Review Article

Effect of inorganic fertilizer on entomopathogenic nematodes(EPNs)-A review

Abstract:

In orderto increase the present crop productivity modern cultivation technique should be incorporated. The addition of organic and inorganic fertilizers improve soil fertility, plant growth or crop productivity. The major challenges to agricultural productionis the low yield due to infestation of insect pests. Integrated pest management practices is the best option for pest control. Integrated agriculture should include biological methods, such as biopesticides.Among the biopesticides, Entomopathogenic nematodes (EPNs) are obligate insect parasites in nature, can confer substantial benefits upon plants are safe biopesticidal alternatives to hazardous chemicals. Since these organisms live in an environment that continuously receives the addition of agrochemical compounds,viz.,inorganic fertilizer, their abundance and infectivity of may be effected.This review presents an overview of compatibility of EPNs with inorganic fertilizers in agricultural management practices .

***Key words*:**Biopesticides, Entomopathogenic nematodes(EPNs), Agricultural management practices, Inorganic fertilizer,Interaction with EPNs and inorganic fertilizer.

1.Introduction

The growing population arises much pressure on agriculture to meet the escalating demand for food.To make agriculture more productive in the face of rising costs and rising standards of human and environmental health, the best combination of available technologies has to be used. Crop productivity may be increased by high-yielding varieties, improved water and soil management (fertilization) and other cultivation techniques. The addition of organic and inorganic soil amendments to improve soil fertility, plant growth or crop productivity is among the oldest and beneficial agricultural practices. However,the yield losses caused by pests, pathogens and weeds are major challenges to agricultural production (Oerke, 2006).Increased awareness of potential benefits associated with soil conservation and integrated pest management practices has resulted in increased use of nonchemical pest control tactics. Integrated agriculture should include biological methods, such as biopesticides and protection of natural enemies of pests with other non-chemical and chemical methods.Entomopathogenic nematodes (EPNs) are obligate insect parasites in nature, can confer substantial benefits upon plants are safe biopesticidal alternatives to hazardous chemicals (Tomalak, 2005;Lacey*et al.*, 2015). When applied appropriately, EPNs can control a variety of soil-dwelling insect pest (Hiltpold,2015) as well as aboveground herbivorous insects (Shapiro-Ilan*et al.*,2017).

2.Entomopathogenic nematodes(EPNS)

EPNs live in soil and belong to the families Steinernematidae and Heterorhabditidae (Order:Rhabditida) in the Phylum Nematoda (Laznik and Trdan, 2014). Free-living, non-feeding third stage infective juveniles (IJs) are predisposed with the ability to track and infect hosts. Infection occurs when IJs gain entry through the natural openings of the host and through the cuticle, releases the symbiotic bacteria in hemocoel thereby contributing to killing the host quickly and effectively(Koppenhofer*et al.*,2020).The insect host eventually dies, while the nematodes feed on the bacteria and reproduce before emerging from the host cadaver (Burnell and Stock, 2000). EPNs can kill insect pests within several days of infestation.The bacteria utilize the host to reproduce, while the multiplying nematodes feed on the bacteria inside the cadaver. Tens to hundreds of thousands of new EPNs can be produced from a single infested insect host, exit the host cadaver and then travel to infest new hosts, thus theoretically allowing EPNs to persist in the field throughout the growing season.Thus, their potential to recycle in their host populations could be further employed for long-term pest management.For successful EPN application against insect pests, several factors directly influence the insecticidal activities in the soil .These factors are humidity, temperature as well as different agronomic practices (Laznik and Trdan, 2017), or the resistance of certain insect pests to EPN penetration (Lewis *et al*., 2006; Georgis*et al*., 2006; Toepfer*et al*., 2014). Since these organisms live in an environment that continuously receives the addition of agrochemical compounds, their abundance and infectivity of may be effected (Poinar and Grewal, 2012).Due to the direct toxic effects of fertilizers or their decomposition productsor an increase in biotic activity may increase predation and parasitism on EPNsand thereby reduce their abundance. Fertilizers may reduce EPN survival by modifying the soil-physical status (Glazer, 2002). However, the effects of inorganic fertilizers varied according to their chemical composition, the innate characteristics of EPN species, and the duration of their exposure to the fertilizer.

3.Inorganic fertilizers

Inorganic fertilizers are synthetic, comprised of minerals and synthetic chemicals. Most of the inorganic fertilizers contain ammonium sulfate, magnesium sulfate, and potassium chloride. The excessive use of inorganic fertilizers causes a variety of environmental problems such as soil salinity, heavy metal accumulation, greenhouse effect, eutrophication in water bodies and nitrate accumulation (Thorat and More , 2022).

4.Compatibility of EPNs with Inorganic Fertilizers:

Currently, many investigators have paid attention to investigating the effects of inorganic fertilizers on different traits of EPNs.

Entomopathogenic nematodes are likely to be compatible with tank mixes of inorganic NPK fertilizers and may be mixed and applied simultaneously to reduce application costs. The short term use of mineral fertilizers in the concentration of 0.1% causes low decrease in the vitality of invasive larvae of three species of EPN.Adverse effects from inorganic fertilizer may be more likely to occur in the field following application and with long exposures where nitrates can be converted to ammonia (Rodriguez- Kabana,1986). In mineralization, its rate may vary with soil moisture, aeration, and temperature.

Georgis and Gaugler (1991) recognized the potential of inorganic fertilizer to limit the efficacy of EPNS. Prolonged (10-20 day) laboratory exposure to high inorganic fertilizer concentrations inhibited nematode infectivity and reproduction whereas short exposures increased infectivity. *H. bacteriophora* was more sensitive to adverse effects than *S.feltiae* and *S.anomali*. Similarly, Gaugler et al., (1992) observed that heterorhabditids tend to be less tolerant of environmental stress than steinernematids.

Bednarek and Gaugler (1997) assessed the impact of some inorganic and organic fertilizers on the infectivity, reproduction, and population dynamics of EPNs. They concluded that inorganic fertilizers were likely to be compatible with EPNs in tank mixes and should not reduce the pathogenicity of EPNs used for short-term control as biological control agents, but may interfere with attempts to use EPNs as inoculative agents for long-term control. However, NPK fertilizer suppressed EPN densities regardless of manure application.

Koppenhofer and Grewal, (2005) investigated and found that EPN IJs can tolerate short-term exposure (2-24h) to many chemical and biological insecticides, fungicides, herbicides, fertilizers and growth regulators, and can thus be tank-mixed and applied together. However, the actual concentration of the chemical to which the nematodes will be exposed will vary depending upon the application volume and system used (Alumai and Grewal, 2004).

Susurluk (2008) found that prolonged exposure to high concentrations of NPK inhibited the activities of *Steinernema*spp. and *Heterohabditis*spp.

Fertilizers may lower EPN activity by modifying the soil-physical status. Some or all of these factors may contribute to reducing nematode virulence (Shapiro-Ilan*et al*.,1996;2006).Inorganic fertilizers can upset the entire ecosystem, create a toxic build-up of chemicals, and long-term use changes the pH of the soil. When exposed to soil salinity, the movement of EPNs is restricted and their ability to find and recognize their host is reduced (Nielsen 2011).

There is more accumulation of heavy metals in the areas where fertilizer application are conducted than in natural areas (Campos-Herrera *et al*., 2010).Some heavy metals have a direct lethal effect on EPNs and, if not lethal, decrease in their pathogenic abilities, which adversely affects the success in searching and eliminating pests (Jaworska*et al.*, 1996; Jaworska*et al.*, 1997). In addition, EPNs were found to be more susceptible to heavy metals in the soil than plant parasitic nematodes (Sun *et al*.,2016).

The effect of calcium phosphate on survival, infectivity and penetration efficiency of the Egyptian strains HPS1, HPS2 and HPS3 of *Heterorhabditis*sp. was evaluated by Azazy*et al*. (2012), against larvae of *G. mellonella* in Egypt. According to their results, calcium phosphate (at low concentrations of 0.2M and 2M) was less suppressive on the survival of the three EPN strains and did not affect their infectivity against *G. mellonella*(100% larval mortality), but medium concentrations affected the EPN infectivity. Calcium phosphate at three concentrations reduced the penetration efficiency of all EPN strains.

Shapiro-Ilan*et al*.,(1996) assessed that the effects of inorganic fertilizers varied according to their chemical composition, concentration and the duration of its exposure to the fertilizer as well as the EPN species(*S.carpocapsae*) exposed.

The direct effects of some inorganic fertilizers had been investigated by Şahin and Susurluk (2018), in Turkey, on the EPNs *S. feltiae*(Tur-S3) and *H. bacteriophora*(HBH). *S. feltiae*was more resistant to the tested inorganic fertilizers than *H. bacteriophora*. The diammonium phosphate (DAP), nitrogen phosphorus potassium (NPK) and nitrogen and phosphorus (NP**)** exhibited more adverse effects than the other fertilizers on both EPN species.

Kolombar*et al*. (2020) revealed that mineral fertilizers(mineral additives) slightly reduced the vitality of IJs of different EPN species, while survival and viability of the IJs cultures of the EPNs increased during the use of solutions of ascorbic acid, B1, B6 or B12. Thus, these authors recommended the use of these vitamin solutions for improving the viability of EPN preparations at the concentrations of 6-50, 25-50, 25-50 and 0.1-0.2 mg/mL respectively.

Shehata *et al*. (2021) examined the effects of different inorganic fertilizers (such as ammonium sulfate, ammonium nitrate, calcium nitrate, ammonium phosphate, potassium sulfate, NPK, potassium nitrate)on the virulence of *S.glaseri* in Egypt. Based on their results, virulence against insects is lower in soil treated with phosphorus than in soil treated with potassium, NPK, and nitrogenous fertilizers. Except for phosphorus fertilizers, 1% fertilizer concentrations are compatible with *S. glaseri*in tank mixes for short-term (1-7 days) insect control but may affect long-term control.

Downs *et al*. (2022) investigated the effects of various inorganic fertilizers on the density of symbiotic bacteria of EPNs,*Xenorhabdusnematophila*and *Photorhabdusluminescens*(symbiotically associated with EPNs *S. carpocapsae*and *H.*

bacteriophora, respectively). They concluded that *P. luminescens*are generally more sensitive to fertilizers than *X. nematophila*. Moreover, those fertilizers containing high nitrogen content suppressed the bacterial densities more readily than those with lesser content. Also, bacterial symbionts exposed to inorganic fertilizers had greater population declines as well as greater mortality rates than those treated with organic amendments.

5.Conclusion and future perspectives

As the soil entomopathogens particularly EPNs are intimately associated with their soil environment; any disruption of the soil environment could cause a change in activity or survival of EPNs. Incompatibility between inorganic fertilizer and EPNs can be managed by choosing an appropriate time interval between the applications, the length of which may depend on the persistence of chemicals in the target substrate. Since there appear to be no clear trend as to the sensitivity of different nematode species to different classes of agrochemicals, any new nematode species, fertilizer combination needs to be evaluated for compatibility. Otherwise, the two agents should be applied with 1-2 weeks time interval between them.The possibility of combined use of nematode preparations and mineral fertilizers is through chemigation which reduce the negative effect of agricultural measures on the plant organisms, and also reducing economic costs on growing plant production. In other words, understanding these interactions is essential to reveal suitable ways to enhance the potential of EPNs as biocontrol agents in a particular soil type.

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