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Spraying application of pesticides and the environment – a micro-data base under preparation

ABSTRACT. Nowadays, database could be considered as one of the vital tools that support a decision maker to approach the nearest proper solution to a given problem in the shortest time with minimum effort and cost possible. It is well known that the application of pesticides is greatly responsible for pollution that might occur to the environment. Since the mid of the seventies, preparation of a specialized database in this trend was initiated with about one thousand articles at that time upon a generous direction from professor Janusz Haman, Poland. Recently, the number of articles jumped to more than twelve thousands, with an ambitious expectation to jump to twenty thousands through the forthcoming few years. The principal aim of establishing such data base is to serve and support persons, institutions and agencies acting in both applied and academic branches of application techniques (ground/aerial), Integrated Pest Management (IPM), and environmental protection as well as manufacturers and sellers of pesticides, bio-agents, spraying systems, ag-aircraft and others. The skeleton of this database could be presented as follow: Key words: About 1600 codes covering mainly: History & Development (1870-2004); Countries (71 countries); Chemicals & Bio-agents; targets (plants, animals, areas,); Pests (Insects, Fungi, Bacteria, Weeds … etc.); Ground and aerial operations; Ground sprayers; Ag-aircraft; Atomizers/Nozzles; Droplets & Coverage; Precautions & Safety; Pollution; Economical & Biological aspects; Concerned Organizations and Appendices. The informative base: About twelve thousand articles, which appeared in 27 languages since 1870 were crystallized, analyzed and classified including: Related codes – Author – Year – Title – Publisher – Correspondence data – Subject / Summary / Abstract – Page/s / Figure/s / Reference/s / Comment. The articles: The bulk of articles composing this database are kept – after classification and analysis in the form of a computer file or traditionally on library shelves waiting for transference to be computer files. Taking into consideration that key words, informative base and articles – kept as computer files – are connected with a computer program to allow the three parts acting together in an integration form.

KEY WORDS: database, pesticides, sprayer

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The world population is expected to grow by more than one billion people or about 20% in the next decade, which requires more ag-production and more use of agrochemicals for efficient agriculture to face such expansion. This can be achieved by the most effective use of the current pesticides and the development of better application techniques for the years ahead.

Agricultural pests destroy approximately 40% of all potential food production worldwide. This major food loss occurs despite the application of 2.5 million tons of pesticides at a cost of more than $25 billion each year. Pesticides provide many important benefits in pest control, returning about $4 for every $1 invested. However, this cost/benefit ratio does not include the annual environmental and public health costs of using pesticides, which include 3 million human poisonings and 220,000 deaths annually worldwide. With more than 2 billion people under nourished in the world, a major effort is required to reduce the continuing 40% loss of crops to pests. [Pimentel 1997].

According to the Food and Agriculture Organization [FAO UN. 2001. Guidelines on minimum requirements for agricultural pesticide application equipment, Vol. I. Portable (operator-carried) sprayers; Vol. II. Vehicle-mounted and Trailed sprayers; Vol. III. Portable (operated-carried) foggers., FAO, United Nations, Rome; FAO UN. 2001. Guidelines on organization and operation of training schemes and certification procedures for operators of pesticide application equipment. FAO, United Nations, Rome; FAO UN. 2001. Guidelines on organization of schemes for testing and certification of agricultural pesticide sprayers in use. FAO, United Nations, Rome; FAO UN. 2001. Guidelines on standards for agricultural pesticide application equipment and related test procedures, Vol. I. Portable (operator-carried) sprayers; Vol. II. Vehicle-mounted and trailed sprayers. FAO, United Nations, Rome], safety and quality standards for pesticide sprayers do not exist in all countries and the existing international standards for this type of equipment are often inappropriate for many countries. Since 1995, FAO has worked on the formulation of two guidelines to improve the safety and efficiency of the most commonly used spray equipment. The first guideline covers minimum requirements to assist FAO and other agencies to ensure that sprayers are safe to users and to the environment as well as being efficient and durable in operation. The prime objective therefore is that member countries should adopt them immediately, to begin to eliminate substandard and unsafe sprayers from national markets and ultimately from the international scene. The second guideline on standards provides more precise safety targets for spray equipment. Each member country can then decide on the form and speed of introduction of the respective guidelines into its national practice and into legislation where appropriate. By incorporating into national legislation, a requirement for manufacturers and importers to declare that application equipment meets standard of safety and durability, it should be possible to gradually reduce and eventually eliminate sub-standard equipment from the market. A guideline on the organization of schemes for testing and certification of the used agricultural pesticide sprayers covers the testing and certification of the sprayers currently in use.

The recent century could be considered as the era of gigantic specialized informative databases, which qualifies and supports decision makers to solve their problems very efficiently in the shortest time possible. Agricultural spraying techniques stand in urgent need to such a base, as it depends on an interacted net of fundamental and applied sciences such as biophysics, fluid and aerodynamics, chemical engineering, pest control; meteorology; physiology of plant, insects, fungi and bacteria; toxicology; electromagnetic; environment and many other fields.

Since the last decades of the former century, thousands of publications have appeared and hundreds of conferences have been held around this subject all over the world. Nowadays, when pest control by chemicals becomes essential in the frame of IPM system, it seems necessary to concentrate on the role played either by misapplication techniques or negligence in polluting environment.

The present phase of database are based on more than twelve thousand articles scattered on more than one hundred thousand pages and published in nineteen languages over 71 countries in the world. In my expectation this number of articles could increase to twenty thousand during the forthcoming few years.

It is hoped that this work could be helpful to persons, institutions, agencies, universities and research centers, in addition to manufacturers of pesticides, bioagents, spraying equipment, atomizers & nozzles and ag-aircraft, as well as, for environmentalists, ground and aerial applicators, operators, training schools, farmers, legislators and international organizations, such as the European Union, FAO, ISO, ICAO and others involved.

Up-to-date developments and improvements in the spraying application of pesticides

Haggar et al. [1983] used a sensor to detect the presence of green vegetation against a brown background, which has been fitted to an Oxford precision sprayer so as to activate the sprayer whenever the nozzle passes over patches of weeds. The operation of the sensor depends on measuring the radiance ratio of red (R) and near infrared (IR) of the form (R+IR)/IR. This ratio is higher for green canopies than for soil. The patch sprayer was field-tested, using both regular and irregular shaped patches of grass. The amounts of herbicide spray used were highly correlated with the total patch area and approximately 90% of the grass was killed.

Grisso and Varner [1989] evaluated the accuracy of sprayers and developed computerized templates for database and spreadsheet program. These microcomputer programs were developed to emphasize the need for proper calibration of pesticide sprayers and to create a knowledge base of spray equipment, chemicals, and common errors associated with pesticide application.

Ozkan et al. [1990] reported results of some research into pesticide application and technological developments in the USA, including in line pesticide injection systems, uniform mixing of pesticides in sprayer tanks, retention of spray droplets on targets, application accuracy, wear life of spray nozzles, subsurface placement of chemicals, spray drift evaluation, droplet size characterization and its effect on pest control and electrostatic spraying of pesticides.

Reed and Stevens [1996] described a computer-controlled spray system that provided optimum precision during pesticide application and provided for environmentally clean handling of reinstate and small amounts of pesticide mixtures remaining in the system following pesticide application. The controller prepared the spray system for the pesticide to be sprayed, and, following initiation by the operator, automatically governed spray, rinse, and system purge operations prior to loading another compound.

AIR-BORNE DROPLETS AND COVERAGE OF TREATED TARGETS

The droplet spectrum of a sprayed toxic or nontoxic chemical applied for pest control purposes are one of the vital factors affecting biological results required and the level of environmental pollution expected. Thus, the two principal factors which may affect the availability of a pesticide to an agricultural pest are the droplet sizes and their distribution, i.e. air-borne droplet spectrum and its deposition/coverage on the treated target surface. The optimum droplet size for coverage by ground sprayers without air assistance, is from 80–150 μm – as MMD. Contact weed killers require a better coverage of droplet spectrum ranging between 50 and 600 μm with a mean 350 μm fungicidal and insecticidal sprays. Space air borne droplets that are required to kill flying insects should be between 10 and 30 μm form a good compromise between maximum control and prolonged floating and have to be adjusted: (i) for the size of the insect, while (ii) kept sufficiently small so as not to be filtered out too much by foliage [Ripper 1955].

Himel [1969] defined the optimum size for insecticide spray droplets as that which gives the best control results of the target insect with minimum insecticide and minimum ecosystem contamination. Optimum sizes of droplets are the sizes small enough to be produced in maximum numbers for maximum coverage and large enough to have an optimum critical impingement velocity for optimum capture on the target insect. The optimum size for insecticide spray droplets is in the range of 20 μm diameter. Spray droplets of 50-100 μm diameters were marginal in efficiency.

The optimum diameter suggested by Akesson et al. [1979] should be of the order of 400 to 600 μm vmd (volume medium diameter) for hydraulic spraying machines and down to 150 to 200 μm vmd for LV air-carrier applications.

Graham-Bryce and Matthews [1981] identified the Controlled Droplet Application (CDA) as a system of applying sprays, which attempts to avoid these limitations: the most appropriate size and number of droplets for the biological target; a narrow range of droplet size; the minimum volume of liquid to achieve the optimum effect.

Hewitt et al. [1998] designed schemes for classifying agricultural sprays according to droplet size and drift potential. These schemes have particular benefit for the comparison of spray data generated using different particle measurement techniques. Labels for agricultural chemical products can refer to the classification schemes for specification of the droplet size spectrum needed for effective application and drift minimization.

CALIBRATION AND ADJUSTMENT OF SPRAYING EQUIPMENT

Grisso et al. [1984] considered the misapplication of toxic chemicals used for controlling agricultural pests as one of the major reasons for environmental pollution, especially in the developing countries. In the United States, one in three cooperators was applying pesticides within 15% of their proper rate, most errors could be traced to incorrect calibration. The principles of spray metering were studied by Hughes and Frost [1985] with a special attention to the application rate control by regulation of the total flow and active ingredient concentration. The principles involved and the weaknesses and strengths of each system were studied, with a commercial example of both types of system. The study includes an estimation of the flowmeter and ground speed transducers currently available and their operation and suitability for this application. Calculation of the required sprayer or nozzle/s flow rate, l min. (Q), under Egyptian measures and stipulations was given by Gabir [2004], as follows: Q, liter/min. = (Rate of application, l fed. × Speed, kph × Swath width, m)/652 (constant). Adjustment of flow rate (1 feddan = 4200 m^2) should be done by setting the correct pressure at the gauge using the pressure-regulating valve. By collecting and measuring the output of each sprayer/nozzle for one minute. The output of each individual nozzle should be approximately the same; taking into account that nozzle tip deliver more or less than 5% is inaccurate.

Pesticides have over the years become more specific and generally less toxic to humans but still hardly any pesticide is harmless to humans. Moreover, many of the products classified by the World Health Organization in category I, signifying that they are highly or even extremely toxic, are still used in developing countries. The figures illustrating the situation are horrifying; some sources report up to 25,000,000 cases of poisoning per year worldwide. WHO reports 500,000 cases of acute poisoning every year with a mortality rate of 2%, which would mean there are 10,000 fatalities annually that mostly take place in these countries. Legislation and the actual implementation of the legislation on the use of these pesticides should bring improvement in this situation.

According to Ayres and Bosley [2002] inaccurate pesticide application rate, spray pattern and droplet spectrum can lead to the movement of pesticide from the targeted area and reduce pesticide effectiveness. Due to timeliness and effectiveness, chemical pesticide application has become a leading method of weed and insect control in U.S. agricultural production. The continued use of pesticides in the agricultural industry has led to concerns of chemical trespassing by ground water contamination or drift. A recent study in Nebraska, USA revealed that two-thirds of the applicators were applying pesticides improperly (application rate errors greater than 5%). A similar study conducted in North Dakota indicated that 60% of tested sprayers had calibration errors greater than 10%. Although inaccurate tank mixing causes some of these errors, a majority of the problems result from improper spray equipment calibration and worn nozzles. Based on surveys done by Landers [2003] in the USA, many farmers are using inaccurate sprayers; faulty sprayers contribute to increased drift levels and waste money through inefficiency and overuse of chemicals. Therefore, sprayers must be regularly checked over to ensure that proper maintenance has been carried out and that no outstanding repairs need to be done.

MAIN CONFIGURATIONS OF THE DATA BASE

List of key words. One thousand sixty key words were distributed on the following 19 main topics: Article description; World countries (71 countries and national/international institutions related); Languages (29 languages); Targets (various world crops of economic importance) – Animals – places (open/closed); Chemicals & Bio-agents and connected aspects; Pests (Insects – Fungi – Bacteria – Virus – Weeds) and IPM system; Economics: ground and aerial services – Marketing: Tenders and contracts (national/international) – Cost/revenue – calculations; Management: ground / aerial operations – Crew – staff – workers – mapping – assisting services; Nozzles / Atomizers: History – Classification – construction – types and subtypes – combined nozzles / atomizers – special droplet generators – manufacturers – prices; Sprayers: History – types and subtypes – components – combined sprayers – manufacturers – prices; ag-aircraft: fixed-wing – helicopter – auto giro – Jets – UL aircraft – a/c spraying systems. Spray parameters: flow rate – spray angle – pattern / swath – rates of application – (droplets / coverage) – Optimum parameters; Calibration and Adjustment: nozzles / atomizers – Sprayers – Ag-aircraft – special spraying machines; Air Borne Droplets: Theory – Atomization / formation – spectrum – categories – properties – measurement – presentation – calculations; Coverage: Transformation – deposition / bounce / capture – quality – collection – measurement - calculation – evaluation – result indicators; Meteorology: macro/micro – air temp. / stability / speed & direction – relative humidity – rain – specific climates – database / optimum climate; Safety Precautions: ground / aerial applications – rules/regulations – obligatory checks – Standards – Legislation; Pollution: sources – avoidance – hazards – exposure (in/off targets); Appendices.

The informative base. 11767 articles appeared in 27 languages covering the period between 1870 till 2004, i.e. 134 years. These articles were classified, analyzed and computerized in accordance with: author/s co-author/s, year, title, publisher, correspondence data, subject, abstract, article's data, and rich key words for each article.

The Articles. The bulk of articles of this database are presented in the following shapes: full-text and summarized articles. The majority of the articles are kept in paper form and the rest are computerized. Few hundred articles are in microfiche shape and other forms.

It should be noted that the three main parts of the base are in the phase to be used in an integration way through a special computer program prepared for this purpose.

General recommendations for spraying application techniques

For the sake of satisfactory pest control results on vegetables plantations and cleaner environment the following recommendations are concluded:

1. To take an immediate and serious action towards the official legislation of the whole aspect of the spraying application techniques. This includes: certification of spraying machines, licensing of applicator and obligatory checks on spraying operation and machine performance.

2. To pay full respect and attention to fulfill all operations of pesticide spraying in a strict accordance with the national standard of each country initiated in this regard, in order to attain the satisfactory results required.

3. To define and adjust proper spray parameters capable of giving the required optimum coverage on the treated targets, which provides good pest control results with the minimum acceptable level of environmental pollution.

4. To activate the academic environment and individuals and institutions concerned either in the private sector or in the government to understand the role played by the application techniques in increasing agricultural production qualitatively and quantitatively as well in protecting the environment.

5. To encourage the arrangement of training courses of various levels for the public concerned with this activity.

6. To encourage the organization of seminars and conferences on national and international levels to exchange ideas and to activate publishing in this field.

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