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Studies on suitable formulation of entomopathogenic nematode for the management of cardamom root grub, *Basilepta fulvicorne* (Jacoby)

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Entomopathogenic nematodes (EPN) are used to control several agriculturally important insect pests of different orders. EPN have been applied successfully against soil inhabiting insects as well as above ground insects in cryptic habitats (Arthurs *et al*., 2004; Shapiro-Ilan *et al*., 2006). An indigenous nematode strain *Heterorhabditis indica* (strain ICRI-EPN18) which was isolated from the soil of cardamom growing tract, play a major role in biological control of cardamom root grub *Basilepta fulvicorne* (Varadarasan *et al*., 2006; 2011a). The grubs feed on cardamom roots, leading to reduction of uptake of nutrients, can cause 29-66 per cent yield loss (Varadarasan *et al*., 2006).

Evaluation of various formulations of *H.indica viz*., *Galleria* cadaver, talc and liquid indicated that cadaver formulation could significantly reduce root grub under field condition than other two formulations. Gel formulation of EPN was also reported to be effective with longer shelf life than cadaver formulation (Divya *et al*., 2011). Shelf life of formulation of EPN is an important factor to meet the requirement of farmers at a critical period. Maximum shelf life of cadaver formulation is 10 days and the extended period as 30 days in gel formulation. So attempt was made to evaluate the suitability of gel formulation of EPN in comparison with cadaver formulation for cardamom root grub management. Apart from *H.indica* (strain ICRI-EPN 18) another EPN strain *viz*., *Steinernema thermophilum* was also included in the trial for comparison.

The experiment was conducted at Indian Cardamom Research Institute, Myladumapara, Kerala, India. There were five treatments consisting of cadaver and gel formulation with varied number of infective juveniles (ijs) population *viz*., (i) *Steinernema thermophilum* four lakh ijs per plant (gel formulation), (ii) *Heterorhabditis indica* four lakh ijs per plant (gel formulation), (iii) *H.indica* three lakh ijs per plant (gel formulation), (iv) *H. indica* two lakh ijs per plant (cadaver formulation, standard control) and (v) a control plot. The experiment was laid out in exploaded block design (Ramachander *et al*., 1989) with about 50 plants per treatments at ICRI farm, Myladumpara.

Field application of cadaver formulation

Galleria mellonella (L.), the wax moth larva is the most commonly used insect for *in vivo* mass production of entomopathogenic nematodes (Grewal, 2002) as it produces high nematode yields, widely available commercially, and is very susceptible to infection (Woodring and Kaya, 1998). EPN infected *Galleria* cadavers were implanted at five cm depth at the rate of four infected cadavers ten cm away from plant base.

Field application of gel formulation

H. indica and *S. thermophilum* were formulated in gel by M/s Multiplex Pvt. Ltd., Bangaluru and shipped to ICRI, Myladumpara, Kerala in sealed polythene cover. Depending on the population of

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ijs g^{-1}, the required quantity of gel was mixed with water and applied at the rate of three and four lakhs ijs per plant around the plant base.

After EPN application, the field was irrigated for maintaining subsoil moisture. Data on number of root grubs per plant were recorded 30 days after treatment. Student 't' test was employed to compare the mean root grub per plant between the control and EPN treated plots.

The result obtained in the study indicated reduction of grub of *Basilepta fulvicorne* with both the formulation of entomopathogenic nematode. The *H. indica* with very low ij population (two lakh ijs per plant) in cadaver formulation and *S. thermophilum* with higher ij population (four lakh ijs per plant) in gel formulation recorded higher reduction of root grub with 52.7 per cent and 45.9 per cent respectively (Table1). *H. indica* cadaver formulation even at two lakh ijs per plant recorded significant reduction of grubs (52.7%) compared to control. Gel formulation of *H. indica* at the rate of two and three lakh ijs per plant did not significantly reduce root grub as compared to cadaver formulation.

Laboratory studies have indicated that application of infected cadavers can result in superior nematode dispersal (Shapiro-Ilan and Glazer, 1996), infectivity (Shapiro-Ilan and Lewis, 1999) and survival (Perez *et al*., 2003). Superior efficacy in the infected host cadaver application might also have been due to compounds in the infected host cadaver that can enhance nematode infectivity or dispersal (Shapiro-Ilan and Lewis, 1999; Shapiro-Ilan *et al*., 2000). Comparative evaluation of cadaver, talc and liquid formulations of EPN (strain ICRI-EPN 18) on cardamom root grub, *B. fulvicorne* indicated that cadaver formulation caused significantly higher reduction of grubs 30 days after application (Varadarasan *et al*., 2011b).

Table 1. Evaluation of gel and cadaver formulation of EPN on root grub management

Treatments	No. of root grubs per plant	% of reduction over control
T_1- *Steinernema thermophilum* @ 4 lakh ijs per plant- Gel formulation	4.0	45.9
T_2- *Heterorhabditis indica* @ 4 lakh ijs per plant-Gel formulation	5.4	27.0
T_3- *H.indica* @ 3 lakh ijs per plant- Gel formulation	6.1	17.6
T_4- *H.indica* @ 2 lakh ijs per plant- Cadaver formulation (Standard control)	3.5 *	52.7
T5- Control	9.5	-

* Significant at 5% level (t-test)

Entomopathogenic nematodes may be applied with infected insect cadavers (Jansson *et al*., 1993), and in this approach, nematode-infected cadavers are disseminated and pest suppression is subsequently achieved by the progeny ijs that exit the cadavers. Field application of EPNs in infected host may be superior to application in aqueous suspension, in terms of infectivity, dispersal and survival (Shapiro-Ilan and Glazer, 1996; Shapiro-Ilan and Lewis, 1999). EPNs can survive dry or harsh conditions or desiccation for extended periods within host cadaver (Brown and Gaugler, 1996; Koppenhofer *et al*., 1997). Improved persistence within the host cadavers has been reported as compared to aqueous suspensions wherein EPNs might face osmotic stress (Perez *et al*., 2003). However, EPNs carried within infected hosts are compromised by limitations of storage (shelf life) and application (Shapiro-Ilan *et al*., 2001).

The present study indicates that entomopathogenic nematode application in infected cadavers tends to be more efficient than application in gel formulation. The lesser efficacy observed in gel formulation might have been due to physiological stress of ijs in the gel as well as osmotic stress when ijs in gel were mixed with water.

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