REVERSE LOGISTICS OF AGROCHEMICAL PACKAGING IN BRAZIL: OPERATIONAL PRACTICES

Geni Satiko Sato[1]; Gleriani Torres Carbone[23]; Roberto Giro Moori[3].

[1]Agricultural Economics Institute (Instituto de Economia Agrícola); [2] Mackenzie Presbiterian University (Universidade Presbiteriana Mackenzie); [3] Mackenzie Presbiterian University (Universidade Presbiteriana Mackenzie).

ABSTRACT

This article analyses the relevant factors for implementing reverse logistics for empty agrochemical packaging in Brazil. The objective was to map the practice of reverse logistics for different crops. A comparison of the data from 2002, 2003 and 2004 indicated that: a) the return of empty packages per hectare increased 242.8%; b) the state of Mato Grosso accounted for the largest returns of empty packaging, with 0.44 kg/ha. The states of São Paulo and Paraná accounted for 0.37 kg/ha and 0.34 kg/ha of the returned packaging, respectively. Analysis of the data showed that the volume of returns per state depends on the total area planted and on the type of crop, since the consumption of pesticides and fertilizers according to the biological requirements of each crop.

Key-words: Reverse logistics; empty packaging; agrochemicals.

INTRODUCTION

Logistics is usually seen as the management of the flow of materials, stock in process, finished products, distribution and information from the origin of the raw material up to the point of consumption, with the intent of meeting client requirements (Ballou, 2001). However, concern with environmental devastation due to the demographic explosion, unprecedented industrialization and boundless market competitiveness of the last few decades led firms to see that logistics management should extend beyond the point of end consumption. They understood that the strong competition for winning over consumers made it necessary for companies to include the environment in their corporate strategy. From this standpoint, reverse logistics management is an extension of logistics management. From a business point of view, whereas logistics management focuses on the upstream flow of material and information, reverse logistics management focuses on the return of product wastes, rendering them inert in the environment, or of empty packaging and its accessories, for recycling and absorption in the productive process.

In some industries, reverse logistics management is a practice of long standing, although each one has its own peculiarities. The producers of beverages manage glass bottle returns from the point of sale to consumers back to their distribution centers. Steel mills make significant use as raw material of scrap metal generated by their customers and, to this end, they use load collecting centers. In the aluminum can industry, the use of recycled raw material is significant and innovative ways of collecting discarded cans have been developed, such as cooperatives. Additionally, there are sectors that try to minimize or even avoid reverse logistics. The automotive industry, in component manufacturing, tries to use raw materials from renewable sources, such as coconut fiber, jute and sisal hemp in the upholstery and lining of seats. These raw materials, besides being recyclable and environment-friendly after they are discarded, offer the advantage of being more comfortable in temperature terms and more resistant than the usual petroleum-derived resins. Since it has natural resources, land for crop farming and varied species of plants available, Brazil could lead research on replacing synthetic raw materials in the production of components or products whose production process damages the environment. Thus, agribusiness can become very important not only for food production but also for supplying key raw materials to a range of industries. However, this high degree of importance requires essential care in managing this, to avoid traditional problems: social issues, such as the appearance of illnesses affecting humans and animals, and environmental issues, such as soil and water contamination. Brazilian agribusiness, which accounts for 30% of the country’s GDP, consumed 170 tonnes of agrochemicals in 2003 (Abiquim, 2005). Although Brazil is not one of the major consumers of agrochemicals per farmed hectare, recycling packaging through a reverse logistics process is a necessary and important task.

In the light of what has been explained and assuming that for growing a certain type of crop one has a certain dose of agrochemicals, the basic issue established is the following: regarding the several crops that employ agrochemicals, is there a relationship between the return of empty agrochemical packaging and the planted area? The objective is to map the practice of reverse logistics for different crops, such as soybeansand cotton.

The reason why this question is important is that the function of management is to evaluate results continuously, so as to maintain, improve or redefine action plans. Being aware of factors or variables that incorporate or interfere with new experiences, consolidated through quantitative indices or analyses, is crucial for managerial development and for the process of continuous improvement.

THEORETICAL FRAME OF REFERENCE

Sustainable agricultural development

According to Brazilian Law 7802 passed in 1989, agrochemicals are defined as “chemical products for use in the sectors of production, storage and processing of agricultural products, on pastures and for the protection of native or planted forests and other ecosystems, as well as in urban, water and industrial environments, whose purpose is to alter the composition of the flora or the fauna in order to protect it from other living beings considered to be harmful, as well as the substances and products used as defoliants, dryers, and growth inhibitors and stimulators” (Anvisa, 2006).

During the 50s, Brazil began using organophosphoric insecticides instead of organochlorinated ones, due to the latter’s persistence in the environment (Moraes, 1999). Organochorinated pesticides belong to the chemical group that has one chlorinated hydrocarbon, with one or more aromatic rings, and that persists in the body and the environment, causing chronic pathological effects, even though they have lower acute toxicity with immediate death. The agrochemical DDT (dichlorodiphenyltrichloroethane) is part of the group of organochlorinated pesticides; it used to be employed in agriculture as a pesticide but is now prohibited.

In connection with obtaining bank financing for crops, the production, sale and use of agrochemicals depend on prior registration with the federal government, which defines specifications, including identification through a package label that must indicate, based on colors, the toxicological class of agrochemical products.

In 2003, the sales of agrochemicals reached some US$ 3.1 billion, or 170 th tonnes. This sales volume reflected growth of 63% vs. the previous year, while, during the same time span, imports grew 55% (Abiquim, 2005). According to the same source, Brazil is a country of average consumption, equal to 3.2 kg of agrochemicals per hectare. To better illustrate what this ratio represent, Table 1 shows agrochemical consumption per hectare in several European countries.

Table 1 – Consumption of Agrochemicals (kg / ha), 2003

Country	kg / ha	Country	kg / ha
The Netherlands	17.5	United Kingdom	3.6
Belgium	10.7	Brazil	3.2
Italy	7.6	Luxemburg	3.1
Greece	6.0	Spain	2.6
Germany	4.4	Denmark	2.2
France	4.4	Portugal	1.9

Source: Sindag (2005).

Brazil is a country with large expanses of agricultural areas and its consumption of agrochemicals is fairly high. This means that a high volume of packaging is used and, therefore, should be returned and recycled. In the 2000/2001 harvest, 130 million packages of agrochemical were used in the fields. The 2001/2002 crop consumed 32 th tonnes of agrochemicals (Inpev, 2004). Exactly what happened to most of this agrochemical packaging, however, is uncertain.

The environmental problems this packaging causes have been studied by many governmental and non-governmental organizations. Most authors in this field of knowledge work with the concept of "sustainable development", i.e., satisfying current needs without jeopardizing the capacity of future generations of satisfying their own needs. In connection with conserving the environment, in June 2001 Brazil passed Law 9974, complemented by decree-law 4074, which came into effect in 2002 and regulated, among other activities, the transport and final destination of empty packaging.

Reverse logistics and agrochemicals.

The reverse logistics process depends on the material and the reason why it is being returned to the production system. The type of material can be divided into two large groups: products and packaging. In the case of products, reverse logistics flows can be dictated by the need for repair or recycling, or merely because clients return them. Table 2 shows the typical percentage of product returns by clients for certain industries.

Table 2 – Product Returned

Industry	Returns %
Catalog sales	18 - 35%
Computers	10 - 20%
Printers	4 - 8%
Automotive parts	4 - 6%
Electronic products	4 - 5%

Source: Lacerda (2004).

One can see that the percentage of product returns varies depending on the industry and that in some of them, such as catalog sales, efficient management of the reverse flow is crucial for the business. According to Lacerda (2004), the reverse flow of products is also used as a way of managing stock, in an attempt to minimize costs due to the low turnover of certain items. This is the case of the phonographic industry and of newspaper and magazine publishers, which work with a large number of items and releases. The risk of retailers facing very low turnover and therefore building up stock when they buy these products is very high. Consequently, in order to encourage the purchase of a product mix, these companies have the strategy of accepting returns of unsold items. They believe that thanks to this practice, lost sales are lower than they would be otherwise, although the cost of returns is high.

In the case of packaging, reverse logistics flows occur basically because the packages are reused or due to legal, environment-related restrictions. As Brazil's environment-related restrictions to packaging are not strict, the decision on what to do with returnable or reusable packaging takes into account economic issues. Furthermore, the purchase cost of a large variety of returnable packages and containers is substantially higher than that of one-way packaging. However, the larger the number of times the returnable packages are used, the smaller the cost per trip, which tends to make their cost lower than the cost of one-way packaging (ibid.).

According to Kumar and Tan (2003), certain factors have driven firms to adopt reverse logistics as a management strategy, such as:

a) Government legislation – legislation disciplines the final destination of empty agrochemical packaging and defines the responsibilities of the farmer, reseller and manufacturer, as well as of the government itself, responsible for the issue of education and communication. Failure to comply with these responsibilities can imply in the penalties set out in specific legislation and in the Environmental Crimes Law (Law 9650 of 13 February, 1998), such as fines and even imprisonment.

b) Product life cycle – reverse logistics must be considered within a broader frame of reference, namely, the product's life cycle. From the logistical standpoint, it does not end with delivery to the client. Products may become obsolete, be damaged or defective and have to be returned to their source to be suitably discarded, repaired or reused. From the financial point of view, besides the cost of purchasing raw materials, manufacturing, stocking and storing the product, product life cycle also includes other costs, connected with the full management of its reverse flow;

c) New distribution channels – new distribution channels such as e-commerce are being exploited in order to serve clients better and faster. These new direct distribution channels must prepare themselves to manage a reverse logistics network as sales become global. The management of products that do not reach the consumer in good condition will require reverse logistics, if the client is to be properly served;

d) Market forces – retailers believe that clients value firms that have liberal product return policies. This is a perceived advantage and, in this context, the suppliers or retailers bear the burden of the risk of damaged products. This obviously involves a structure for receiving, classifying and dispatching returned products. It is a trend that became stronger due to consumer protections laws, which guarantee to consumers the right to return or exchange merchandise. Initiatives connected with reverse logistics have yielded substantial returns for firms. Savings due to using returnable packaging or to re-using materials in production have provided gains that encourage the use of reverse logistics. Furthermore, efforts to develop and improve reverse logistical processes can also yield considerable returns that justify the investment made in them;

e) Changes in the forces within the supply chain – according to Lacerda (2004), factors such as good control of entry, standardized and mapped processes, short cycle times, information systems, logistical network planning and collaborative relations between clients and suppliers can provide positive contributions to the performance of the management of reverse logistics. Within the context of current reverse flows between retailers and industries that handle the return of damaged products, there are issues connected with the degree of confidence the parties have in each other. Conflicts concerning the interpretation of who is responsible for product damage are common. Retailers tend to consider that damage is caused by transport problems or by manufacturing defects, whereas manufacturers can infer that retailers are over-using this advantage or that it is the consequence of poor planning. Under extreme circumstances, this can give rise to dysfunctions such as refusing to accept returns, lateness in crediting returns and adopting expensive control measures. Therefore, reverse logistics can only be implemented if the organizations involved develop collaborative relations.

Another important aspect that concerns adopting reverse logistics management is the expansion of consumers' environmental awareness; they now expect firms to reduce the negative impact of their activity on the environment. This has led some companies to take action in order to communicate to the public an “environmentally correct” institutional image. Adopting a procedure that focuses on the final destination of empty agrochemical packaging is complex and calls for effective participation of all the parties involved in the manufacturing of the product: sales, use, licensing, inspection and monitoring of the activities connected with the handling, transport, storage and processing of this packaging.

METHODOLOGICAL PROCEDURES

In terms of its purposes, this was an exploratory and descriptive study; in terms of the means used, it was bibliographic and documental (Vergara, 2004). The purpose of exploratory research is to develop, clarify and modify concepts and ideas in order to help to formulate problems and hypotheses for further research (Gil, 1999). The main objective of this study was to map the practice of reverse logistics for different crops. The intermediate objectives were to find out a) the quantity of empty packaging returned, in kilograms; b) the planted area in hectares; and c) the consumption of agrochemicals by type of crop.

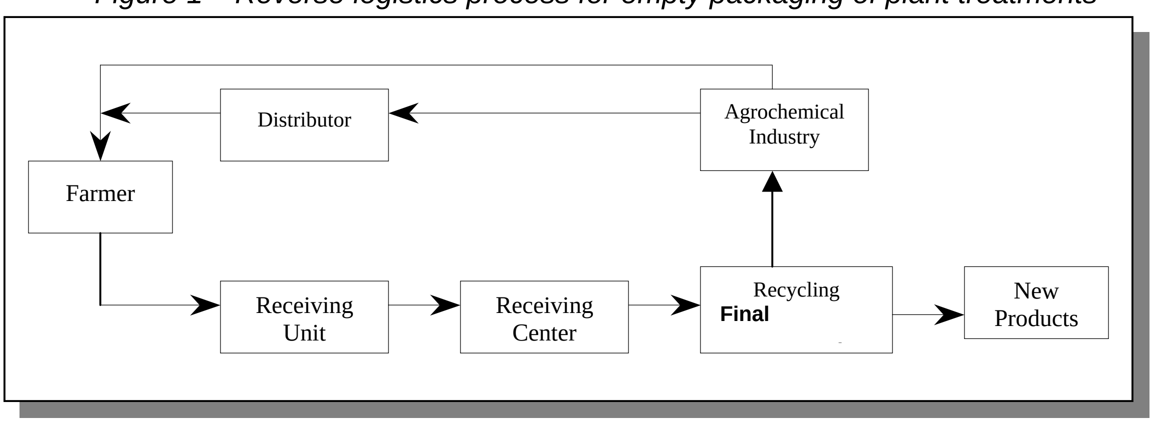
Data collection was based on secondary sources. To this end, an assessment was conducted on the legislation about package control issues, quantitative agrochemical consumption data, empty packaging returns, planted areas and type of crop. The secondary sources were Inpev (the National Institute of Empty Packaging Processing), Abiquim (the Brazilian Chemical Industry Association), Sindag (the National Union of the Industry of Agricultural Defense Products), Andef (the National Plant Defense Association) and Anvisa (the National Sanitary Surveillance Association).

Secondary data collected in quantitative form were treated using descriptive statistics, averages and percentages. Secondary data collected in qualitative form were treated through the content analysis approach, documental analysis (Bardin, 1977).

CHARACTERIZATION OF THE REVERSE LOGISTICS OF AGROCHEMICAL PACKAGING

The several sanitary measures adopted to defend plants (agrochemicals) call for responsible management, because of the risk they pose to health and the environment. Regulated by specific legislation, both the transportation and storage of these products are carefully inspected by the government. In 1994, the earliest discussions started on adopting legislation concerning the disposal of empty agrochemical packaging. The agrochemical industry is a highly regulated one and each product launch calls for detailed research reports with data and information to be submitted to federal bodies – the Ministries of Health, Agriculture and the Environment – so as to insure that they are harmless to human and environmental health. However, one must take into account that the care and instructions on the use and responsible disposal of the empty packaging of these products do not help much when there is no awareness of environmental conservation. Before the legislation was passed, all products sold reached the grower with a package insert that provided guidance on how best to dispose of this packaging in a rural environment – the most common recommendation being to bury it, following a series of technical procedures seldom performed by farmers, and to incinerate it. Figure 1 illustrates the logistical organization of the process of disposing of empty packaging for phytosanitary products.

Figure 1 – Reverse logistics process for empty packaging of plant treatments



Source: adapted from Inpev (2005).

The reverse logistics process for empty packaging begins with the farmer, who has the legal obligation of washing the packaging three times or under pressure and of returning it within one year of purchase or six months after the product's due date. Washing under pressure is used only in the case of stiff packaging, such as high density polyethylene packages and metal packages, which account for 85% of the material in the market. The advantage of washing is that it turns the packaging into regular garbage, as it reduces or eliminates contamination and also provides the farmer with an added benefit, as he can use some 3% more of the product, which previously used to end up as residue inside the packaging. The washed packages must be delivered to a receiving post indicated by the reseller in the invoice. The lids of the packages must be rendered useless with holes. The packaging should never bet transported together with people, animals, food or medication, nor within closed vehicles, when it is not washable. As for flexible packaging, such as paper, laminated aluminum foil or low density polyethylene packages, they must be incinerated, since they are difficult to wash.

The resellers of agrochemicals are the party responsible for building units or posts for receiving returned packaging. Furthermore, it is up to them to indicate on the invoice the address of the post closest to the farmer's property, providing the latter with guidance as to how to deliver the packaging and what is the deadline for doing this. Packages returned by farmers are inspected one by one by trained staff at the receiving post, to check on the conditions of the return and on whether or not the packaging was washed. After checking, a receipt of delivery is issued for inspection purposes. Some of these receiving posts are larger than others and can compact the discarded packaging to make it easier to transport to its final destination. The sites that receive and classify bulk packaging delivered to the units within their area of responsibility are called receiving centers or central units. On the other end of the reverse logistics process we find the manufacturers of agrochemicals. Based on the central package-receiving units, the industries have legal responsibility for the coordination of transportation, the incineration, the recycling site, and the manufacturing of the goods that use the washed and returned packages as raw material. They also have the social responsibility of instructing resellers and farmers both on the use of the product and on the importance of the reverse logistics process.

After Federal Law 9974 of 2000 was passed, the firms created Inpev (the National Institute for Processing Empty Packaging), in order to comply with and perform the activities the law required. It is a non-profit organization that represents several class associations and agrochemical firms. Its mission it to manage the process of disposing of empty phytosanitary packaging in Brazil, in addition to providing support and guidance for industries, distribution channels and farmers in complying with the responsibilities that the law defines.

However, one sees that long before treating packaging was compulsory, there were already some initiatives that focused on reusing it. In 1992, Andef (the National Association of Plant Defense) implemented a project in the town of Louveira (state of São Paulo), together with the Dinoplast company that specialized in recycling urban waste, for working with agrochemical packaging. With its facilities modified, Dinoplast installed an effluents treatment system, since the material would have to undergo another washing for decontamination. Once the construction work was completed, Dinoplast became responsible for transforming empty plastic packaging into flexible corrugated conduits for electrical wiring to be used in construction. Besides Dinoplast, Inpev has an agreement with the company that makes incineration equipment for chemical products, Metalúrgica Barra do Piraí, in the state of Rio de Janeiro, to whose industrial incinerators the contaminated packaging is sent.

Inpev has a network for empty packaging collection that comprises some 350 posts in the areas with the greatest demand, such as the Southeast, South, Midwest and part of the Northeast of Brazil. These posts are divided into two types of collection sites: units (or posts) for receiving packaging from resellers, and central units for receiving packaging that are strategically located, in order to serve a certain number of packaging receiving units (or posts).

To plan this entire network and hire carriers for returning packaging to their end destination, Inpev created CPT (the Transport Scheduling Center) within its own logistics department and, as the manager of the entire chain, it trains local, regional and nationwide carriers to take care of the transportation of this cargo.

In 2002, empty packaging returned through Inpev totaled some 30 to 40% of the volume of packaging placed in the domestic market, which amounted to approximately 150 million units.

DATA AND RESULTS ANALYSIS

The dimensions of Brazilian agribusiness are shown through the triennial averages of sector data. Brazilian production in the 2002/03 harvest totaled 169 million tonnes, of which 105 million tonnes of grain (cereals and pulses), as shown on Table 3. From 1994/95 to 2002/03, the consumption of NPK fertilizer grew 51.8%, reflecting the expansion of the planted area from 45.0 million hectares to 49.9 million hectares (Anda, 2003).

Table 3 – Performance of Brazilian Agricultural Production

Indicators	94/95 to 96/97	97/98 to 99/00	00/01 to 02/03
Agro-vegetable production (th t)	130,872	140,808	169,962
Grain production [2] (th t)	73,886	79,919	105,436
Harvested area ,16 crops (th ha)	45,054	45,345	49,934
Consumption of NPK fertilizer (th t)	4,629	5,592	7,029
Productivity (kg/ha)	2,905	3,105	3,404
NPK Consumption (kg/ha) harv. area	103	123	141
Population (th inhab.)	161,245	167,914	174,630
Production per capita (kg/inhab)	812	839	973

(1) 16 main export and domestic consumption crops

(2) cereals and pulses

Source: Anuário ANDA (2003).

The main agricultural inputs are fertilizers and agrochemicals. Fertilizers help to increase agricultural output. Furthermore, 2003 data from Anda (the National Association for the Dissemination of Fertilizers) indicates that the crops that use the largest amount of fertilizer are soybeans, corn, sugarcane, coffee and herbaceous cotton (Table 4). Other crops for domestic consumption such as rice, wheat and beans, although their harvested area is significant, do not use much fertilizer. Inpev information, however, indicates that reverse logistics currently only takes place in connection with the packaging of agrochemicals, i.e., fertilizer packaging is not been collected.

Table 4 – Fertilizer consumption estimates by type of crop in Brazil

Crops	Planted area (1000 ha)			Total consumption (1000 ton)		
	2001	2002	2003	2001	2002	2003
Soybean	16,331	17,893	21,069	5,625	6,731	8,428
Corn	13,377	11,865	13,043	2,978	3,304	4,082
Sugarcane	5,022	5,214	5,592	2,245	2,333	2,600
Coffee	2,357	2,376	2,551	1,154	1,291	1,375
Cotton	762	753	1,012	689	696	950
Rice	3,181	3,096	3,575	554	612	872
Wheat	1,730	2,063	2,480	431	569	742
Bean	3,862	4,286	4,223	514	534	650
Pasture	90,000	90,000	90,000	463	482	378
Potato	152	154	147	436	426	420
Tobacco	339	382	453	354	414	483
Orange	825	828	823	339	362	406
Banana	524	525	527	179	181	169
Sorghum	484	477	752	134	139	150
Tomato	62	61	60	122	139	116
Reforestation	1,147	1147	1150	121	131	129
Subtotal	140,155	141,120	147,466	16,338	18,344	21,951
Other	5,168	5,142	5,418	841	820	405
Total	145,323	146,262	152,884	17,179	19,164	22,356

Source: *Anuário ANDA* (2003).

According to Vicente et al. (2002), intensive use of agrochemicals in Brazilian agriculture began in the 70s, helping to improve productivity, but also increasing the number of human intoxications and contaminating the environment.

Ongoing agrochemical improvement made it possible to cut dosages from 15 liters to 80 ml per hectare, where weed control is concerned. The time during which the chemical remains active within the environment, before it is degraded by microorganisms, was also reduced from 90 to 22 days (ibid.).

The said authors detected that soybeans are the crop that accounts for the greatest domestic consumption of agrochemicals, namely, 35.2% of the value of total sales of these products in Brazil. This is followed by cotton (11.1%) and oranges (4.1%). Among the 500 different agrochemical products, the main classes are herbicides, fungicides, insecticides and acaricides. In 2000, agrochemical sales reached 313.8 th tonnes of commercial products or 140 th tonnes of active ingredient (herbicide, fungicide, insecticide, acaricide, etc) and, in 2003, 375.0 th tonnes or 182.4 th tonnes of active ingredient, as shown on Tables 5 and 6 (ibid.).

Table 5 – Agrochemical sales, Brazil

	Commercial product (t)		Active ingredient (t)	
	1999	2000	1999	2000
Herbicides	142,855	174,070	68,131	81,862
Fungicides	48,826	41,111	20,168	19,072
Insecticides	68,158	67,305	19,231	19,447
Acaricides	13,655	12,561	9,676	8,985
Other	16,581	18,777	10,379	11,107
Total	288,075	313,824	127,585	140,473

Source: Vicente et al. (2002).

Table 6 - Agrochemical sales, Brazil

	Commercial product (t)		Active ingredient (t)	
	2002	2003	2002	2003
Herbicides	175,748	215,090	83,859	110,215
Fungicides	34,407	41,863	17,262	19,363
Insecticides	57,576	73,232	18,404	24,422
Acaricides	15,055	14,362	10,804	9,627
Other	23,643	30,501	15,223	18,819
Total	306,429	375,048	145,552	182,446

Source: Sindag (2005).

The more recent Sindag data shows that agrochemical sales in 2003 reached 375 th tones of commercial product, i.e., 182 th tonnes of active ingredient.

The country's different crops and regions do not have the same consumption patterns, so that the information by crop or by state is imprecise. 1990 Andef data (Table 7) indicates that citrus and soybeans crops are the leaders of agrochemical consumption. This volume varies depending on the expansion or reduction of the planted area.

Table 7 – Sales of agrochemicals in tonnes of active ingredients by crop in Brazil, 1990

Crop	Herbicides (t)	Fungicides (t)	Insecticides/acaricides and formicides (t)	Total
Citrus	498	2,096	8,560	10,096
Soybean	6,688	26	3,215	9,929
Sugarcane	6,197	3	11	6,211
Corn	4,153	-	270	4,423
Coffee	635	1,209	1,752	3,596
Potato	37	2,615	798	3,450
Cotton	564	-	2,841	3,405
Rice	3,298	5	44	3,347
Tomato	9	1,726	374	2,109
Wheat	824	674	523	2,021
Total	22,903	8,404	18,388	49,695

Source: Andef, 2005.

The most consumed agrochemicals in volume terms are herbicides, which account for 46.0% of total sales. Sugarcane and soybeans account for 25.7% of total sales and citrus crops for 20.3% (Table 7).

The volume of agrochemicals used in agriculture depends on the consumption per hectare and the total planted area. One can see that tomato and potato crops use a high amount of fungicides per hectare, whereas citrus crops appear to make intensive use of insecticides and acaricides. Soybeans, because they cover a large planted area, consume a larger yearly volume of herbicides, insecticides, acaricides and formicides, but a low volume of fungicide. Unfortunately, there is no data available on returned packaging by crop (Table 8).

Table 8 – Indications of agrochemical, per hectare, for Brazil's main crops, 1990

	Herbicide (t)	Fungicide (t)	Insecticides/acaricides and formicides (t)	Total
Citrus	-	2.30	9.39	11.69
Soybean	0.58	-	0.28	0.86
Sugarcane	1.44	-	-	1.44
Corn	0.36	-	-	0.36
Coffee	-	0.41	0.60	1.01
Potato		16.55		16.55
Cotton			2.05	2.05
Rice	0.83	-		0.83
Tomato		28.20		28.20
Wheat	0.24	0.20	0.16	0.60

Source: Andef (2005).

Inpev data collection began in 2002, when the total volume of collected packaging amounted to 3.7 th tonnes. In 2003, returned packaging increased by 248.5% (7.8 th tonnes) and, in 2004, by 188.7% (14.8 th tonnes), as shown on Table 9. The rising scale indicates that initial fixed costs are being gradually diluted.

Table 9 – Collection of empty packaging per state
2002, 2003 and 2004 (kg/ha of plantation)

State	2002			2003			2004		
	Kilograms of collected packaging	**1000 ha**	**Kg/ha**	**Kilograms of collected packaging**	**1000 ha**	**Kg/ha**	**Kilograms of collected packaging**	**1000ha[1]**	**Kg/ha**
Paraná	209,869	8,629,2	0.02	2,012,338	9,509,7	0.21	3,482,480	10,175,3	0.34
Mato Grosso	1,833,600	5,705,6	0.32	1,598,015	6,523,9	0.24	3,055,046	6,980,5	0.44
São Paulo	696,990	5,932,1	0.12	1,327,157	6,243,9	0.21	2,472,429	6,681,0	0.37
Minas Gerais	152,673	4,191,8	0.04	462,640	4,449,6	0.10	1,281,683	4,761,1	0.27
Goiás	190,070	3,500,9	0.05	699,266	3,749,7	0.19	1,252,933	4,012,2	0.31
Rio Grande do Sul	129,560	7,480,2	0.02	452,132	7,917,1	0.06	1,054,303	8,471,3	0.12
Bahia	136,048	4,316,6	0.03	436,378	4,392,6	0.10	716,119	4,700,1	0.15
Mato Grosso do Sul	308,860	2,104,0	0.15	538,220	2,578,3	0.21	693,390	2,758,8	0.25
Santa Catarina	30,240	1,730,2	0.02	108,144	1,795,4	0.06	400,504	1,921,1	0.21
Alagoas	0	685,1	0.00	8,190	594,0	0.01	113,590	635,6	0.18
Maranhão	14,600	1,327,4	0.01	82,154	1,445,5	0.06	100,746	1,546,7	0.07
Pernambuco	56,370	1,149,8	0.05	89,685	1,112,4	0.08	59,822	1,190,3	0.05
Espírito Santo	8,720	784,5	0.01	13,488	799,5	0.02	52,739	855,4	0.06
Ceará	0	1,958,3	-	27,200	1,965,3	0.01	52,180	2,102,9	0.02
Tocantins	0	363,2	-	0	416,7	-	24,715	445,9	0.06
Paraíba	0	565,6	-	0	626,8	-	12,160	670,6	0.02
Total	**3,767,600**	54,511,6	0.07	**7,855,007**	58,460,9	0.13	**14,824,839**	**62,553,2**	0.24

(1) Calculated with a 7% average increase vs. 2003.

Source: prepared using data from Inpev (2005) and IBGE (2005).

If one works out the ratio between the total volume of returned packaging (kg) and the total planted area (hectares) one obtains an indicator that shows the rising rate of returns in Brazil. In other words, this ratio was 0.07 kg/ha in 2002, whereas by 2004 it had reached 0.24 kg/ha, having grown 242.8% (Table 9). One sees that the North and Northeastern regions have low indicators per planted area. As these states lacked implemented programs in 2002, they posted an increase of roughly 400-600% (Table 9).

Paraná is the state with the highest agrochemical packaging returns and this indicator is proportional to the total area planted with both permanent and temporary crops. The states of Mato Grosso and São Paulo follow. Rio Grande do Sul, despite a planted area of 8 million hectares, has low packaging returns, as shown on Table 9.

Table 10 – Planted area of several crops, by state, 2003

Crop / State	Mato Grosso (1000 ha)	São Paulo (1000 ha)	Paraná (1000 ha)	Rio Grande do Sul (1000 ha)
Soybean	**4,414**	642	**3,649**	**3,592**
Sugarcane	196	**2,817**	373	-
Corn	883	**1,114**	**2,846**	**1,417**
Coffee	34	227	126	-
Potato	-	34	30	
Cotton	290	64	30	-
Rice	440	35	70	962
Tomato	-	12	3	2
Wheat	1	48	**1,255**	**1,064**
Citrus	-	637	15	2

Source: IBGE (2005).

Due to the lack of data on the returns of agrochemical packaging by crop, one has inferred the volume returned from the total planted area of the main crops. In the state of Mato Grosso, soybeans account for most of the planted area; in the state of São Paulo, we have sugarcane, corn and orange; in the state of Paraná, soybeans, corn and wheat; and in the state of Rio Grande do Sul, soybeans, corn and wheat (Table 10). These crops probably account for the higher volume of agrochemical consumption and packaging returns.

FINAL THOUGHTS

Given the important of agribusiness in Brazil, reverse logistics of agrochemical packaging has a significant dimension in both economic and social terms. Furthermore, the structure of the chain of reverse logistics for agrochemical packaging in Brazil is an innovative and recent process. Empty packaging returns have grown from 3.7 th tonnes to 14.8 th tonnes from 2002 to 2004. What enabled the efficiency of this process was the integration of several points of the logistics chain, taking into account factors such as the actual participation of the agrochemicals industry and class associations; training farmers, distributors and salespeople; and an up-to-date legislation that encourages returning and recycling packaging (Law no. 9974/2000 and Decree no. 4074/2002). From the social point of view, the activity of reverse logistics is a job generator, in that it creates economically viable activities within the reverse process and enables recycling. Regarding the environmental issue, its contribution is very relevant, because it avoids the contamination of ecosystems, which might, in turn, put the health of humans at risk. It thereby ensures better quality of life for future generations.

The results obtained indicate that the volume of returned packaging depends on factors such as total planted area, the crop that is exploited and the prior infrastructure of a center of collection. Among the crops evaluated, we found that soybeans consume the largest amount of fertilizers and agrochemicals.

The state of Mato Grosso is the one with the highest packaging return per hectare in 2004, namely, 0.44 kg/ha. It is followed by São Paulo, with 0.37 kg/ha, and Paraná, with 0.34 kg/ha. Because of the lack of data on packaging returns by crop, it was impossible to calculate an indicator by planted hectare.

In the states in which there is a high rate of packaging returns, the fundamental elements that led to this were the legislation, corporate initiative and the infrastructure organized by Inpev.

As a suggestion for continuing to pursue this line of research, we propose an inferential statistical analysis, relating the planted area and the returned packaging; however, a broader series of data would be required.

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