that having a perfectly representative sample of producers was not very realistic. Our population sample was eventually composed of interviewees, all members of cooperatives, to whom questionnaires were distributed during the October-November 2007 period by agents from two cooperatives and from COODETEC (an R&D organisation funded by agricultural cooperatives in Parana State). To ensure the goodwill of the producers in responding to our survey, we decided to make it short, with only one page of questions requiring qualitative and quantitative answers. The questions mainly pertained to the types of soybean producers were growing, the yields they achieved, their feelings about RRS, as well as the market premium for CS they might possibly obtain. This is an *ex post* survey opposite to the survey that Mauro et al. (2009) have conducted to gauge Canadian producers' views as part of an *a priori* risk analysis related to the commercial release of RoundUp Ready wheat in Canada.

During the survey and after, interviews of soybean sector stakeholders were continued in 2008 in order to complement the data from the 2007 survey and to gauge whether perceptions had persisted or changed. Over the whole of the 2007 and 2008 period, representatives from a dozen elevator cooperatives were interviewed. The cooperatives were of various sizes and some were involved in input and/or credit supply, while a few were also engaged in processing soybeans into animal feed. In total, fifteen representatives were interviewed some of them also holding the function of technical consultants to producers. Eight elevator representatives and traders were interviewed; their business sizes were small and they were not directly linked to multinational trading companies. No representatives of multinational trading companies agreed to be interviewed. The interaction with four suppliers of production inputs was sufficient to ascertain the arrangements for soybean seed sales. We met with representatives from five organisations involved in breeding and seed production; they included public, cooperative and private sector organizations. The survey included responses from 232 producers in Parana

State.

3. Results

3.1. Soybean production area

Six categories of soybean producers were distinguished according to the size of their soybean area. Some farms had less than 50 ha of soybean, accounting for 23.7% of the sample (Table 1). Farmers having 50-100 ha and 100-200 ha of soybean respectively accounted for 25.8 and 24.1% of the sample. There were 26.3% of the farms cultivating soybean on more than 200 ha.

Table 1. Distribution of producers according to the evolution of soybean acreages

Sizes of soybean areas	What is the evolution of soybean areas in the last three years?				
	Area has diminished	Area has remained unchanged	Area has increased	No answer	Total
≥400 ha	3	14	5		22
200-400 ha	2	24	12	1	39
100-200 ha	8	31	16	1	56
50-100 ha	13	37	10		60
10-50 ha	8	33	10		51
<10 ha	1	3			4
Total	35	142	53	2	232

Compared to other states in Brazil, the sizes of farm holdings in Parana are relatively small. For more than 60% of the surveyed producers (142 producers), the areas allocated to soybean over the last three years has not changed. For those who had modified their soybean areas, the numbers of producers who increased or reduced their soybean areas were similar. The size of these acreages had little effect on the evolution of the soybean acreages. These results corroborate those from a similar study sponsored by the federation of cooperatives in Parana State (Mafioletti et al., 2008).

3.2. Coexistence with three kinds of RRS adoption

Our survey revealed three scenarios on the landscape involving RRS (values in parentheses represent proportion): 1) zero adoption (21%), 2) full adoption (34%) and 3) partial adoption and internal coexistence within farms (45%) (Table 2).

Before further analysing these figures, one must know that there are no public rules in Brazil regarding coexistence scenarios or fixing segregation standards between GM and non-GM plots of soybean[1]. The unique rule pertains to the threshold of 0.1% of GMO content at the marketing of conventional soybean. This rule is scrupulously implemented although the interviewed people could not say how it was adopted and how it was justified.

Conventional soybeans were still grown by 2/3 of producers (153 producers in the

[1] The unique technical resolution regarding separation distances was issued in August 2007 about corn by the National Technical Commission of Biosecurity (CNTBio).

sample) and RRS were grown by 77% of producers (178 producers in our sample). Adoption scenario was influenced by the size of the farm holding. Internal coexistence was more frequent on bigger farms, where it was easier to comply with the separation distances between CS and RRS plots.

Table 2. Distribution of the coexistence farm types according to soybean production acreage per farm

	Internal Coexistence	Exclusively CS	Exclusively RRS	Total
≥400 ha	77%	9%	14%	100%
200-400 ha	58%	18%	24%	100%
100-200 ha	48%	20%	32%	100%
50-100 ha	42%	17%	42%	100%
10-50 ha	25%	35%	39%	100%
<10 ha	0%	25%	75%	100%
Total	45%	21%	34%	100%

In the case of internal coexistence, there was not necessarily equal distribution between RRS and CS (Table 3). Five classes of internal-coexistence producers were identified depending on the extent of RRS adoption. Only 31% of the producers (104 in our sample) demonstrated an equal adoption of both soybean types (RRS accounting for 40-60% of the total soybean area) while 40% of these producers devoted less than 40% of their soybean area to RRS (versus 29% who allocated more than 60% of their soybean area to RRS). Generally, internal-coexistence producers showed more interest in CS than RRS, even for those with large acreages.

Table 3. Distribution of internal-coexistence producers depending on the shares of RRS in soybean areas

Sizes of soybean areas on farms	RRS share in total soybean area					
	<20%	20-40%	40-60%	60-80%	>80%	Total
≥400 ha	35%	24%	12%	24%	6%	100%
200-400 ha	14%	32%	41%	9%	5%	100%
100-200 ha	8%	12%	38%	31%	12%	100%
50-100 ha	8%	36%	28%	28%	0%	100%
10-50 ha	0%	38%	31%	23%	8%	100%
Total	13%	27%	31%	23%	6%	100%

3.3. CS vs RRS production levels and yields

For producers managing internal coexistence (Table 4), the area share of RRS was 37%, smaller than the general adoption rate for RRS (43%). Conventional soybean was still the dominate soybean type in our survey (57%).

The choice of CS over RRS was likely due to the higher yield of CS varieties. Yields clearly differed depending on the level of RRS adoption (Table 5). Among the 55

producers who exclusively cultivated RRS, the average yield was 3006 kg/ha as opposed to 3276 kg/ha for the 46 exclusively CS producers. When comparing producers having cultivated only CS and the others (having cultivated RRS exclusively or not), the related average yields were 3228 and 2090 kg/ha, with a significant yield differential of 138 kg/ha (p value = 0,015).

Table 4. Area and production share of RRS depending on extent of adoption

Producers	Area, ha				Production, 60 kg bags			
	CS	RRS	Total	% RRS	CS	RRS	Total	% RRS
Internal-coexistence	18 395	10 673	29 067	37%	962 026	539 810	1 501 836	36%
Exclusively RRS	-	7 161	7 161	0%	-	392 936	392 936	100%
Exclusively CS	8 678	-	8 678	100%	409 051	-	409 051	0%
Total	25 556	19 350	44 906	43%	1 354 962	948 861	2 303 824	41%

The average yield of the 97 internal-coexistence producers was 3138 kg/ha, in between the average yields of the exclusive CS and RRS producers. Within this group of internal-coexistence producers, the average yield of CS was 3210 kg/ha vs 3060 kg/ha for RRS, with a significant yield differential of 150 kg/ha (p value = 0.005). The yield differential observed from within-farm comparisons was of the same order as that observed when comparing between farm types.

Table 5. Average yields depending on coexistence type and sizes of soybean areas (standard deviation in brackets)

	Internal Coexistence		Exclusively CS		Exclusively RRS	
	No. producers	Yield kg/ha	No. producers	Yield kg/ha	No. producers	Yield kg/ha
≥400 ha	17	3150 (312)	2	3480 (168)	2	2964 (372)
200-400 ha	22	3330 (330)	7	3420 (450)	7	2958 (282)
100-200 ha	23	3090 (330)	10	2994 (330)	13	3132 (402)
50-100 ha	22	3012 (378)	10	3264 (354)	16	2856 (510)
10-50 ha	13	3066 (294)	16	3390 (294)	16	3120 (540)
<10 ha			1	2800	1	2400
Total	97	3138 (348)	46	3276 (366)	55	3006 (468)

Source: our survey

3.4. Royalties and premiums

Our survey results confirmed that producers were not reluctant to pay royalties to use RRS (Table 6), regardless of whether producers had or had not cultivated RRS at the time the survey was conducted. But the majority of farmers found the royalty level excessively high.

Table 6. Distribution of producers' opinions about royalty payments

What do you think about the royalty rate of 2% on soybean marketing?	Producers without CS	Producers with CS	Total
Rate is very high	38.0%	36.3%	36.9%
Rate is high	41.8%	41.8%	41.8%
Rate is normal	17.7%	19.9%	19.1%
Rate is low	2.5%	0.0%	0.9%
Rate is very low	0.0%	1.4%	0.9%
Do not agree with royalty payment	0.0%	0.7%	0.4%
Total	100.0%	100.0%	100.0%

After the commercial release of RRS, producers expected that CS would lead to some market premium over RRS, but not the opposite. Our survey shows that CS marketing gave rise to little payment of market premiums. Among surveyed producers, 73% declared not having received any premium. For those who claimed to have obtained a premium, the average value was R$ 1.6/bag, or about 3% of the soybean price (this price fluctuated between R$ 30 and 45 per bag in 2007 and 2008).

4. Discussion

4.1. Factors favouring CS cultivation

4.1.1 Yield advantage

Contrary to the yield superiority announced for RRS (Monsanto, 2005), CS has demonstrated higher yields. According to the people we interviewed, the CS yield advantage was estimated at 5 bags/ha on average (300 kg/ha), in agreement with, although higher than the outcome of our survey.

This yield superiority does not seem surprising, particularly in the early years of RRS marketing. Only a limited number of transgenic varieties were offered, and they could seldom prove to be adapted to the diversity of cultivation conditions in a huge country, notably to the particular ecological conditions of Parana State. It lacked very short-cycle varieties to escape attacks by Asian soybean rust (*Pakospora pachyrhizi*). This situation is nevertheless evolving, as a result of the licensing policy for the Roundup Ready gene and the concentration of research efforts in recent years. According to the records of the National Service of Cultivar Protection, 48 new varieties of RRS were registered in 2006 and 2007 by eight distinct breeding organizations. This evolution should mean that the CS yield advantage will soon vanish.

The people we interviewed in fact pointed out some variation in the yield differentials they observed between RRS and CS. The yield differential might reach 10 bags/ha (or 15-20% more than RRS yield) but it could also be very low, if not nil, notably among skilled producers who effectively implemented crop rotations. It turned out that it was not appropriate to deal with yield differential in absolute terms without considering, for instance, producers' cultivation conditions. This was in line with the variation in yield differentials we observed in our survey, particularly in the case of

internal-coexistence producers who grew both types of soybean.

More basically, it was not appropriate to overlook the weed infestation status of the soybean plots as it was pointed out for RoundUp Ready spring wheat in Canada (Harker et al., 2005). Where plots had few weeds, RRS use offered little agronomic advantage. On the contrary, by using RRS varieties that were agronomically less adapted, yield losses could be seen in those plots, at values indicated through our survey. Where plots were very weedy, RRS use made it possible to control a major constraint for yields, which could thus be improved and approach CS yields. In this case, yield differential, where it existed, was lower.

Producers having low weed pressure had little interest in adopting RRS. Those who faced serious weed pressures were tempted to use RRS exclusively. Finally, for those who only faced weed problems on parts of their farms RRS adoption was partial.

4.1.2 Market premiums

The interest shown by producers in CS did not arise from the market premiums. The market premium seldom reached them, sometimes because its level was perceived to be so low (R$ 1.5/60-kg bag) that their cooperatives decided not to proceed with individual distribution. If the perception of the market premium obtained remains so negative, producers may divert from cultivating CS. A few elevators were already considering giving up the segregation of CS. Of course, such a decision would make CS marketing more troublesome for producers and could encourage the latter to grow less CS.

4.2. Factors favouring RRS

4.2.1 Direct and indirect cost reduction

It was declared that the release of RRS would lead to a reduction in production costs. This was confirmed by the calculations provided by several cooperatives in Parana State (Table 7) indicating direct and indirect cost reductions.

Table 7. Comparison of input costs and machinery costs, R$/ha

		2006/07	2007/08	2008/09 (forecast)
CS	Seeds	65	64	98
	Herbicides	109	91	
	Pesticides	218	180	249
	Fuels	107	106	
	Machinery maintenance costs	138	139	
RRS	Seeds	84	82	101
	Herbicides	57	63	
	Pesticides	175	151	185
	Fuels	99	98	
	Machinery maintenance costs	127	128	

Sources: OCEPAR

With RRS use, less herbicide spraying is required. Glyphosate can control both monocotyledon and dicotyledon weeds and the efficacy is high. The same is not true for many selective herbicides used on CS, where efficacy is much more dependent on good weather and applications sometimes have to be repeated. Several selective herbicides have to be used to control mono and dicotyledon weeds separately. Cost reduction therefore comes from a reduction in the number of herbicide sprays, although the resulting cost reduction fell from R$ 48/ha in 2006/07 to R$ 28/ha in 2007/08, lower than what was reported in earlier research work (Bragagnolo et al., 2007). This is the consequence of the herbicide price adjustment: price increase for glyphosate on the one hand and a price decrease for the selective herbicides used on CS on the other.

The cost reduction from using RRS could be indirect. Cleaner plots are easier to harvest and harvesters can operate faster, meaning lower costs for fuels and maintenance (Table 7). Harvest losses are also substantially reduced where plots are clean of weeds (Ferrell et al., 2008, Brookes, 2003). In Parana State, the COCAMAR cooperative has estimated that harvest losses can be reduced from 56 kg/ha to 4 kg/ha.

4.2.2 Diverging options in the management of RRS use

Interviewed producers expressed their faith in technological progress and their agreement to pay royalties as confirmed by our survey (Table 6). This situation somehow derived from the fact that producers could seldom escape paying royalties, given the systems put in place to collect them (Reis, 2005, Mendez del Vilar et al., 2007).

The faith in technological progress explains why most producers did not show real concern about the emergence of weed resistance to glyphosate or a weed complex shift, although such a phenomenon is already being reported in Argentina (Tuesca et al., 2001, Cerdeira and Duke, 2006) and even in Brazil (Bidens pilosa or "picão preto" and Coryza bonariensis or "buva" are already reported gaining serious ground) in soybean fields and fruit orchards (Vila-Aiub et al., 2008). Some producers believed that research would help to overcome the weed resistance or shift, if confirmed. Other producers were confident that weed resistance or shift experienced in soybean monocropping would not emerge because of the crop rotation they use in Parana State: all producers manage two crops a year, soybean is frequently followed by corn and it could be replaced afterwards by winter wheat the next year.

More interesting is the "rodizio" approach that a few producers mentioned and which consisted in alternating the use of RRS between plots depending on weed infestation levels. This was consistent with the internal-coexistence our survey revealed. The approach mentioned in fact pertains to reasoned management of RRS on a farm holding level.

Nevertheless, the "rodizio" approach remained an individual initiative, not really promoted by any extension service, either public or private. Distributors of RRS seeds might have little incentive to promote this kind of approach whose expansion thus remains to be confirmed. Besides, the economic interest of the mentioned approach depends on the quality of CS seed control. Interviewed producers reported several cases of producers whose production was found to be transgenic

at the marketing stage (GMO content over 5%) and who had to pay higher royalties (3% of the grain value instead of 2%). Uncertainty on the purity of CS seeds could push producers to shift to RRS so as not to face the risk of paying higher royalties rate. The government of Parana State has recently prohibited the marketing of CS seeds if GMO content is above 0.1% but the effectiveness of this regulation remains to be confirmed because it was fought before it was adopted and even after it was issued.

5. Conclusion

Ten years after the adoption of RRS in Brazil, coexistence remains a reality. RRS has not totally supplanted CS. Our survey showed that RRS accounts for 43% and 41% of soybean area and production respectively. This survey highlights three levels of RRS adoption: nil, full and partial adoption on individual farms. More than 50% of soybean producers manage internal-coexistence on their farms.

CS remains attractive to producers because of better yield, although that advantage should disappear as a consequence of research efforts in favour of RRS. The market premium for CS is low and may not be sufficient to compete against the agronomic and economic advantages of RRS in terms of convenience in managing weed infestation and of reduced production costs. The prospects for further adoption of RRS will depend on the level of Monsanto royalties, which producers already find high and which Monsanto can adjust unilaterally.

Our research work showed that it is not appropriate to talk about yield difference between RRS and CS without taking into account weed infestation pressure in soybean plots. A few producers use RRS to "clean" their plots suffering from excessive weed infestation, indicating its integration as an additional tool in plot management on a farm holding level (Bragagnolo et al., 2007), and confirming the impact of RRS in the soybean cropping systems of Brazil (Osaki and Batalha, 2007).

The dissemination of such an agronomic approach would preserve the current balanced coexistence, but it depends on action to ensure the purity of CS seeds with regard to GMO content, on Monsanto's strategy on royalties, and on the level of market premium received by CS producers.

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