Chapter 4

Contamination of rural environment and production

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Introduction

Target 3.9 of the Sustainable Development Goal 3 (SDG 3) is "By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination." (United Nations, 2018). The contamination of the rural area has been pointed out as one of the serious problems of the present times, since it puts at risk human health, natural resources and biodiversity. In most cases, the contamination of this space is attributed to chemical contamination, a direct result of the use of agricultural inputs, mainly insecticides and herbicides, which pollute the soil and water, and can even reach foods human beings consumed, causing various diseases.

Studies show that pesticides can affect human health during their manufacture, preparation and application and when consuming a contaminated product, and regardless of the form of contact, the effects are extremely dangerous. Surveys have estimated that millions of agricultural workers in poor countries suffer from some form of intoxication caused by pesticide exposure.

Reduction of contamination of rural areas and protection of human health through agricultural activities

The growing concern about the impacts of agricultural activities on natural resources and human health has led to the development of research focused on the rational use of agrochemicals, seeking to mitigate their harmful effects. Embrapa has been generating and/or perfecting technologies, products, processes and services (TPPS) in order to reduce the use of these inputs in crop production.

In this sense, Embrapa has been working on different fronts, such as integrated and organic production, development of biopesticides, nanoproducts and production systems for impact management.

In the Integrated Production (IP) approach, which encompasses alternatives to the conventional production system with the main goal of rationalizing the use of pesticides, stimulating the balance of ecosystem and maintaining the quality and safety of products, Embrapa has been contributing with studies aimed at different crops (mango, grape, citrus, strawberry, among others). Currently, the Ministry of Agriculture, Livestock and Food Supply (Mapa) coordinates the program, called Produção Integrada Agropecuária (Agricultural Integrated Production – IP Brasil), which can be certified by the National Institute of Metrology, Quality and Technology (Inmetro). The program also has the support of a large number of research, teaching and extension institutions for its technical development and training of multiplier agents involved in the process of converting from conventional to sustainable. This technology has contributed decisively to increasing exports, especially to the more demanding markets such as the European and North American.

In São Paulo, Produção Integrada de Morango (Integrated Strawberry Production – PIMo) organizes society segments involved in the culture to develop and implement this production system, which protects the environment, the rural worker and the consumer, generating strawberries of high quality and safety, branded by Brasil Certificado seal.

For several years, strawberry appeared in the media as a product that contains pesticide residues beyond the safety thresholds. In addition to endangering consumers, this information also threatens family farmers with marketing difficulties. As this crop is very susceptible to pests and diseases, some farmers use pesticides without need, and, consequently, are the first ones to be contaminated. With the aim of disseminating and demonstrating the technologies needed to convert the conventional system to a sustainable integrated strawberry production (PIMo) in the regions of interest, the technology proposes to sensitize and train extension agents, farmers and other actors on the basic themes necessary for PIMo implementation; prepare, publish, validate and update technical standards; take to the field the technologies disseminated in the theoretical-practical trainings performed after the installation of demonstrative units (DUs); conduct training on the main themes, using multiplier agents to carry out evaluations in the DUs (research methods) and expand knowledge to other regions; propose public policies that guarantee the program sustainability in the region and for other interested parties. Thus, the first certification of strawberries in IP Brasil occurred in the state of São Paulo in 2011, and then expanded to Minas Gerais in 2016 and Rio Grande do Sul in 2017.

The integrated crop-livestock-forestry system comprises another technology that has contributed to reduce the use of external inputs and to a potential decrease of the negative environmental impacts of conventional agriculture (Reis et al., 2015). Specifically, in crop rotation with pasture, species of brachiaria break the cycle of pests and diseases, reducing population of fungus species (*Fusarium* spp. and *Rhizoctonia* spp.) causing root rot in soybeans, beans and other crops and diminishing the germination of fungus causing white mold (*Sclerotinia sclerotiorum*). Studies by Embrapa show that a dense straw of brachiaria hampers the incidence of white mold on beans. The control mechanisms are the physical barrier, which reduces the contact of soil fungi spores with the plants and, mainly, the allelochemical, since, from the third year of brachiaria cultivation in one area, the germination of sclerotia that cause mold is greatly reduced. Thus, adopting rotation with brachiaria pasture is a good management practice for an infested area. Other observations relate to the reduced need for post-emergent herbicides such as in maize and bean crops, since, due to the large amount of soil cover, together with the low rate of decomposition of brachiaria straw, there is lower incidence of weeds in rotational areas with pasture-grains (Oliveira et al., 2015).

Organic Agriculture (OA) and Agroecology (AE) are areas of research developed by Embrapa, which have contributed significantly to the reduction of contamination of food and the environment. According to Abreu et al. (2012) these practices represent a new field of knowledge in support of the transition process towards sustainability. In this sense, agriculture can be more or less sustainable when it is able to meet, in an integrated way, the following principles: low dependence on external inputs and internal recycling; use of renewable natural resources locally; minimum adverse impact on the environment; long-term maintenance of productive capacity; preservation of biological and cultural diversity; use of knowledge and culture of the local population; satisfaction of human needs for food and income (Gliessman, 2009).

In this sense, the Plataforma Digital de Conhecimento Agroecológico (Digital Platform of Agroecological Knowledge –Plataforma Agroecológica) was created to systematize, popularize and make available public domain publications generated by Embrapa on Agroecology knowledge.

The Integrated System of Agricultural Production (Sipa), or *Fazendinha Agroecológica*, is one of Embrapa partner institutions' technologies, which proposes consortia of vegetables, green manure, organic compounds, vegetable cultivars adapted to organic management and biological control by conservation for the use of natural enemies of pests. Among the activities, the actions linked to federal government programs stand out, such as Mais Alimentos e Bancos Comunitários de Sementes de Adubos Verdes (More Food and Community Banks of Green Fertilizer Seeds). Farmers from different regions of Brazil adopted the management techniques developed at Sipa.

Embrapa has been developing another line related to the development of nanoproducts for agriculture. By means of nanotechnology, which consists of a set of techniques used for visualization, characterization, production and manipulation of matter in the scale of atoms and molecules, products have been developed seeking to improve the quality of life. As in any area of technology making intensive use of new materials and substances, it may pose a risk to the environment and human or animal health. Thus, the assessment of the potential biological impact of nanomaterials has become of great importance in recent years, since the rapid pace of development of nanotechnology has not been followed by a thorough investigation of its safety. The same properties that make nanoparticles interesting for applications, such as their small size, large surface and high reactivity, also make them accessible to previously inaccessible sites in living systems with potentially significant consequences for the environment. There is still much discussion about the regulation of these materials as a new area of knowledge. Understanding potentially at-risk situations is complex and challenges evaluators to choose priorities among the multiplicity of factors. In general, indicators and methodologies development for at-risk assessment of nanoproducts is important to support the work of nanotechnology developers. Embrapa AgroNano team and the focus on the development of these evaluations by Embrapa Environment should support both scientific and regulatory agents to address the most relevant concerns in this area.

Sistema de Avaliação de Impactos Ambientais de Inovações Tecnológicas Agropecuárias (The System of Environmental Impact Assessment of Agricultural Technological Innovations – Ambitec-Agro) is another example of a technological solution developed by Embrapa. This system is a set of multicriteria matrices that integrate indicators of the performance of technological innovations and management practices adopted in rural activities. In it, seven essential aspects of evaluation are considered: use of inputs and resources, environmental quality, respect for the consumer, employment, income, good health, and management and administration.

The criteria and indicators are constructed in weighting matrices in which data obtained in the field are automatically transformed into graphically expressed impact indexes. The evaluation results allow the producer/manager to determine which impacts of technology are dissatisfied with their social well-being goals. To the decision maker, the results allow for the indication of measures to enhance or control the technology adoption, according to sustainable local development plans, and, finally, provide an objective measure of impact, helping in the qualification, selection and transfer of agricultural technologies.

The Ambitec-Agro indicator system aims to provide a simple and practical, expeditious and low cost approach, applicable to the multicriteria evaluation of socio-environmental impacts, for the wide variety of technological innovations and rural activities focused on Embrapa RD&I projects and their partners of the Brazilian Agricultural Research System.

Sistema de Avaliação de Impacto Social da Inovação Tecnológica Agropecuária (Social Impact Assessment System for Agricultural Technological Innovation – Ambitec-Social) consists of a set of electronic spreadsheets that integrate 14 indicators of the contribution of a given agricultural technological innovation to social well-being within a rural establishment. This system aims to assist agricultural RD&I institutions in the evaluation of projects, as well as rural producers and decision makers in the choice of best practices, management forms and technologies aimed at the sustainable development of rural activities.

Another line of action of Embrapa is the agrochemicals application technology, which is an applied science of multidisciplinary nature, involving knowledge of agriculture, biology, chemistry, trade, economics, engineering, medicine, physics, among others (Matthews, 1982). The exchange of information between those involved in the practical problems of phytosanitary control and researchers in application technology is essential to achieve some progress in this area of knowledge.

Application type, treatment number, pesticide formulation, applied dose, equipment type, characteristics and spatial distribution of spray nozzles, droplet diameter and density, micrometeorological conditions are partially interdependent and should be selected to achieve the best biological effects, according to the application purposes. However, actual agrochemical application does not differ essentially from that practiced in the last century, and is characterized by considerable waste of energy and chemicals (Chaim, 2009).

Volume selection of liquid in which a pesticide is applied is on the user's criterion, in which in practice the same volume is applied against a wide variety of pests and is usually determined by the flow of the sprayer nozzles. Both in Brazil and abroad, there is no definitive information on the wastes that occur during spraying. Some information available in the international literature indicate that pesticide applications are extremely inefficient; however, they base only on theoretical facts, that is, based on theoretical doses of pesticides necessary to control populations of pests that cause economic damage. Chaim et al. (1999b) developed a method to quantify wastes that occur during spraying on creeping crops. The results of the losses verified in low size crops are around 40% to 70%, depending on the stage of plant development. Studies on shrub-like crops also point to similar results (Chaim et al., 1999a). Currently, Embrapa is proposing solutions to some problems of pesticide application technology through suggestions on methodology for deposition calibration and development of more efficient spraying technologies.

A system for droplet electrification produced by hydraulic nozzles was invented after the discovery of hydrophobic material to serve as a support for induction electrodes with specific geometries for conical jet nozzles or fans. The system consists of a high voltage source, powered by two AA batteries, which are connected by a high voltage cable to the induction electrode attached to the head of hydrophobic material. When the electrode is energized by positive energy, it attracts electrons in the droplet-forming zone of the hydraulic nozzle. The droplets acquire loads of polarity opposite to the induction electrode at the time of their ejections, and some are retro attracted, causing head wetting. For this reason, the head needs to be hydrophobic; otherwise, it would form a trail of liquid that would bind the electrode to the nozzle, and the system would collapse. The system can be coupled to any sprayer that uses hydraulic nozzles, transforming a common spraying into an electrostatic. It promotes a significant increase in the efficiency of droplet deposition in biological targets and in the broth economy. Its use has a positive impact on the environment and preserves the applicator's health by reducing spray drift. The technology is protected by patent and promotes good health and well-being to consumers.

Producing quality foods

Products of animal or vegetable origin go through various intermediates until reaching the final consumer. Monitoring of food safety conditions at each stage of the process is essential, and one of the most efficient ways to do this is by tracking agricultural products. A traceability system is a set of measures that make it possible to control and monitor the steps between the production and food supply. Therefore, any harmful changes in the production, storage and transport stages can be quickly detected, thus ensuring greater food safety.

Embrapa provides traceability solutions for animal (meat from goat and sheep, beef, milk, among others) and vegetable (pineapple production, planting, grape processing, among others) production chains. The purpose of these solutions is to ensure the obtaining of safe and quality food, as well as the preservation of these characteristics in the product supply to the final consumer.

Milk is a good example of food that is often produced in an inadequate way, and sometimes can cause risks to consumers' health. Embrapa makes available several solutions for correct production and storage of bovine and goat milk, such as milking kits (Figure 1), storage quality monitoring training for workers involved in production. In addition, the standardization of milk processing, such as in cheese production, is a way of contributing to maintain the sanity and quality of its derivatives. These solutions involve the implementation of good production practices that avoid food contamination.

For plant products, several good practice courses are offered in various productive activities, including the extractivism of native products such as Brazil nuts, *cupuaçu* (Figure 2), *pequi* and acai, besides the processing of crops such as cashew, grape, cassava, pineapple, sesame, among others.

The availability of machinery and the adoption of adequate procedures are of great importance to maintain hygiene during the production process. In this sense, solutions such as the standardization of dryers developed for the production of

Photo: Alcides Okubo Filho

Figure 1. Training in operation and maintenance of mechanical milking machines.

Photo: Felipe Santos da Rosa

Figure 2. Thermal pasteurization process of cupuaçu pulp for freezing.

raisins and *Capsicum baccatum*, besides the use of specific boxes for vegetable and fruit packaging, promote the hygiene and the efficiency of the processes.

Another type of approach is the development of methods of analysis to detect the chemical and biological contamination in foods, especially meat products. These methods detect, by chemical, bacteriological or DNA analysis, residues with the potential to cause disease. In addition, Embrapa offers consulting services for disease prevention and control during the production process.

In the future, innovative technological solutions should emerge from the progress of research in new fields of knowledge, such as biotechnology and nanotechnology. Biotechnology involves the in-depth knowledge of biological processes and the use of these processes as a transformative component, be it in industry, agriculture, medicine, and many other fields. Nanotechnology can be defined as matter manipulation at the atomic and molecular level, giving rise, among other innovative products, to new materials with unprecedented properties. The application of these new sciences to agricultural production can give rise to safer inputs and processes with a more positive impact on the consumers' good health and well-being.

Some examples of solutions that have already emerged through these surveys are flexible films, biocomposites and coatings, which can be used in the food preservation industry. As these materials come from harmless substances such as starch and other natural polymers, they can substitute chemical preservatives as significant advancement in the sanity and safety of food products.

Post-harvest fruit treatments that combine the use of clean technologies are other examples of alternatives that can have a positive impact on food safety. In these technologies, combinations of time and water temperatures are used along with doses of ultraviolet radiation according to the characteristics of each fruit or pathogen. In addition to not using fungicides in the process, providing fruits free from residues and chemical contaminants, these processes preserve the qualitative aspects and increase the shelf life of the treated fruits. Therefore, clean technologies are considered an economically viable and technologically safe option for food sanity control, which can benefit farmers, exporters and the final consumer.

In addition to contaminations of chemical origin, food may also present biological contaminations. Agricultural products of vegetable origin are highly consumed throughout the world, mostly fresh, with no treatment by means of heat that eliminates possible microbiological contaminants. Among the possible pathogen sources in crops of agricultural products are the use of irrigation water or for pesticide preparation; use of fresh or improperly composted animal manure; presence of domestic animals close to the plantations, among others. Considering that these foods are part of Brazilian diet, as salads or fruits, there is a potential risk of pathogens presence such as *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli*, *Shigella* spp., *Aeromonas hydrophila*, *Clostridium botulinum*, parasites, and viruses. At Embrapa Environment, microbiological analyzes are being applied to test extracts/vegetable oils as well as to prove the efficiency of alternative physical methods of controlling microorganisms in foods, such as UV combined with hot water treatment. This approach results in the guarantee of the absence of pathogenic microorganisms, resulting in good health and well-being of the consumer population.

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