

## Bio-rational pesticides: Alternative Pest Control Strategies

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### INTRODUCTION

Plants generally lack immune system as evident in animals but nature it has developed a firm stunning array of structural, chemical, and protein based defences to counteract the effect of invading infections caused by a number of plant pathogens such as fungi, bacteria, viruses, nematodes, higher parasitic plants and even herbivores. A well programmed complex surveillance mechanism exists in plants that actually help to recognize potentially devastating pathogens causing economical damage to the crops. The sophisticated surveillance system actually is found to link with the specific programmes defence responses called as basal resistance or often as an innate immunity. It is the first line of pre-formed and inducible defences triggered against the entire pathogen community. It happens only when the plant recognizes the microbe-associated molecular patterns (MAMPs) including specific proteins, lipopolysaccharides, and pathogens cell wall components.

If the basal resistance is suppressed by the counter effect of pathogens, plants may switch over to another line of defence i.e. the hypersensitive response (HR). It is a deliberate rapid plant cell death or suicide at the site of infection to ward off the further advancement of the cells by the pathogens by limiting their nutrition availability. Once there is activation of the HR, plant tissues may become highly resistant to a broad spectrum of pathogens for an extended period of time. This kind of phenomenon is known as Systemic acquired resistance (SAR) and for rest of the time plant resources get mobilized and plants as such prepared themselves for the challenges posed by the pathogens. With the advancement of the research it is possible to artificially induce resistance in the plants by SAR chemicals which are also known to as bio rational or plant activators. Gradual momentum of using such chemicals is seen in the past and it is recently gaining popularity among the agricultural community.

Because of the less toxicity associated with these chemicals to human, wildlife and environment and long-lasting protection against broad spectrum of plant pathogens of number of crops these chemicals are becoming a part of the bio-pesticides.

## **NOVEL TECHNIQUE OF PLANT IMMUNIZATION AND PLANT DISEASE CONTROL**

A novel unique technique of priming or inducing the natural defence mechanism like activity in plants as exists in nature against a wide spectrum of the plant pathogens is possible and can be practiced using systemic acquired resistance (SAR) chemicals. Plant growth promoting bacteria can also induce the systemic acquired resistance independent of salicylic acid known as Induced systemic resistance (ISR) whereas SAR become active with pre-treatment with salicylic acid and other related products. The most important and commonly used SAR chemicals are salicylic acid, jasmonic acid, 2,6-dichloroisonicotinic acid, isotianil  $\beta$ -aminobutyric acid (BABA), 2,6-dichloroisonicotinic acid (INA) and its derivatives and the benzo [1–3] thiadiazole derivatives with S-methyl benzo [1–3] thiadiazole-7-carbothiate acibenzolar-S-methyl (ASM) hydrogen peroxide, benzo (1, 2, 3) thiadiazole-7-carbothioic acid S-methyl ester (BTH), isonicotinic acid, 1, 2-benzisothiazole derivatives, 3-allyloxy 1, 2-benzisothiazole-1, 1-dioxide (PBZ), inducible acidic glucanases or chitinases.

These are the products derived from the plants or pathogen effectors molecules which activate the defence mechanism of the plants after receiving the signal molecules. Chemical DCA (3, 5-dichloro anthranilic acid) was found effective towards *Hayloperonospora parasitica* and *Pseudomonas syringae* by inducing expression of SA related defense genes *PRI*, *CaBP22*, and *WRKY70*. Application of TDL or N-(3-Chloro-4-Methylphenyl)-4-Methyl-1,2,3-thiadiazole-5- Carboxamide (V-GET®) is a commercialized thiadiazole derivative and its metabolite 4-methyl-1, 2, 3 thiadiazole-5-carboxylic acid (SV-03) help in activating defense mechanism in several crops such as tea, tobacco and rice without showing any antimicrobial activity. However, it along with SV-03 protects plants infected by bacteria (*Pseudomonas syringae* pv. *tabaci*), TMV, and fungi. Similarly INA and ASM, both TDL and SV-03 target the signal steps downstream of SA and induce disease resistance. Isotianil (3, 4-dichloro-N-(2- cyanophenyl)-1, 2-thiazole-5-carboxamide) gave protection and long lasting effect against rice blast and bacterial leaf blight diseases. N-cyanomethyl-2-chloro

isonicotinic acid (NCI) also induced a broad range of disease resistance against rice and tobacco plants as well as reported to be active against several pathogens such as TMV, *Oidium lycopersici* and *P. syringae pv. tabaci* in tobacco. ASM when applied as trunk injection in sweet orange provided significant control of HLB by reducing the progress of infection caused by '*Candidatus Liberibacter asiaticus*'. It has been revealed out that ASM alone has provided control in more than 120 pathogens and host combinations and its response is generally crop specific that include fungal, bacterial, and virus diseases in a variety of crops such as grapefruits, pear, apple, tomato, cowpea, cucumber, etc. Diuretics compounds, Clopamide (4-chloro-N-(2,6-dimethyl-1-piperidyl)-3-sulfamoyl-benzamide), Bumetanide (3-(butylamino)-4-phenoxy-5-sulfamoylbenzoic acid) and Bendroflumethiazide (3-benzyl-1, 1-dioxo-6-(trifluoromethyl)-3,4-dihydro-2H-1,2,4-benzothiadiazine-7-sulfonamide) are well known group of bioactive compounds which is capable of inducing defense against bacteria through enhancement in *PR1* expression. Diuretics and sulfanilamides actually contain sulfonamide group that impart critical defence against bacterial pathogens. Adipic acid monoethyl ester derivatives mixtures were also tried to induce immunity in plants and it was seen that when such a mixture of furfurylamine and FGA (1, 2, 3, 4-tetra-O-acetyl- $\beta$ -D-glucopyranose) was applied to plants, it increased activity of *PAL* gene as well enhance the phenolics compounds accumulations. These are quite effective to result in resistance against many pathogens such as bacteria, oomycetes, and fungi.

The induced resistance method is entirely different from the conventional breeding and modern gene transfer technique which are costly, cumbersome, time consuming, non durable for long period, and particularly for perennial plant species in short span of time. SAR as such is robust, long lasting, less costly and have high potential to diminish the use of toxic chemicals in the agriculture/ allied sciences and has emerged as an alternative, non-conventional, non-biocidal and eco-friendly approach for plant protection against serious biotic/abiotic stresses and hence suitable for sustainability and emerging as a safe alternative to plant protection. It is a base of immunization and mechanism behind works with activation of the cascade of signal molecules like salicylic acid, jasmonate, ethylene, glycerol lipids, glycerol –phosphate, indole compounds etc. that often accumulate the expression of antimicrobial compounds pathogenicity related proteins, cystein rich proteins, defensin 1.2

genes, phytoalexins, activation of enzymes like chitinases,  $\beta$ 1, 3 gluconases, peroxidases, active radical species, hydrogen peroxide and phenolic like compounds include biochemical defenses to give hypersensitive responses. Whereas the structural changes may lead to lignifications of the infected area, callose deposition, cell wall thickening, abscission layer formation are few changes which occur frequently due to initiation of salicylic acid or jasmonic acid/ethylene dependent pathways that helps to ward-off or seal off the infection by the plant pathogens. The resistant compounds get distributed in intercellular spaces of cells and distributed via phloem throughout the plant parts giving systemic resistance just like the mobile signals. Pathogenicity-related (PR) genes get generated in both local and systemic infections in tobacco following challenging with TMV (Tobacco Mosaic Virus). Tomato spotting wilt virus in tobacco, iris yellow spot virus, apple scab, leaf blight, Xanthomonas leaf blight are few other examples where the PR gene responses are evident.

Moreover this type of induced or primed resistance is an efficient way of epigenetically imprinted defence that would allow us to generate the plants with broad spectrum of resistance that will be sustainable as it can be carried to their progeny epigenetically. The actual mechanism is based on NONEXPRESSOR OF PR GENES 1 (NPR1/NIM1) that is also known as NON-INDUCIBLE IMMUNITY 1 (NIM1). NPR1/NIM1 has emerged as an important positive regulator of SAR and it has a role also in ISR too. This type of regulation induced by NPR1/ NIM1/ NIM1 is known to mediate cross-talk between SA and JA signaling pathways. However, in plants it is normally present at low levels, but due to pathogen infection or SA pre-treatment, NPR1/ NIM1/ NIM1 level increases two to three times that accelerate the resistance to wide pathogens ranges.

## CONCLUSION

SAR chemicals is a eco-friendly approach in present context compared to pesticides practices in plant protection. It provides resistance to the subsequent infections induced by the pathogens due to its transgenerational impact that can sustain over one stress free generation indirectly by the phenomenon of its epigenetic basis. Thus acting as independent defence response in plants which requires intact transcription factor - NPR1 protein which is associated with priming of the SA (salicylic acid) dependent defense now called as phenomenon of transgenerational SAR or next-generation SAR. Thus demonstrating its

inheritance nature through hypo ethylated regulatory genes which directs NPR-1 dependent histone H3 modification in chromatin or we can say reconfiguration in following generation to retain the resistance. The inducible defences are accompanied by extensive transcriptional reprogramming of defence-related genes. With advancement in the research, these bio rational pesticides will certainly replace the chemicals and become an alternative in near future for retaining sustainability in agriculture.

