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HERBICIDE USE: BENEFITS FOR SOCIETY AS A WHOLE- A Review

Zvonko Pacanoski[1]

ABSTRACT

Herbicides are one of the crucial factors in a worldwide increase in agricultural production. Herbicides contribute effectively and profitably to weed control, environmental protection, and, in the same time, saving labour necessary for weed control practices, reduced soil erosion, saved energy, increased crop production, reduced the cost of farming. Therefore, herbicides benefit society as a whole. But, use of herbicides has created considerable concern for human health and environment. Fortunately, the health and environmental risks associated with herbicide use are largely a manageable problem. In most cases, herbicide misuse is a human health and environmental risks.

Key words: Herbicides, weeds, benefits, chemical control.

INTRODUCTION

Weeds have been a problem in agriculture since about 10,000 BC (Hay, 1974; Avery, 2006). They have always represented one of the main limiting factors in crop production (Avery, 1997). Damages globally caused by weeds are responsible for a loss of 13.2% of agriculture production or about $75.6 billions per year (Oerke *et al.*, 1994). Berca (2004) goes further when he says: "Weeds eat the food of about 1 billion inhabitants". Crop losses due to weeds in the United States are estimated to be nearly $6 billion per annum, which is up from an estimate of 4.1 billion about a decade ago (Bridges, 1992). According Bridges (1994), weeds represent the most important pest complex and estimated that the impact of weeds on the United States economy exceeds $20 billion annually. Weeds are different from the other pests that pose problems in crop production in that they are relatively constant, whereas outbreaks of insects and disease pathogens are sporadic (Gianessi and Sankula, 2003). Apart from the quantitative damages caused by weeds due to competition with water, light and nutrients (Coble *et al.*, 1978;1981; Jordan *et al.*, 1987) and to the antagonism (parasitism and allelopathy), weeds are able to cause qualitative indirect damages due to crop yield reduction, contamination of seeds (Anderson *et al.*, 1983; Ashton *et al.*,

[1]Faculty for Agricultural Sciences and Food, 1000 Skopje, R. Macedonia, E-mail:zvonkop@zf.ukim.edu.mk

1991), slowing of tillage and harvesting practices, and degradation of quality of milk or other animal products (King, 1966). In the past farmers spent a lot of energy in weed control, using different methods, all not completely efficient. By the end of the Second World War, agriculture came into the "chemical" age and production began to rise. World agricultural production 25 years after Second World War was bigger than 80 years ago, or equal to 500 years during the Middle Age (Janjic, 1994). Herbicides are one of the crucial factors in the development of agriculture production. Herbicides can effectively control weeds, saving labour necessary for weed control practices and in the same time, reduce soil erosion, save energy, increase crop production and reduce the cost of farming. The importance of herbicides in modern weed management is underscored by estimates that losses in the agricultural sector would increase about 500% without the use of herbicides (Bridges 1992; Bridges 1994). Nowadays agriculture (food and fibre production) is facing a difficult situation; on one hand, world population is rapidly increasing (over 6 billions inhabitants on Earth surface now and 9 billions in 2050) (Berca, 2004), every day decreasing the arable surface (nearly 2 billion hectares worldwide have been degraded since mid of the previous century) [Scherr and Yadav, 1996] and on the other side, lack of knowledge, delusions, and controversy in the world about herbicides use and its potential benefits for world food production.

The objective of this review was to give scientific and argument answers for the benefits of herbicides in modern agriculture, world wide hunger prevention, and their impact on environment, human health, and society as a whole.

Pesticide industry in global frame

The pesticide industry is very big because pesticides are an integral component of intensive world agriculture. World-wide pesticide sales in 2004 were a record $32.665 billion. Herbicides accounted for 45.4% of the pesticide market (Figure-1). More than half of the world's pesticides are used in North America and Western Europe (Figure-2) [Dinham, 2005].

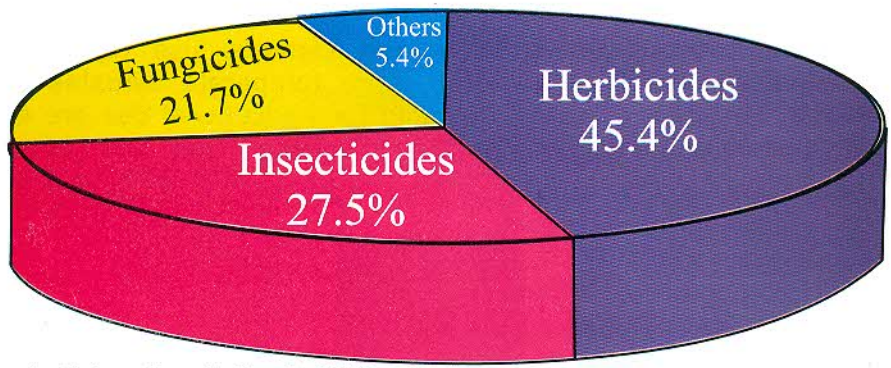

Figure-1. Sales of pesticides in 2004

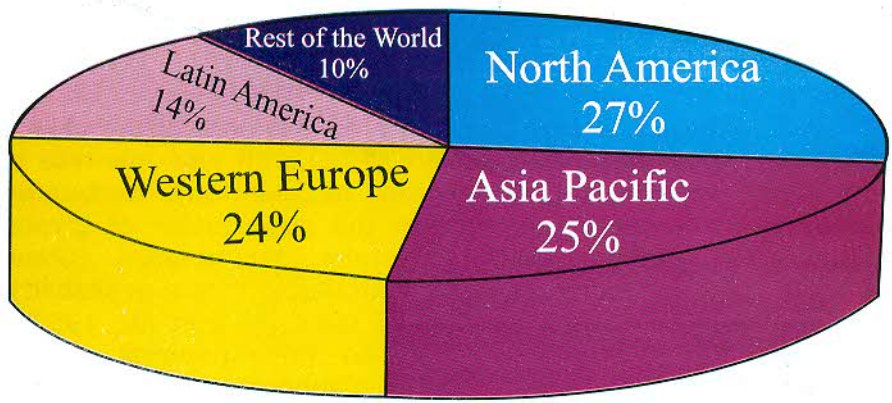

Figure-2 . Global pesticides sales by regions in 2004

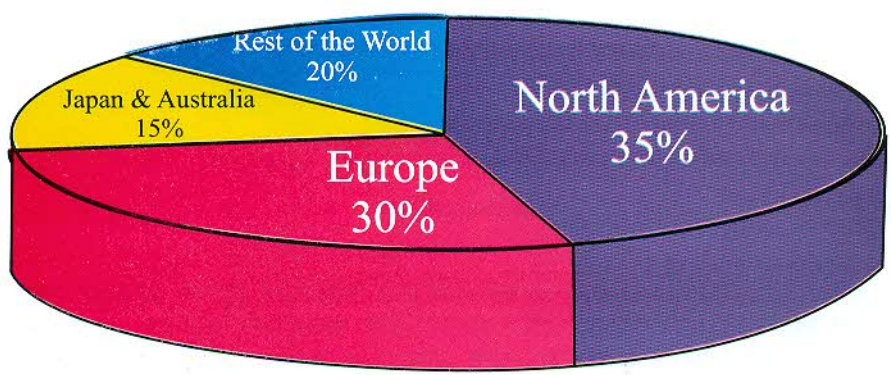

Figure- 3. Herbicides use as a function of geographical area

Developing countries in warmer climates use half of insecticides whereas industrialized countries in more temperate climates use most of herbicides. The 80% of herbicides sold for agricultural use are employed by few developed countries: 35% in North America (USA and Canada), 30% in Europe, 15% in Japan and Australia (Figure-3) and 20% in the rest of the world.

Herbicides protect environment

The increasing production and use of the new "low-rate" and "environment-friendly" herbicides has reduced the risks for non-target organisms and the environment as a whole. According estimates of Giantess and Reigned (2006), the quantity of herbicide active ingredients used on crops fell between 2001 and 2005. Total herbicides use in US agriculture was 186000 tons in 2001 and 158000 tons in 2005. Herbicides use in corn declined by 23000 tons, largely due to the replacement of the older high rate herbicides (e.g. cyanazine, metolachlor, EPTC) with new low-rate herbicides (e.g. flufenacet, mesotrione, rimsulfuron, nicosulfuron). Herbicides use on cotton decreased by 5000 tons due to the substitution of glyphosate for several older herbicides: MSMA, trifluralin, fluometuron (Gianessi and Reigner, 2006). These decreases were attributable to the availability of more effective herbicides with lower application rates (Pike *et al.,* 1997).The new weed management technology based on environmental principles use "environment-friendly" herbicides, mainly glyphosate and glufosinate. These herbicides have little residual activity, are low in mammalian toxicity, and have an average half-life in soil of about 40-60 days, which means little restriction for crop rotation and low environmental (Pacanoski, 2006). Also, the price of glyphosate declined by 16% between 2001 and 2005 (Salassi and Breaux, 2005). Because of these characteristics glyphosate and glufosinate are the most sold out farm products in the world (Dinham, 2005).

Herbicides save labor for weed control

Use of herbicides for weed control reduces hand labour requirements for many agricultural activities, which has become scarce and expensive in many parts of the world. In the past, a large proportion of the active population, sometimes up to 90%, was devoted to agricultural activities in

small farms, which scarcely produced enough to survive. For many centuries the life of farmers was particularly tough. During this age, the subsistence ratio was 3 to 1, meaning that three farmers produced and sustained only one person involved in non agricultural activities (Figure-4). In 1830, four farmers supported five non farmers, but one-hundred years later, in 1930, subsistence ratio was 1 to 10. Today, in the industrialised world where use of pesticides, particularly herbicides is height only 2% of the population is involved in agriculture production, or in other words, one farmer can produced enough food for 50 non farmers (Stephenson, 2000). In underdeveloped countries this situation is very difficult, because 46% of the population is involved in field works, mainly in weed control. In Brazil it is 20%; Mexico 25%; in Kenya it is 70%, or two people in every three (Akobundu, 2000). In addition to the high level of labor required and many working hours, weed control would still be inadequate, and yield losses would result. Nowadays it is estimated that in underdeveloped countries more than 30% of the entire food production is lost due to weeds (Fletcher, 1986) and in developed countries such losses of yield are 5-7% (Catizone, 1990)(cit.by Dinelli and Benvenuti, 2003). According to American National Centre for Food and Agricultural policy (NCFAP), as a major replacement of herbicides for many crops such a wheat, corn and soybean, a minimum of 1.1 billion hours of hand labour would be required at peak season for hand weeding, necessitating the employment of 7.2 million more agricultural workers to provide weed control if herbicides were not used. An approximate estimate of amount of labour that would be required to prevent any yield loss in comparison to herbicides is 10 times, or additional 72 million workers at the peak time for hand weeding. Weed control without herbicides sometimes is a problem in organic production. Organic farmers substitute labour and tillage for herbicides, which is very costly (Gianessi and Reigner, 2006; Avery,2006). The problem of controlling weeds without herbicides has been cited numerous times as the single largest obstacle that organic growers encounter. This activity takes a lot of time and is very costly for them. They do the weeding by tractor or by hand, which is very labour intensive. Conventional farmers spend only about $50 an acre on herbicides that knock out every weed in sight. Organic farmers may have to spend up to $1.000 an acre to keep weeds under control. However, organic growers also use cropping system approaches, such as rotation, cover crops, smother crops, and no-seed-return methods to reduce weed populations and decrease the impact of weeds on crops. In addition, organic farmers give great attention to enhancing soil quality, which favours crop growth and makes weed cultivation easier. Since organic farmers generally operate at a smaller scale than industrial grain farmers, they also use modified cultivation tools adopted for their specific operations. As a result, mechanical weed control in organic farming can not

be considered simply a substitution of standard tillage for herbicides. This is partly why organic production is the fastest rising sector of the agricultural market in the US.

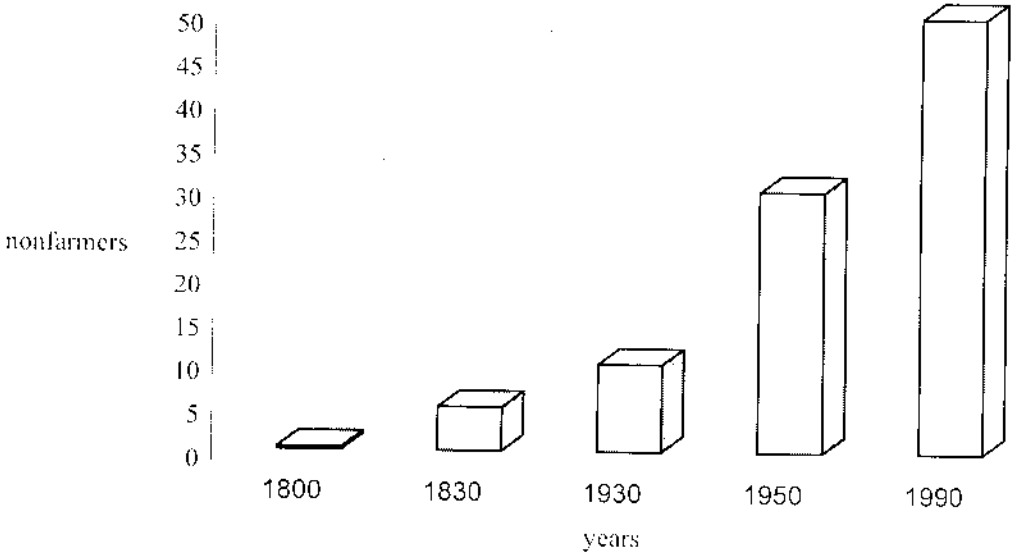

Figure-4. Non-farmers supported by the activity of a single farmer in different historical periods.

Herbicides save cropland of erosion

Escalating land degradation threatens crop and pasture land throughout the world (Lal and Pierce, 1991; Pimentel *et al,* 1995). The major types of degradation include water and wind erosion (Kendall and Pimentel, 1994). Worldwide, more than 10 million hectares of productive arable land are severely degraded and abandoned each year (Houghton, 1994; Pimentel *et al.*, 1995). Agricultural erosion by wind and water is the most serious cause of soil loss and degradation. Current erosion rates are greater than ever previously recorded (Pimentel and Hall, 1989; Pimentel *et al.,* 1995). Soil erosion on cropland ranges from about 13 tons per hectare per year (t/ha/yr) in the United States to 40 t ha^{-1} yr^{-1} in China (USDA, 1994; Wen, 1993; McLaughlin, 1993). Worldwide, soil erosion averages approximately 30 t/ha/yr, or about 30-times faster than the replacement rate (Pimentel, 1993). Erosion adversely affects crop productivity by reducing the water-holding capacity of the soil, water availability, nutrient levels and organic matter in the soil, and soil depth (Pimentel et al., 1995). Estimates are that agricultural land degradation alone can be expected to depress world food production between 15% and 30% by the year 2020 (Buringh, 1989). These

estimates emphasize the need to implement no-till, ridge-till, strip-till and mulch-till crop production, practices associated with conservation tillage systems, in which the soil is relatively undisturbed by tillage (Fawcett and Towery, 2002). Elimination of tillage means that the growers must rely entirely on herbicides to control weeds (Triplett *et al.*, 1977; Triplett, 1985). Otherwise, without herbicides growers could no longer practice no-till agriculture, which means that erosion would have increased by 152 million tons in 2001 and 178 million tons in 2005 (USDA, 2006). Tegtmeier and Duffy (2004) estimated that external costs of eroded cropland soil ranged from $2.34 to $13.98 per ton. These costs include flood damage, lost reservoir capacity, increased water treatment cost, and costs impacts to waterway navigation and recreational activities. Using the midpoint of the range ($8.16 per ton) implies that by reducing soil erosion from cropland by 178 million tons in 2005, no-till practice reduces external damages by $1.5 billion per year. This is main reason that number of conservation tillage acres in US has increased from 21 million hectares in 2001 to 25 million hectares in 2005 (Gianessi and Reigner, 2006).

Herbicides save energy

Herbicides use can increases the energy efficiency in crop production, particularly in corn and soybean (Swanton *et al.*, 1996). This is largely due to elimination of the need for primary tillage (ploughing). In crops, like soybean and maize, energy efficiency is even greater if at last one secondary tillage operation can be eliminated. The use of low-rate herbicides is also decreasing the energy investment in each herbicide application. Precisely, the amount of fuel used per acre for a herbicide application is estimated at 0.42 litres, while the amount of fuel used to cultivate an acre is estimated at 1.7 litres (Williams and Selley, 2005). According these authors, the total number of herbicide applications currently made on treated acres is 367 million, which implies the use of 151 million litres of fuel for herbicide application. The total number of cultivations that would be made as replacement for herbicides is estimated at 838 million, which implies the use of 1.43 billion litres for cultivation. The use of herbicides rather than cultivation would result in an aggregate reduction of 1.28 billion litres fuel annually. If we take into consideration the fact that fuel costs continue to increase, the energy benefits of herbicides use should continue to increase, as well (Stephenson, 2000).

Herbicides protect and increase crop production

Herbicides help to maintain high and stable world-wide yields (Gianessi and Sankula, 2003) and prevention of world wide hunger (Borlaug, 2000). Historically, in 1950 the world produced 692 million tons of grain for 2.2 billion people; by 1992 production was 1.9 billion tons for 5.6 billion people-2.8 times the grain for 2.2 times the population. Global yields rose from 0.45t/A to 1.1 t/A; yields of corn, rice and other foodstuffs improved similarly. The world's 1950 grain output of 692 million tons came from 1.7

Others benefits of herbicide use

Herbicide use has a great impact on the growers as direct participants in crop production. Namely, most studies indicate about a 30% yield benefit when herbicides are used (Fernandez-Cornejo *et al.*, 1998). For the USA in 1997, when a 30% increase in crop value was compared to total expenditure on herbicides, the return to growers was approximately $3-$4 for every dollar spent on herbicides. Herbicide use also provides some benefits directly to consumers. Zilberman *et al.*(1991) estimated that every $1 increase in herbicide expenditure raises gross agriculture output by $ 3.00-6.50. Most of that benefit is passed on to consumers in the form of lower prices for food. Herbicide use has economic benefits to society a whole. A study entitled. "An economic assessment of the benefits of 2,4-D in Canada" done in 1988 under Canadian government sponsorship, concluded that the net benefits of 2,4-D in Canada totalled a third of a billon dollars annually. A worldwide study of the benefits of 2,4-D measured in terms of increased food production and lower food prices has never been done, although those benefits are known to be enormous. 2,4-D has for the past sixty years, been a major tool in the continuing fight to reduce world hunger (Anonymous, 2006). Finally, herbicide use allowed in many parts of the world, many people, especially women and children quality education and better standard of living because their labour is not needed any more for hand weeding and hand cultivation of each crop.

Controversy about herbicide use

The use of herbicides has created considerable controversy in the world wide. It is widely believed by the public that herbicides pose substantial dangers to the population at large through residues on food and ground-water contamination, to farm workers through occupational exposure (Sachs *et al.*, 1987; Jolly *et al.*, 1989; Weaver *et al.*, 1992). In our industrialised society, the common feeling about herbicides is often unreasonably hostile. Statistical studies made by herbicides manufacturers revealed that more than 90% of the interviewed, even without contact with agriculture, consider herbicides dangerous for man and for the environment. This poor social acceptance is probably due to the poor communication existing between the scientific world and the society. Scientis and researchers have to give objective and scientific explanations for developing herbicides. Many experts are involved in creating and marketing a new herbicide: research chemists, economists, toxicologists, residue environmental metabolism (REM) specialists, biologists/botanists, patent officers, agronomists (agriculturalists), process research chemists, registration specialists, formulation chemists, marketing specialist, manufacturing specialist (Boerboom, 2004). All herbicides, including surfactants which aid herbicide adherence and penetration and inert ingredients, are required to undergo rigorous testing before registration. These tests typically include animal toxicity (carcinogenicity, teratogenicity, acute toxicity), effects on non-

target organisms, and mode of degradation in the environment. These are extensive tests that take years to complete. It takes chemical companies 7 to 10 years an 40 to 80 million dollars to satisfy US-EPA requirements and bring a new and safe active ingredient to the market (Klassen, 1995; Sigg, 1999). By law, herbicides must always be applied according to label instructions. In some instances, recommendations in this manual suggest a concentration lower than that recommended on product labelling. It is legal to dilute herbicides with an appropriate diluent- refer to the label. If you use them according to directions at recommended rates, you can use them safely (Swingle, 2005). Taking into consideration all previously mentioned facts, the health and environmental risks associated with herbicide use are largely a preventable problem. It means that, only herbicide misuse can be a human health and environmental risks.

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