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Pesticides in Crop Management: Environmental Implications and Future Challenges (A Review)

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ABSTRACT

No one can imagine an agricultural revolution without pesticides, in addition to fertilisation and mechanisation. The world should have been more crude without food or probably highly diminished in population due to chronic competition for scarce and raw food. There is population boom due to quicker and more dependable access to food and medicare. The economic growth of citizens and nations have depended primarily on agriculture. Part of the aftermath of human civilisation is chemical and pesticide contamination/pollution. The danger lies on the pollution level of these substances in our food chain and the environment. This paper reviews the place of pesticides in crop management, environmental implications and challenges for the future. It proffers acceptance of opinions of major stakeholders: scientists, investors, farmers, government, policy makers, regulators, health professionals, environmental experts/carers, regulators and recommends the use of contaminant level pesticide in contrast to pollutant level pesticide in crop management, pending the discovery of alternatives to synthetic pesticides, including botanic or bio-pesticides, to feed a hungry world.

Introduction

The earliest recorded use of pesticides was the burning of sulphur to fumigate Greek homes around 1000 BC. The use of sulphur (iv) oxide from the burning of solid sulphur was partly by incorporation in candles and persisted into the 19th century. The use of hydrogen cyanide to preserve specimens in museum was recorded in 1877. A few years later it was used to control insects in fruit trees. For hundreds of years, inorganic sodium fluroride and boric acid have been used to control ant and cockroaches. Likewise oils from petroleum or living sources such as fish and whales have been used for hundreds of years as pesticides. Again, the use of arsenic and its compounds to control insects dates back to Roman times and was employed by the Chinese in the 16th century. It became quite widespread from the late 19th century until the second world war. During the same war, exactly 1940, dichlorodiphenyltrichloroethane (DDT) was manufactures for Allied use. It was discovered by a famous German scientist, Paul Muller in 1939 who was working for the Swiss firm (Geigy) on the development of various chemicals to fight agricultural pests. It was commercialized within Switzerland in 1941. The product met with unprecedented success against a number of insect-borne diseases. For example malaria in the tropics and typhus in Italy. By then it was acclaimed to have several advantages: cheap to manufacture, persistent in the environment and could be applied from the air. After the war, DDT was used extensively not only to control insect populations responsible for the spread of diseases but to control insect pests attacking agricultural crops. The success of DDT resulted in the development of other pesticides such as lindane and dieldrin (Horn, 1998; Baird, 2001; Jackson and Jackson, 2000)

Today, pesticides have become a major element in modern agriculture production practices. The advent of pesticide use has coincided with the tremendous increase in agricultural productivity. Together with the adoption of improved varieties, the use of synthetic fertilizers to increase nutrient supplies, improved irrigation practices for water supplies and more efficient machineries. Synthetic organic pesticide use has been credited as one of the major contributors that modernized agricultural production. These innovations led to dramatic improvement in crop yields and nutritional quality of the products as well as efficiency in production management (Cheng, 1990).

The importance of pesticide to modern agricultural production practices is now well recognized. Synthetic organic chemicals have essentially replaced inorganic chemicals and many tillage and cultural practices as the tool of choice for pest control. The recent trend toward conservation tillage systems has also meant an increased reliance on chemical pesticide use for insect, weed and disease control, although other means of pest control are constantly being sought, such as the integrated pest management approach combining nonchemical means with the chemical use for pest control (Cheng, 1990).

For conventional sake pesticides includes all insecticides, fungicides, herbicides, fumigants and other chemicals used for related functions. The advantages of these modern pesticides over other means of pest control include their effectiveness in controlling pests, even when the chemicals are applied at such low levels as a few milligrams per hectare concentration. When pesticides are applied under appropriate soil and environmental conditions in prescribed amount using specified procedures, they can be proven to be effective in pest control with little adverse effects on the surrounding environment (SSSA, 1990; Cheng, 1990).Growing evidence indicates, however, that trace amounts of pesticides are present on non agricultural land, in the atmosphere, and in water, both in surface bodies and underground, far from the sites of pesticide applications. Since pesticides are toxic, there is concern on their impact of their presence in the environment on human health and environmental quality. Over the past decades, the adverse effects of certain

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pesticides to human and environmental health have increased. Although sporadic information on their adverse effects are in literature since the early days of pesticide use, the current awareness and concern for the adverse effects had its course after the second world war. Some of them example DDT was widely overused, particularly in agriculture, which consumes 80% of its production. This led to rapid rise in environmental concentration and started affecting the reproductive abilities of birds which indirectly incorporated them into their bodies. Infact, by 1962 DDT was being called an “elixir of death” by the Writer Rachel Carson in her influential book called “silent spring” because of its role in decreasing the populations of certain birds such as the bald eagle, whose intake of the chemical in their diet was very high (Baird, 2001; Cheng, 1990; SSSA, 1990).

Currently, in addition to concern for the acute and chronic toxicity of pesticide chemicals, their potential as carcinogens, teratogens and mutagens, and their presence in all corners of the earth, from the arctic icecap to the groundwaters used for drinking puposes, have led to questions on the wisdom of continued use of pesticide. These concerns on the potential threats on human health and environmental quality are serious issues. There is call for pesticides use to be restricted to certain geographical locations or under certain agricultural practices. The improper disposal of pesticides is another case of concern (Cheng, 1990).

The cause and effect relationship between pesticide use for agricultural production at a locale and observation of pesticide contamination of the surrounding environment, causing adverse effect on environmental health, cannot be readily established from many cases (Cheng, 1990). According to this author, reported incidents on pesticide contamination of the environment or on adverse environmental effects from pesticide use can often be traced to improper application or inappropriate practices. Either lack of knowledge or a disregard for the sensitive nature of the environment has been the root of many pesticide contamination problems. For instance, Cheng (1999) argues that common sense would predict that injudicious application of highly water-soluble pesticides to irrigated crops in sandy soils would likely result in the presence of these pesticides in shallow aquifers under the irrigated fields. The basic problem according to this scientist has been a lack of understanding of the processes affecting the behavior and fate of pesticides from the point they enter the environment to the point at which they would affect the target organisms.

Since concerns are mostly associated with the presence of pesticide in the soil environment, it is essential that the processes affecting the transport of pesticides in soil be understood before any cause and effect relationship can be established. Similarly, to the issues of contamination of the air and water environment. For most of the processes, the fate of a pesticide in the environment is governed by the retention, transformation, and transport processes, and the interaction between the pesticide chemical and the soil-water-air surfaces or soil-water-air components thereon. It manifests the extent of their affinity. The retention processes are frequently described as adsorptive or simply as sorption. They may be reversible or irreversible. They can retard or prevent the pesticide movement and affect its availability for plant or microbial uptake or for biotic or abiotic transformation. Whereas retention is mainly considered to be a physical process, transformation is characteristically a change in the chemical nature of the molecule, although the demarcation between a physical and a chemical process is not always easily differentiated. The transformation processes may be purely chemical in nature; they may be catalysed by soil constituent or induced photochemically. Most pesticides are, however, transformed predominantly by biochemical means, such as by soil microorganisms. Biotic transformations of a pesticide generally result in degrading the molecular structure into simpler forms. Degradation tends to decrease the chemical’s toxicity although occasionally the metabolic products could be even more toxic than the parent compound. Just as the transformation processes dictate whether and how long pesticides may be present in the environment, the transport processes determine where the pesticides may be present in an environment (Cheng, 1990).

Volatilization leads to the distribution of pesticides from the soil to the atmosphere; leaching leads to the movement of the pesticides toward the groundwaters, and overland flows move the pesticides into surface waters. To assess the fate of a pesticide in the soil environment, one must assess the kinetics of the individual processes as well as the combined effects of all the processes (Cheng, 1990). The worker also detail procedures for determining pesticide fate, including chemical structures and properties, soil properties and conditions, the climatic status, presence or absence of plants and microorganisms, and soil management practices. Likewise, soil properties such as its organic matter and clay contents, pH, and ion exchange capacity. Others include, the condition of the soil, such as its moisture or oxidation state and the location of the soil on the landscape. Soil conditions are also affected by climatic conditions, temperature, precipitation, wind and radiation. Similarly, the variety of plant species and their growth stages and the presence of multivarious types of plant species and their growth stages and the presence of multivarious types of microorganisms (Cheng, 1990; SSSA,1990).

Cheng (1990) is of the opinion that when both the benefits and risks of the presence of a pesticide in soil environment are weighed, approaches to manage pesticide use and maintaining of environmental quality can be more appreciated. The Royal Society of Chemistry (2001) did a great work in trying to distinguish the presence of chemicals in the environment namely: contamination and pollution. According to the workers, these terms tend to be used in similar ways in everyday speech and journalism. However, in the scientific areas, there is a broad consensus that the term contamination should be used where chemical is present in a given sample with no evidence of harm and pollution used in cases where the presence of the chemical is causing harm. Thus, according to the experts pollutants are chemicals causing environmental harm.

Since pesticides are also chemicals causing environmental harm, it is useful to differentiate when it is a contaminant and when it is a pollutant. It is very difficult for traces of chemicals not to be found in air, water and soil; but the attention is when it becomes a pollutant. That is the point it is critical and calls for concern. To establish contaminant and pollutant levels of pesticides in the environment is an onerous task that calls for putting many factors into equation. Since agriculture is a prerequisite for feeding the teeming population of the world (over 6 billion), with a projection of over 9 billion by 2050 and many of the hungry ones located in sub-saharan africa, latin america and asia. Additionally, pests and diseases incidences are limitations in crop production and can only be controlled by use of pesticides. The onus lies on the use of sustainable pest and disease management practices namely biopesticides, cultural practices, farm sanitation, good farming systems, adequate management of biotechnology and genetic modification of crops and green practices that will address problems of global environmental degradation. Therefore, this paper reviews pesticides in crop production, environmental implications and future challenges.

The place of pesticides on crop production and national economy

Modern farmers have come to depend upon a great variety of insecticides, herbicides and fungicides to control the pests, weeds and diseases that threaten crop and animal productivity. These pesticides are now big business, with global sales exceeding US$31 billion in 1998 and triple over the past decade. Each year, farmers apply 5 billion kilogrammes of pesticides' active ingridients to their farms. Nine-tenths of this market is now controlled by just eight companies. Yet, it is only in the past century, less than 1% of agriculture's history, that such dependence has emerged. Many of the chemical industries producing pesticides are in North America and Western Europe. They have been in production since 1940s and 1950s. In US annual production is over 200 million kg. and in UK over 107.6 million tonnes. In UK 25 million kg of pesticides are used in farming per year. The US and UK external cost of pesticide is put at US$7,825 million and £150 million per year respectively. The world figure is put at over US$8 billion, with the private expenditure of some US$4 billion. Of the US$8 billion external costs, US$3 billion is paid effectively by farmers, leaving US$5 billion to be absorbed by the society The quantities of pesticides applied in developing countries are minor compared to those in the industrialised countries. In developing countries, they are mainly used for export crops (Pretty, 2002; DEFRA, 2001; Horn, 1998; Baird, 2001).

The estimated benefits associated with reduced crop losses is put at US$16 billion. In developed countries like US they contribute to the massive agriculture worth over US$520 billion, employing more than 15 million people. Between 1975 to 1997 California farm sales tripled from US$8.5 billion to US$26.8 billion and as at the year 2000 comprise one eight of the total cash receipts of US agriculture, thanks to the use of pesticides in their agriculture. In California, agriculture provides 7.9% of gross state product and creates more than one in ten jobs in the state. More than 350 different crops and commodities are produced by almost 74,000 farms in California. More than half of the nation of US fruits, nuts and vegetables are produced in California on only 3% of US farmland. In short, California agriculture is one of the most productive and efficient in the world. According to the US department of agriculture (USDA) 1997 census of agriculture, California had 27,698,779 acres of land in farms. It is renowned as diversified, US$28 billion empire. California applies about 202 million pounds (91.71 million kg) of pesticide active ingridients each year (White, 1994; Blank, 2000; Bryon, 2000; Johnson and Carter, 2000; Swezey and Broome, 2000).

Agrochemicals industries have been concentrating their efforts on promotion of conventional pesticides in Latin America and Asia. Since 1996, pesticides use increased by 6% in Latin America and countries such as Brazil, China and India have become important producers and users of conventional pesticides (Meermann *et al*, 1997). The same workers reports that in a number of developing countries pesticides can be obtained very cheaply at the local market, thereby raising the level of usage. This assertion does not hold in most countries of africa, where they are highly expensive, unaffordable and unavailable.

The effect of pesticides on human health

A WHO report suggests that at least 3 million and perhaps as many as 25 million agricultural workers are poisoned each year by pesticides (WHO, 2015). In US it is estimated there are 80 million cases of food-borne diseases a year, killing more than 9,000 people and costing more than US$1 billion. National surveillance data show that microbial contamination is by far the most mysterious risk of food contamination, yet the public is also concerned with the more mysterious risk of chemical contamination namely: pesticides, herbicides, antibiotics residues (Glosser *et al*, 1994). For more than 30 years, most public and regulatory concern about pesticides residues in food has focused on whether life-long exposure to some chemicals in the diet could increase the incidence of cancer. Public concern about diseases other than cancer has been stimulated by the results obtained from thorough toxicity testing of pesticides. As scientific understanding of the full range of pesticide toxicity increases, the question of effects of pesticide residues on diet, reproductive, neurological or immune system has been raging. It is clear from results of toxicological studies on laboratory animals that many pesticides in widespread use have the capacity to damage important physiological systems. There is also epidemiological evidence that workers with relatively high levels of pesticide exposure can suffer from a variety of acute and chronic health effects (Pease, 1994).

Since pesticides has been confirmed to be reproductive toxicants, the normal sperm count of workers formulating dibromochloropropane (DBCP) was lowered substantially because this nematicide is toxic to critical germinal cells in the male testes. The same is applicable to furadan being used in some developing countries. Highly exposed workers became infertile. Other pesticide like endosulfan has been proved to mimic the activity of human hormones and this affects female reproductive capacity. Toxicological evidence indicates that many pesticides can cause birth defects. Of 200 pesticides tested as at 1994, nearly half were reported to induce defects in experimental animals (Pease, 1994). Some pesticides trigger hypersuceptibility to chemical exposures or hindering an organisms's ability to successfully fight off infections. Occupational exposure to captan, has been shown to induce contact hypersensitivity, a type of dermatitis. Toxicological studies have also demonstrated that other pesticides can damage the immune system. Pesticides such as carbofuran, methyl parathion has reduced experimental animals capacity to resist bacteria infections.

Entire classes of pesticides, like the organophosphate and carbamates insecticide target enzymes that are essential to the functioning of healthy nervous system. Exposure of farm workers to mevinphos and methomyl have resulted in several mass poisoning incidents. Workers experience both physical and neurological symptoms including nausea, breathing difficulties, irritability and confusion. Epidemiological studies have reported long term damage such as memory disturbance and defects in intelligence and motor functioning as a result of repeated acute exposure to neurotoxic pesticides. These are known as endocrine disrupters. In US, 30 out of 42 crops in a study showed residues of endosulfan,cabaryl was detected on 27 crops and both pesticides are endocrine disrupter. (Pease, 1994). The maximum residue level (MRL) of all crops grown in UK between 1994 – 1999 shows that out of 2514 samples, 15 exceeded the MRL. Between 1995 – 1999 out of 2171, 2002, 1490, 1227 and 1524 sampled; 26, 19, 3, 6 and 10 samples exceeded the MRL respectively (DEFRA, 2001). In 2000, the UK pesticide forum report listed top agricultural pesticides most frequently exceeding 0.1 µg in surface freshwater in England and Wales. These include: mecoprop, isoproturon, 2-4D dichloroprop, simazine, atrazine, bentazone and chlorotoluron (DEFRA, 2001).

The effect of pesticides on the environment

The effects of pesticides on soil environment, the medium of crop growth is another controversial area. It is the center of perturbations in the course of pesticide applications, cultivations and other husbandry operations. One consequence of this peculiar environment is that the resident fauna and flora are likely to be limited to species equipped to survive under these constraints. The attributes which might allow animals and plants to persist in these conditions include high mobility and life cycles which offer an ability to escape the effects of sudden changes, or to recover afterwards. Many of the species likely to be successful in these areas are generalist. Others include cumulative effects of repeated exposures to one or more pesticides and indirect changes such as depletion of prey or removal of vegetation cover. The severity of short term effects has been linked to the toxic effects of the pesticides, but much more importantly from an ecological point of view, an exposure to chemical is determined jointly by the pattern of the product and its subsequent distribution and persistence in the environment, and by the ecology and behavior of the species, affecting contact with it. The expectation is that the exposure of non-target organisms will vary in space and time. Species or individuals whose habitats allow escape from the site of application, by movement to and from protected parts of the field habitat will experience less damaging exposures than others (Greig-Smith, 1990).

Similarly, the ability to recover from population reductions by immigration from adjacent habitats, recruitment from seed banks or reproduction, has been reported to help in overcoming short term effects. Therefore, mobility and breeding seasonality are important determinants of the severity of short-term adverse effects, in conjunction with the timing and scale of local use of the insecticides (Greig-Smith, 1990). The same properties are also relevant to long term toxic effects of pesticides on soils. The indirect effects include prey depletion and habitat change. For example, it is reported that dietary specialists might be at risk from reductions in the density of their prey, whereas general feeders are likely to be less vulnerable if they can switch to alternative prey. Other workers have reported community of animals or plants altered by direct or indirect effects on vulnerable species. There may be new opportunities for certain other species. These are likely to be poor competitors, normally held at low density by predators or superior competitors, but which are able to increase in numbers when these pressures are relaxed (Greg-Smith, 1999).

Addition of any pesticide to the soil ecosystem has been reported to cause significant changes in the kinds and numbers of soil microorganisms (Greig-Smith, 1990). A related case, was observed in US corn belt where chemically induced changes in the microbial populations of soils with a history of heavy pesticide applications was reported. It is well known that bacteria and fungi are major factors in the decomposition of organic matter, but rather little is known of the specific pathways of pesticides. There is report that some bacteria utilize pesticides for nutrients, breaking them down chemically and rendering them non-toxic (Brady, 1982). The regular, repeated applications may indeed favour such microbes, reducing the efficacy of insecticides applied to the soil. For example, several soil pesticides formerly effective against corn rootworms in the Midwestern US have recently become ineffective, though laboratory studies revealed no appreciable resistance in the insect populations. This is a case where application of an insecticide can result in resurgence of a pest by removal of its natural enemies (Brady, 1982; Horn, 1988; Greig-Smith, 1990)

Many insecticides such as arsenic compounds are not biodegradable. Once released into the environment, they remain indefinitely in the soil or sediments and may enter the food supply if liberated from these sites. DDT was widely overused, particularly in agriculture, which consumed 80% of its production. As a result its environmental concentration rose rapidly. Immediately it was discovered to persist in soil for several years it was listed to be discontinued in agriculture on phased basis. However, DDT is still being used in developing countries to control diseases or pests. For example in 1996, Mexico used 600 tonnes of DDT for malaria control and agreed to reduce this usage to 120 tonnes by2001 and to stop using it entirely by 2007 if effective substance can be found (Baird, 2000). But this was not done. Mexico is yet to get rid of DDT, just as other countries like California are yet to get rid of methyl bromide (Elmore *et al*, 1997; Stapleton *et al*, 2000).

During the 1970s, after DDT was conventionally listed on banned substances by developed world, toxaphene, a mixture of hundreds of similar substances replaced it. It became the most heavily used pesticide in US before its ban in 1982. The current levels of toxaphene accumulation has made the UNEP and International Joint Commission for the Great Lakes to list it as a priority organic pollutant. The cyclodiene pesticides starting with aldrin, dieldrin arrived on the market in about 1950. Given their tendency to accumulate, the compounds have been banned or severely restricted in North America and most western European countries. However, some of the compound like endosulfan is still used as an insecticide for domestic and agricultural purposes and it is one of the endocrine disrupters. The agricultural uses of dieldrin in North America were largely prohibited by the mid 1980s. It was used extensively in tropical countries to control the tse-tse fly, and is still used in some countries to kill termites. Although banned from most uses in the region, dieldrin is still in IJC priority list since its persistence levels has not decreased compared to other cyclodiene based pesticides. Dieldrin has been discovered to enter water systems via leachate released from waste disposal sites (Baird, 2001).

Mirex is a pesticide effective against the fire ant found in the southeastern US. It is marketed under the trade name – dechloane. Although, banned in mid 1970s mirex is presently classified as a persistent organic pollutant by the UN and as an IJC priority pollutant in the Great Lakes. Mirex entered Lake Ontario and accumulated there because it was commercially produced along the nearby Niagara River. Both accidental spills and its presence in the effluents of the manufacturing plants led to deposition of quantities of the chemical in rivers draining into the lake. Because of its high persistence, the mirex clearance from the area has been projected to take a century (Baird, 2001).

Organophosphate insecticide represent an advance over organochlorines. However, they are generally more acutely toxic and persist in the soil than the organochlorines. Many organophosphates have been banned or suspended in developed countries. The use of malathion in US (California, Florida, Texas) and Chile to combat infestations of Mediterranenan fruit fly, a dangerously destructive pest has been controversial (Baird, 2001; RSC, 2000).The mode of action of carbamates is similar to the organophosphates, but are short lived in the soil. They are short lived in the soil.

Alternatives to synthetic pesticides and factors limiting their use and commercial production

The natural pesticides, like nicotine, rotenone, pheromones, juvenile hormones, pyrethrins are generally considered safe to use, like organophosphates, since they paralyse insects, but not kill them. They are unstable in sunlight, but the synthetic prethrins (pyrethroids) are stable outdoors. Rotentone is a complex natural product derived from the roots of certain bean plants. It is also unstable and easily decomposed by sunlight. Anti-juvenile hormone activity has also been discovered in plants. Azadirachtin from *Azadirachta indica* (neem) is a potential insecticide being developed in developing countries. It has been reported that many insects will starve to death instead of eating plants treated with Azadirachtin. Neem extracts has been proved to exhibit growth regulatory effects on certain species of insects and the substance has very low persistency in the soil (Brady, 1982; Horn, 1988; Baird, 2000)

Other alternatives to synthetic pesticides include: microbial pesticides e.g *Bacillus thurigiensis* (Bt), *Beauveria bassiana*, *Verticillium lecanii*, *Metarhizium anisophilae* . Botanical or bio-pesticides like *Tithonia diversifolia*, *Melia azedarach*, *Cassia spectabilis* and siamea. Pyrethrin as mentioned above is part of botanic or bio-pesticide. Other groups include: synthetic pyrethrins (pyrethroids) e.g cismethrin, bioresmethrin and permethrin (Rosset and Moore, 1997; Thijssen, 1997; Horn, 1998 and Baird, 2001). The level of production of the microbial and botanical pesticides is still low. Kenya is leading in the production of prethrin, with an annual production of 10,000 tonnes, 50% of world's output. Cuba produces 781, 196 and 142 metric tonnes of *Beauveria bassiana*, *Verticillium lecanii* and *Metarhizium anisopliae* per year. US is leading in the production of *Bacillus thurigiensis*. More than 30 Bt insecticide formulations are in US market. Cuba produces 1312 tonnes of Bt per year (Rosset al, 1997; Federici, 1998; Metcalf, 1980).

Future implications of use of pesticides in crop production, human health and the environment

It is impossible to produce enough food to feed the world teeming population without adequate provision for pests and diseases control. There is still a need to fall back on fairly contaminant level concentration of pesticide as defined by RSC (2001), as scientists battle to provide alternative pesticides, including botanic and microbial pesticides. The fairly contamination concentration can be done through judicious and selective use of available ones that have not been totally banned. This requires constant monitoring and assessment in all agricultural systems and environmental samples including water and air to safeguard human health and the environment. The land mass of the world is over 13.07 x 10^9 million ha of which 11.3% is under crops, 24.6% under permanent grazing; 24.6% under forest and 34.1% under woodland and 31% under urban, industries, roads and other infrastructure. The water bodies of the earth is 70% liquid, 10% ice and the rest underground water; while the envelope of gas that surrounds the earth is within 80,000 km of the earth surface, with 99% by mass found in the lower 50 km (Baird, 2001). This makes the reality of adequate assessment and monitoring of contamination and pollution status of pesticides in agriculture and the environment a very difficult task. Moreover, there is no clear divide between the lithosphere, hydrosphere and atmosphere. Nutrient cycling and nature being in everlasting continuum. What is happening in one geographical region has implications in others. Therefore, when one region gets it right and others get it wrong it has not addressed the problem. For everyone to get it right is hindered by political, economic, social, religious and other affiliations.

The world is full of risk. The stark reality is that there are many challenges. The producers of pesticides, the investors, the marketers, the consumers, the farmers, the researchers, the government, decision makers are all in deadlock on what constitutes an acceptable risk. In their assessment of acceptable risk, Meyers and Craigmill (1994) gave two versions: acute and chronic risk. According to the workers, chronic risk is more difficult to assess. In either case, low risk is not zero risk and safety, like beauty, is often in the eye of the beholder. Safety is not the same as zero risk. Life presents people with nothing that is totally risk free. Risk, according to the authors is the probability that something unwanted will happen. There are measurable risk (actuarial risk) and estimated risks. Both risks are for entire populations. They are not individual risks. Individual risk is often lower or higher within populations depending on individual exposure, susceptibility and behavior. What individuals define as safety is acceptable risk and cannot be determined scientifically. Both as individuals and as a society, the amount of risk acceptable from potential hazards decides the safeguards which are necessary. While risk can be scientifically estimated, safety is a matter of public policy and outside the boundaries of science. Thus, pesticides residues on produce are typically miniscule according to regulators, but the public does always agree with scientific estimates of risk (Meyers and Craigmill, 1994).

In another scenario, consumers cut back on produce purchases when news event undermine their confidence in the food supply despite the well publicized conclusions of the National Academy of Sciences (2002) that a diet rich in fruit and vegetables reduces the likelihood of cancer. In a US nation wide survey conducted in 1993, 55% of men and 67% of women told the center for produce quality that they were concerned about pesticides residues. In another survey, 70% of the people expressed concern that current pesticide regulations do not take into account the effects that residues may have on children. To protect their children 15% said they would serve fewer fruits and vegetables and the percentage rose among people of lower income and less education. The Packer Focus Fresh Trends '90 survey also reported that 17% of shoppers in the US were buying less fresh produce because they were concerned about pesticide residues (White, 1994).

In the US, various pesticide regulation primer are in use. The EPA is required to register pesticides based upon the entire picture of risks and benefits. Some of the primers are: acceptable daily intake (ADI), cancer potency factor, federal insecticide, fungicide and rotenticide act (FIFRA), federal food, drug and cosmetic act (FEDCA) and good agricultural practice. Others are negligible risk, reference dose (RfD), registration, risk-benefit analysis and tolerance. Scientific unknown have given rise to several controversies. Other debates concern the political difficulties in pesticide regulation. These include the controversy of actual residue versus tolerance, health-based tolerances, interactive effects, natural carcinogens, re-registration: the EPA backlog and sample in tests (White, 1994).

In the US, the Delaney Clause states that no residue tolerances for pesticides shown to induce cancer may remain in processed food. It got a consent of the court and fear of revocation of tolerances for some pesticides on processed foods and raw agricultural commodities was reported in 1994. As many as 35 pesticides/commodity regulations were to be cancelled because the EPA's policy prohibits establishing a raw commodity tolerance if a tolerance on processed foods is prohibited. This type of revocation hampers the production of specific commodities if alternatives are not available (Stimmann and Melnicoe, 1994).

In the UK, the European Economic Community (EEC) has list I chemicals (black list) which have limit values and environmental quality level. Some of the list I chemicals have been banned or suspended. The dangerous substances directive 76/464/EEC was adopted in 1976 to provide a framework for eliminating or reducing pollution of inland waters by particular dangerous substances. In 1982, the Commission also published a list of 129 potential list I chemicals selected by the Commission on the basis of production volume and estimates of toxicity, persistence and bioaccumulation. List II (grey list) are controlled using the environmental quality objective approach using standards set nationally. Member states are also required by the directive to establish programs to reduce pollution by these substances. The directive concerning the placing of plant protection products on the markets 91/414/EEC contains a positive list of active ingredients that may be used in the formulation of plant protection products. Another directive 79/117/EEC restricts the marketing and use of certain pesticides and list the substances that may not be present in pesticide formulations. The list currently bans several mercury and persistent organochlorine compounds as well as other compounds such as nitrogen and ethylene oxide. Pesticides that are marketed must conform with various classifications, packaging and labeling requirements. Amongst other things, specific application methods, timing, rates and disposal methods are to be given to ensure that there is no pollution (DEFRA, 2001, RSC, 2000).

In UK, those applying pesticides are also required to meet certain training requirements and guidance is given by the ministry of agriculture, fisheries and food. The department of environment, food and rural affairs (DEFRA) are responsible for all environmental issues including monitoring of pesticide use and abuse for food, water and soil web. In 2001, the UK Government also suspended approvals for advertisement, sale and supply of dimethoate, demeton-s-methyl, lambdacyhalothrin and deltamethrin. In the US, there are also pesticides cancellations. In all cases the farmers and other users are always challenged for alternatives or other pest management techniques to replace the losses. However, the development of environmentally sound, efficacious and economical pest management methods is difficult, time consuming and expensive. Incremental pesticide losses allow agricultural technology to develop in response to pest management needs as they evolve. Sudden loss of many widely used pesticides, always poses the problem of identification and development of alternatives before severe production problems results. Regional economies based on agriculture also suffer the consequences (DEFRA, 2001; Stimmaun and Melnicoe, 1994).

In general, pest management alternatives calls for advance knowledge of crop, the pest, the damage, possible biological and known resistance problems. This provides information on monitoring techniques, economic thresholds if any that are available, treatment timing, comments on effective control and spot treatments. Each guideline gives specific information on applying pesticides to ensure effective control (Stimmann and Melnicoe, 1994). Many trials have compared conventional, integrated and no pesticide practice. Some reported that assumptions made in no pesticide scenario are unrealistic, since there was no price effect. In essence, the scenario implies that all of the yield reduction associated with organic systems is absorbed by a system in which fertilizer expenditure remains in the conventional case, pesticides are not used, and no change in price for output. The integrated systems faired better than the conventional. In the no pesticide scenario, the output price for no pesticide crop has to be higher by 20% and 31% respectively to reduce to zero the benefits derived from pesticides in the conventional and integrated scenarios studied. Integrated pest management consists of a combination of biological agents, host plant resistance, cultural control and selective chemical control (Meerman et al, 1997).

Conclusions

The use of pesticide in crop production is inevitable for a hungry world. The majority of world population are hungry, malnourished and hopeless, especially in sub-saharan africa, latin america and asia. For them anything can go for food when it comes to hunger and starvation. The soils in most of these places are impoverished and agricultural output is low. There are many incidences of tropical pests and diseases. All the farmers clamor for improved yield, no matter the means. For them government should not only provide fertilizers and pesticides but highly subsidize or make them free. If increased soil fertility and yield means pouring fertilizer and pesticides to agricultural fields without recourse to rates and soil test, they are ready and free to do so, as little or no regulations are enforced to regulate their use. Nevertheless, if wishes are horses, every developing world farmer will be king. Their wishes are not backed by financial and government power and wherewithal. You see three million farmers competing for 100 bags of fertilizers and 100 liters of pesticide per year with empty pockets. To them the grammar of pesticide in crop production: environmental implications and future challenges are capacity building workshop/seminar grammar where farmers come to wrestle with government and consultant facilitators on breakfast/dinner and envelope money. To them, that is their share of national or international donor cake, because after the workshop there will never be fertilizer or pesticides for their needs. Rather, the facilitators have fulfilled their legal and formal job of pocketing national or foreign donor money into their private bank accounts in the name of bribery and corruption, sometimes including nepotism and all the English in the world.

Nevertheless, in developed world who are free from hunger and starvation, in addition to all the agricultural inputs and finance they need for maximum production; they know that all eyes are on them. What they do will make or mare their business. Since the farmers and investors do not want to loose their money as a result of product bycut or seizure and destroy; they operate under the ambient of the law. On the other hand no investor in developed world wants to be idle or engage in unprofitable business. Hence, all hands must be on deck to maintain maximum output and control price at national and international markets. No wonde,r Meermann *et al* (1997) lamented that even after 35 years of Rachel Carson publication of "silent spring" with devastating account of the effects of indiscriminate use of agrochemicals, the one sided push for increased output continues. Thus, nature is controlled to this end and reliance on pesticide has not diminished. According to the author, in northern countries, the environmental movement, followed hesitantly by government regulation, has had some impact on stabilizing and perhaps curbing agrochemicals; but in the south, the use of pesticides has increased and chemical companies aggressively expand their markets.

Harvey (1997) in his book entitled "the killing of the countryside" worries that nowhere has the destruction been greater than on the chalk downs, those gently contoured slopes that ebb and flow the south of England like an ocean well.

According to the worker, more than 150,000 miles of hedgerow have been lost in England alone since the introduction of subsidies. And they are still disappearing at the rate of 10,000 miles per year. Water meadows, moorlands, marshes and wetlands, all with their own particular flora and fauna have been sacrificed to the obsessive drive for production. The destruction of wildlife and countryside according to Harvey is through a deliberate and sustained national policy which cost the British people £10 billion a year in taxes, both overt and hidden.

According to McCallar (2000), the first and continuing challenge facing world agriculture is to produce enough food to feed a growing population expected to reach 8 billion by 2025 or 2030 and possibly 10 billion by 2050. Again, nearly all the increase of people in the next 25 years will be in developing countries. The urban population in those countries will double from 2 billion to 4 billion in the same period. Urbanization has significant implications for the food system. People in rural areas depend on their own production for more than 60% of their food supply, as opposed to less than 10% for people in urban area. Expanded trade may not solve this problem. Over the last 40 years, a period when the food supply doubled, on average 90% of the world's food consumption tool place in the country where it was produced. Ninety percent of the increase in food production must come from the countries where the additional people will live. The population growth between 2000 and 2030 will occur chiefly between the tropics of cancer and tropics of Capricorn, including most of latin america, most of mexico, all of Africa, except the north africa region and south africa; the southern half of india and all of southeast asia including indonesia. Again, tropical and subtropical farming systems are complex, highly heterogeneous, fragile, generally low in productivity and dominated by small-scale poor farmers. These areas are vulnerable and likely to persist in non-selective use of pesticides in their agricultural systems. This may compound the environmental problems in these areas in particular, as record reveal that africa, asia, latina, north america/australia already have 490, 750, 240, and 600 million hectares of degraded land (Pretty, 2002; McCalla, 2000). However, the search for reliable alternative pest management methods will continue to face farmers, investors and scientists in this century even as pests develop resistance to some available pesticides in midst of transgenic crops. Till that feat food production at extra scale must go on using contaminant level pesticides and avoiding or banning pollutant level pesticides.

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