Mutagenic Effect in Vegetables by Pesticides

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ABSTRACT

The advent of pesticides in vegetable crops is to control insects, pathogens and weeds aimed at increasing the crop yield, but the applied pesticides are not fully reaching the target pests. It escapes to environment or accumulates in crops resulting in some deleterious changes. The disturbances were observed in physiological and cytological levels of the affected plants by blocking mitosis and producing mitotic and meiotic chromosome abnormalities. Some pesticides like acetamiprid, carbendazim, chlorpyriphos, cypermethrin, dichlorvos, dicofol, dimethoate, fenvalarate, indoxcarb, mancozeb, monocrotophos, profenophos, quinalphos, zineb etc. proved to be mutagens. Researchers reported abnormalities like chromosomes with inactivated centromeres, isochromosome, picnosis, vagrant, stickiness, bridges, precocious separation and lagging chromosomes, reduction in mitotic index, micronuclei, multipolar cells, sister chromatid exchanges, c- mitosis are common in vegetables. Such abnormalities were observed in kharif vegetables like Lycopersicon esculentum, Capsicum annum, Solanum melongena, Abelmoschus esculentus, Cucumis sativus, Vicia faba, Phaseolus vulgaris and rabi vegetables like Allium cepa, Coriandrum sativum, Raphanus sativus, Solanum tuberosum, Pisum sativum etc. The pesticides act as potent environmental mutagens that possess a threat to cause alterations in genetic makeup in vegetables.

Keywords: Pesticides; vegetables; mutagen; chromosomal aberrations

1. INTRODUCTION

Several pesticides including carbamates, organochlorine, organophosphate, synthetic pyrethroids and insecticides, fungicides and herbicides are commonly used in vegetables and other crops to increase the agricultural productivity. These pesticides when applied on the plants cause serious effects on genetic materials and are genotoxic. To assess the genotoxic responses, biomonitoring studies on plants exposed to pesticides have essentially focused on cytogenetic end-points, namely mitotic index, chromosomal aberrations and micronuclei frequency etc. According to Duara and Baruah (2003) excessive use of pesticides has resulted in environmental degradation and in vegetables these residues accumulate and induce mutations. Present paper is focused on the mutagenic effects of the pesticides on the vegetables.

2. PESTICIDES USED IN VEGETABLES

Pesticides used for controlling plant diseases causes deleterious effects on the hereditary materials in both mitotic and meiotic cell division and causes genetic damage to vegetables. It is quite ironical that the pesticides used against the pest attack causes serious damages to the plant. This increasing discharge of the chemicals in the environment imbalances the natural ecosystem. The common pesticides used against the pest attack that are reported to be mutagenic in common kharif and rabi vegetables are shown in Table 1

Table 1. List of vegetables and pesticides used against the pest attack in khariff and rabi season

Season	Vegetables	Common pesticides used	Pesticide group	Effect
Kharif	Tomato (*Lycopersicon esculentum*), Chilli (*Capsicum annum*), Eggplant (*Solanum melongena*), Okra (*Abelmoschus esculentus*), Cucumber (*Cucumis sativus*), Broad beans (*Vicia faba*), Beans (*Phaseolus vulgaris*)	Carbofuron	Carbamate	Mutagenic
		Chlorpyriphos	Organophosphate	
		Malathion		
		Metasystaux		
		Lindane	Organochlorine	
		Thiodan		
		Zineb	Organosulphur	
		Cypermethrin	Pyrethroid	
Rabi	Onion (*Allium cepa*), Coriander (*Coriandrum sativum*), Radish (*Raphanus sativus*), Potato (*Solanum tuberosum*), Pea (*Pisum sativum*)	Carbendazim	Benzimidazole	
		Carbofuron	Carbamate	
		Mancozeb	Dithiocarbamates	
		Dimethoate	Organophosphate	
		Zineb	Organosulphur	
		Deltamethrin	Pyrethroid	
		Cypermethrin		
		Atrazine	Triazine	

3. PESTICIDES AS MUTAGENS IN VEGETABLES

The chemical mutagenesis, direct damage of DNA by these environmental genotoxic agents is the primary mechanism of chemical mutagenesis. Various pesticides applied on vegetables resulted in

genotoxicity, cytotoxicity and mutations. Pesticides and its residues in the plants induce different genetic changes are expressed by various endpoints which include:

2.1 Mitotic Assay

Several researchers have used the Mitotic index as an indicator of cytotoxicity of a chemical agent to the vegetables (El-Ghamery *et al.,* 2000; Yuzbasioglu, 2003; Marcano *et al.,* 2004; Celik *et al.,* 2005; Rao *et al.,* 2005). Mitotic index (MI) is the ratio of the number of cells undergoing cell division to the cells not undergoing cell division. According to Thaís *et al.* (2007) increase or decrease in the MI shows the cytotoxicity levels of a chemical. The higher and lower Mitotic index are important indicators in monitoring the environmental mutagenic agents.

2.2 Chromosomal Aberrations (CA)

CA are the changes occurring in the structure of the chromosome. The occurrence of CA indicates the harmful effect of the chemical agent to the plant cell. The aberrations commonly found in chromosomes are as follows:

- chromosome stickiness or clumping, where the chromosomes appear sticky and form clumps,
- inactivated centromeres, where the chromosomes are unable to link up by the centromere and as a result chromosomes do not take part in spindle formation,
- multipolar spindles which results when chromosomes are unable to reach the equatorial plate during metaphase and are stranded behind these chromosomes have asters attached to them and these form multiple spindles when come in contact of the other chromosomes,
- isochromosome formation, where one of the arm (short arm) of the chromosome gets detached due to the effect of the chemical agent and thus it is replaced by the exact copy of the other arm (long arm). The new daughter cells produced lacks the short arm and have extra long arm, this leads to deletion or duplication of the genetic material,
- vagrant and lagging chromosomes, occurs during the anaphase where one or more chromatids gets detached from the rest of the chromatids and is incapable of moving towards the poles,
- chromosome bridges, during metaphase and late anaphase due to break in the chromosome results in formation of bridge as the left behind chromatid gets pulled towards the opposite spindle poles of the cell and an irregular, long chromosome bridge is formed.

CA like bridges and breaks are due to the result of clastogenic effect of the pesticide while chromosome loss, delays, clumping are result of aneugenic effect of the chemical agent (Celik et al., 2005; Rao et al., 2005; Thaís et al., 2007).

2.3 Nuclear disturbances

The abnormalities in the nucleus arises due to the polyploidization process that leads to the elimination of the genetic material from the cell and gives indication that cell is undergoing

apoptosis or cell death (Rao et al., 2005; Thaís et al., 2007; Kontek et al., 2007; Leme and Morales, 2009). According to Daniela and Maria, (2009) pesticides induce morphological alterations in the nucleus like lobulated nuclei, polynuclear cells, nuclei with many nuclear buds in the interphasic nuclei due to the toxic effect. Formation of c-mitosis takes place when nuclear division is aborted in the cell after the metaphase and anaphase is blocked, as a result the chromosome number doubles and this results in unequal distribution of the daughter cells (Sta et al., 2012).

2.4 Micronucleus

Many researchers consider micronucleus (MN) assay as the most effective endpoint to analyze the mutagenic effect of the chemical agents. Pesticides induce clastogenic activity in the cells and micronuclei are formed. Micronuclei are composed of small chromosome fragments, acentric and lagging chromosome, detached from the chromosome resulting from, during the anaphase one of the chromatid in mitosis fails to connect to the spindle apparatus and it fails to be included in the reforming nucleus, instead the chromosome forms a micronucleus in the cytoplasm and is lost from the cell, this results in loss of genetic information in the daughter cells. As micronucleus are visible in the newly formed daughter cells after the telophase as a condensed small nucleus along with the normal nucleus, large MN in the cell indicates aneugenic effect resulting from chromosome loss while small MN indicates clastogenic effect due to chromosome breaks (Leme and Morales, 2009; Kontek et al., 2007).

Different pesticides used in the vegetables showing mutagenic effect are given in Table 2

Table 2. Table showing various studies on vegetables under different pesticide

Pesticide group	Vegetable crop	Mutagenic chemical agent	Mutagenic effect	Reference
Herbicide	Onion (*Allium cepa*)	Atrazine	CA, MN, MI	El-Ghamery et al. (2000)
		Racer	CA, MI	Yüzbaşıoğlu et al. (2003)
		2, 4-D	CA, MN, MI	Tartar et al. (2006)
		Trifluralin	MN	Thaís et al.(2007)
		Atrazine	MI, CA	Srivastava and Mishra (2009)
		Illoxan	CA, MI	Yüzbaşıoğlu et al. (2009)
		Agil	CA	Elena, (2012)

	Garlic (*Allium sativum*)	2, 4-D	CA, MN, MI	Tartar et al. (2006)
	Radish (*Raphanus sativus*) and Beans (*Phaseolus vulgaris*)	2, 4-dichlorophenoxyacetic acid	CA	Truta et al. (2011)
	Broad beans (*Vicia faba*)	Atrazine	CA, MN, MI	El-Ghamery et al. (2000)
Fungicide	Onion (*Allium cepa*)	Afugan	CA, MI	Yüzbaşıoğlu et al. (2003).
		Dinocap	CA, MI	Celik et al. (2005)
		Raxil	CA	Fisun and Rasgele (2009)
		Raxil	CA, MN, MI	Kaymak and Rasgele (2009)
		Blitox	CA	Paul et al. (2013)
	Tomato (*Lycopersicon esculentum*)	Mono and Di-potassium phosphonate	CA, MI	Cali (2009)
	Broad beans (*Vicia faba*)	Dithane M-45	CA, MN	Atef et al. (2011)
Insecticide	Onion (*Allium cepa*)	Cypermethrin	MI, CA	Cavusoglu et al. (2011)
		Acetamiprid	CA, MN	Nag et al. (2013)
	Broad beans (*Vicia faba*)	Dichlorvos	CA, MN, MI	Kontek et al. (2007)
		Telliton	CA, MN	Atef et al. (2011)
		Sulcotrione	MI, CA	Sta et al. (2012)

4. CONCLUSION

The vegetables being an important component in human diet, the pesticide residue accumulation and its mutagenic effect on vegetables play a significant role in human health. The understanding of the extent of damage caused by these mutagenic agents is the need of time and may certainly help in judicious use of pesticides.

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