Crop protection and agrochemicals management

D. Crop protection and agrochemicals management

The global demand for food and agriculture will continue to grow, and this represents a significant challenge for the sustainable agriculture supply. While pesticides and fertilizers application play a vital role in increasing agricultural production and ensuring the supply of agricultural products, their misuse leads to the degradation of soil and water resources, and air pollution, with serious negative impacts over human and environmental health.

Total utilization rate of fertilizers and pesticides is usually low due to poor management of nutrient and crop protection practices, which means that a good portion of the applied substances end up contaminating the soil, water, and air. Groundwater resources worldwide are being polluted by the agrochemical lixiviates, and all the nutrient leaching from agricultural land is causing the eutrophication of aquatic ecosystems.

But the effects of an increased use of agrochemicals[7] transcend their impact on the environment, as many producers in developing countries are experiencing short- and long-term health effects due to their exposure to hazardous chemicals, including chronic effects such as cancer, endocrine malfunctions, and birth defects.

SAN's approach to a responsible management of agrochemicals include a series of best practices to:

- optimize the use of agrochemicals and reduce the associated agricultural production costs;
- reduce and mitigate the negative effect of pesticide residues and fertilizers lixiviates on natural resources and air quality;
- avoid the negative effects of agrochemicals on farmers' and agricultural workers' health; and
- promote an IPM approach for crop protection activities.

Integrated Pest Management (IPM) approaches aim to protect crop and pasture health by combining different pest control methods, thus reducing the use of synthetic pesticides and the toxic footprint of agriculture. Pressure should only be exerted on those pests that can cause significant damage to crop and, therefore, negatively affect the profitability of production units, thus IPM approaches can also contribute to biodiversity protection within the scope of production systems and their area of influence.

[7] Agrochemicals broadly refer to all chemical substances used or added agricultural production including pesticides, fertilizers, veterinary drugs, and feed additives, among others.

The PAMS framework for IPM allows the design of pest management solutions for specific scenarios, considering all the different conditions that can be encountered within the production unit, and including practices for:

- **Prevention:** create optimum conditions within crop and pasture systems to prevent appearance of pests as a first measure.
- **Avoidance:** when a pest appears, measures are taken to avoid its spread.
- **Monitoring:** regular revision of pest behavior and environmental conditions that foster their growth and propagation, to take preventive measures and adjust them when necessary.
- **Suppression:** implement cultural practices and the use of low-toxicity substances to reduce or eliminate pests.

SAN adopts the PAMS framework and additionally implements IPM strategic planning through the participatory methodology designed by the Oregon Integrated Plant Protection Center (USA), based on the following steps:

1. Design the participatory process with key stakeholders. Producers, technicians, company representatives and specialized technical personnel participate in the intervention design, which facilitates the real and correct implementation of all the control measures that are proposed within each specific intervention, and their sustainability through time. This involves field visits, group analysis, decision making processes and other activities in accordance with the participants' characteristics.
2. Identification of productive processes and pest infestation risks. Critical needs and current management strategies are identified and analyzed.
3. Analysis of the biology and life cycle of identified pests. Focused analysis of each pest's characteristics to determine the best control measures (following the PAMS logic), with provisions for the later assessment of the measures' effectiveness.
4. Identification of areas and pests that require further control measures. The use of synthetic pesticides and other pest control substances is evaluated as a measure of last resort, including an analysis of the circumstances in which each substance can be used, proposing guidelines to be followed for their selection, and safe handling; and any additional measures to be taken to avoid or mitigate their negative impact on people and the environment.

D.1. Sustainability goal: Integrated pest management

Outcomes	ID	Performance Indicators /Best practices
Crop health is addressed through training, implementation and learning of Integrated Pest Management approaches.	D101	Operations implement Integrated Pest Management (IPM) practices as the first resource to manage the phytosanitary conditions of crops and pastures to ensure optimal productivity. Pest control actions aim to: - prevent the outbreak and spread of pests; - use cultural practices, biological agents, and low toxicity substances (such as organic solutions, plant extracts or derivatives, minerals, mineral salts, or derivatives) to control phytosanitary conditions; - optimize and reduce the number of synthetic pesticides; - monitor the presence of pests, the conditions under which they appear and spread, and the effect of the applied control measures; and - evaluate the pest control results; and use them to improve the overall pest management system.
	D102	Operations organize, schedule, and keep records of all IPM actions and practices implemented.
	D103	Operations train workers and farmers within their scope for the correct and safe implementation of IPM practices.
	D104	Operations keep records of pest infestations and analyze them to update IPM practices. Records include at minimum: - pest or disease agents; - periods of crop/pasture susceptibility; - environmental conditions during outbreak (weather, soil, light, unusual events); - infestation dates; - area and location; and - degree of damage and pest infestation trends.
	D105	Operations consider the use of fire for virus control purposes only as a last resort measure. If fire is used for pest control: - it is prescribed by a competent professional and included as part of the IPM Plan; - it is applied only by trained workers that are provided with fire suppression tools and PPE8; - it is applied only when wind speed and direction create minimal risk of uncontrolled burning; - fire use areas and history are indicated on updated farm maps; and - soil and biodiversity restoration measures are implemented after the use of fire.
	D106	Operations restore or plant areas as a refuge for beneficial organisms, such as a mixture of patches or stripes of perennial and annual flowering plants that serve as refuge, food source and reproduction sites for pollinating and pest-predating insects or vertebrates.

[8] *See the definition of Personal Protective Equipment on Section IV: SAN Technical Concepts*

D.2. Sustainability goal: Safe management of agrochemicals

Outcomes	ID	Performance Indicators /Best practices
Agrochemicals with low impact on human health and the environment are used.	D201	Operations use permitted pesticides only as part of an IPM plan.
	D202	Operations only use agrochemicals that are legally registered in the production country.
	D203	Operations do not use any of the substances considered as Highly Hazardous Pesticides (FAO/WHO Meeting on Pesticide Management).[9]
	D204	Operations only use agriculture mineral oils that contain less than 3% of Dimethyl Sulfoxide (DMSO) residues.
	D205	Operations practice the rotation of synthetic pesticides based on the application of different pesticide groups with different action modes, to prevent building pest resistance to active ingredients.
	D206	Personnel responsible of synthetic pesticide applications knows which products are permitted and which are prohibited.
Agrochemicals' handlers conduct their tasks safely.	D207	Operations do not allow children (minors of 18 years), pregnant or lactating women to handle synthetic pesticides.
	D208	Operations designate personnel responsible for authorizing agrochemical applications, and determine the type of product, dosage, and equipment type to be used.
	D209	Operations provide Personal Protective Equipment (PPE) [10] to all agrochemical handlers, according to each applied substance requirements.
	D210	Agrochemical handlers receive training on agrochemical management and demonstrate that they know how to correctly perform assigned tasks.
	D211	In case that workers for agrochemical applications are outsourced, operations implement mechanisms to monitor service providers and ensure that they comply with the local legislation to handle and apply agrochemicals safely.
Detailed and updated agrochemical use records are maintained	D212	Operations keep records of agrochemical applications. Records include information about products applied, time and location of application, dosages and volumes, the name of the persons who applied them, and the equipment used.
	D213	Operations demonstrate (through record keeping) a tendency to reduce the number and total volume of agrochemical applications to reduce the toxic load. Any increase in use is short-term, specific for a type of pest, and justified in technical and economic terms.

[9] For detailed lists of pesticides risk classification, see Jepson PC, Murray K, Bach O, Bonilla MA, Neumeister L. Selection of pesticides to reduce human and environmental health risks: a global guideline and minimum pesticides list. Lancet Planet Health 2019: 3: e56–63.

[10] *See the definition of Personal Protective Equipment on Section IV: SAN Technical Concepts*

Outcomes	ID	Performance Indicators /Best practices
The correct mixing of agrochemicals and management of its application equipment are ensured.	D214	Operations calibrate equipment for mixing and applying agrochemicals: - as specified in the equipment and products' application manual; whenever there are changes of physical state of the product (i.e., liquid, solid and/or emulsion); and - after maintenance activities.
	D215	Operations train agrochemical handlers on how to mix products and maintain/calibrate application equipment safely for correct and precise mixing of agrochemicals.
	D216	Operations keep records for application equipment maintenance, repairs, and calibration.
Agrochemicals are safely stored and handled to prevent any negative impact over human and environmental health.	D217	Operations store all agrochemicals in a safely locked storage facility; and allow access to those facilities only to personnel trained in safe handling and management of agrochemicals.
	D218	Operations store prohibited, obsolete and expired substances until safely returned to the supplier. If suppliers do not receive such substances back, operations label the containers, and store them separately in dedicated safe areas/sealed pits for the disposal of agrochemicals.
	D219	Operations keep storage areas for agrochemicals that are: – equipped and identified in accordance with the type of stored substances and materials; – clean and organized; – provided with sufficient artificial or natural light to enable work activities and to find the emergency exits; – provided with sufficient natural ventilation to avoid the accumulation of odors and vapors; – equipped with firefighting mechanisms and means to adequately remediate any spillage of hazardous substances or materials; and – equipped with emergency showers and eye-washing facilities in areas where hazardous substances are stored or mixed.
Empty agrochemical containers are safely stored and disposed to prevent any negative impact over human and environmental health.	D220	Operations ensure that empty pesticide containers and application equipment are triple washed, and the rinse water is returned to the application mix for re-application.
	D221	Operations store empty agrochemical containers in a locked storage area, until safely returned to the supplier. If suppliers do not receive empty containers, operations adopt safe disposal practices such as: triple wash and perforation to avoid their reuse, sequestration (landfills and pits); or destruction by high temperature incineration, base catalyzed dechlorinating, gas phase chemical reduction or plasma arc.
	D222	Operations re-use containers only for the original contents, and only when labeled accordingly.

D.3. Sustainability goal: Implementation of risk mitigation measures

Outcomes	ID	Performance Indicators /Best practices
Agrochemical applications' spray drift is minimized.	D301	Operations select optimum agrochemical application equipment and application techniques to optimize the agrochemical effect and to reduce spray drift.
	D302	Operations implement actions to prevent agrochemical spray drift to all natural-ecosystems and all human activity zones; actions include at minimum one of the two following mitigation mechanisms: a) implementation of non-application zones between these areas and the crops or pastures subject to agrochemical applications: • 5 meters, if applied by mechanical, hand-assisted and targeted application methods, such as for example knapsack sprayers, banding, baiting, specific granule placement, soil or plant injection, seed treatments and weed wiping; • 10 meters, if applied by broadcast or pressurized spray application methods, such as: motorized sprayers or spray booms, air blast sprayers, foggers (Ultra Low Volume fogging machines); b) establishment of functional vegetative barriers that are: • as high as the crop height or the height of terrestrial equipment's application valves over the ground, whichever is higher; • composed of plants that maintain their foliage all year, but which are permeable to airflow, allowing the barrier to capture pesticide drops; • composed preferably of native species. c) use of precision technologies, such as localized applications.
Measures are implemented to mitigate the impact of agrochemical applications over human and environmental health.	D303	Operations prevent the access of people to pesticide application areas by implementing Restricted Entry Intervals (REI) as stipulated in the product's MSDS, label o security tag, whichever is more stringent. When two or more products with different REIs are used at the same time, operations apply the longest interval.
	D304	Operations take actions to effectively reduce the amount of agrochemical residues in the water of drainage canals.
	D305	Operations identify, alert, and warn potentially affected persons or communities about pesticide applications.

D.4. Sustainability goal: Controlled use of hazardous pesticides

Outcomes	ID	Performance Indicators /Best practices
Risk mitigation measures are implemented for the use of hazardous pesticides.	D401	Operations use substances listed in the SAN List of Risk Mitigation Pesticides, only if the specific SAN recommended risk mitigation measures are applied. This includes substances with risks to aquatic and terrestrial wildlife, risks to insect pollinators, reproductive toxicity, and inhalation risk.
	D402	Operations may apply substances listed in the SAN List of Risk Mitigation Pesticides as having risks for pollinators only if: a) less toxic, efficacious pesticides are not available; b) exposure of natural ecosystems to pesticides is minimized by establishing non-application zones or functional vegetative barriers; and c) contact of pollinators with these substances is further reduced: • substances are only applied after 5 pm to avoid pollinator peak activity hours • substances are not applied to flowering weeds or flowering weeds are removed; and • substances are applied while the crop is not in peak flowering period.
	D403	Operations apply substances listed in the SAN List of Risk Mitigation Pesticides as having inhalation risks, only if: - restricted entry intervals are enforced; and - respirators with an organic vapor (OV) cartridge or canister with any N, R, P, or 100 series pre-filter are used; and - all application sites are flagged to indicate inhalation risks to bystanders.

Outcomes	ID	Performance Indicators /Best practices
Risk mitigation measures are implemented for the use of hazardous pesticides.	D404	When less toxic, efficacious pesticides are not available; operations apply the seven substances categorized as GHS repro 1A/1B (Pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals) Borax, Boric acid, Carbendazim, Epoxiconazole, Glufosinate-ammonium, Quizalofop-p-tefuryl and Tridemorph; only if the following reproductive toxicity risk management requirements are fully implemented: a) the listed reproductive toxicity substances are rotated with lower toxicity substances as part of the rotation for resistance management; b) environmental risks of pesticide applications are mitigated; c) substance handlers use higher level PPE[11] to avoid skin exposure (according to pesticide label indications); d) substance handlers are provided with medical examinations, clearly specified as part of an Occupational Health and Safety plan; e) operations implement Restricted Entry Intervals (REI) according the product's MSDS, label or security tag. When two or more products with different REIs are used at the same time, the longest interval applies; f) operations establish and maintain non-crop vegetative barriers or non-application zones between pesticides applied crops and areas of human activity; and g) potentially affected persons or communities are identified, alerted, and warned about applications and prevented from access to application areas.

[11] *See the definition of Personal Protective Equipment on Section IV: SAN Technical Concepts*

Outcomes	ID	Performance Indicators /Best practices
Risk mitigation measures are implemented for the use of hazardous pesticides.	D405	Operations use the nematicides cadusafos, ethoprop, fenamiphos, oxamyl and terbufos, only if the following nematicide risk management requirements are fully implemented: a) lower toxicity nematicides are used as part of the rotation for nematicides resistance management; b) application methods place the product precisely within the plant root zone or use tree injection, uncovered application of granules is prohibited; c) daily maximum application time is limited to eight hours divided into two shifts with bathing to wash off residues from the pesticide handler in between them; d) application is conducted during the coolest hours of the day; e) annual medical monitoring of applicator health (kidney and liver function) is provided; and f) cholinesterase levels of pesticide (nematicide) handlers are tested. Tests are conducted prior to the first-time workers apply these substances on the farm and periodically thereafter if they remain assigned to this task. Other work that does not involve use of these five substances is offered to those organophosphate or carbamate pesticide handlers with results outside of the accepted cholinesterase levels.
	D406	Operations apply substances listed in the SAN List of Risk Mitigation Pesticides as having risk to aquatic life and terrestrial wildlife, only if effective mechanisms to reduce spray drift towards their habitats (aquatic and terrestrial ecosystems) are implemented, including: a) establishment of non-application zones between these areas and the applied crops: – 5 meters, if applied by mechanical, hand-assisted, and targeted application methods, such as knapsack sprayers, banding, baiting, specific granule placement, soil or plant injection, seed treatments and weed wiping; – 10 meters, if applied by broadcast or pressurized spray application methods, such as: motorized sprayers or spray booms, air blast sprayers, foggers (Ultra Low Volume fogging machines), depending on the equipment's technical specifications; and b) establishment of functional vegetative barriers that are: – as high as the crop height or the height of the terrestrial equipment's application valves over the ground, whichever is higher; – composed of plants that maintain their foliage all year, but which are permeable to airflow, allowing the barrier to capture pesticide drops; and – composed preferably of native species.

Outcomes	ID	Performance Indicators /Best practices
Risk mitigation measures are implemented for the use of hazardous pesticides.	D407	Operations may use rodenticides (brodifacoum, bromadiolone, bromethalin, chlorophacinone, coumatetralyl, difethialone, diphacinone, flocoumafen, strychnine, warfarin, and zinc phosphide), only if the following rodenticide risk management requirements are fully implemented: a) rodenticide traps are only used if rodent monitoring demonstrates that mechanical control methods are not effective; b) only formulated rodenticide baited traps are used; c) signs of rodent activity (droppings, tracks, gnaw marks, burrows) are monitored and the results recorded. Traps are inspected daily and bait stations and installations weekly; d) bait stations are tamper-resistant, anchored, and constructed in such a manner and size as to permit only the entrance of rodents; e) food sources attracting rodents and debris are eliminated; f) rodent carcasses are handled with gloves and buried in locations that do not pose risk to human health or water contamination; and g) bait stations are removed, and the number of stations diminished when there are no longer signs of rodent feeding or there is evidence of use by non-target wildlife.