gunited micro-concrete in comparison with the allowed limit.

Gunited concrete with the use of newly designed devices (composition GC_2, Table 1) leads to the best performances (Figure 8). The result was a well-compacted concrete with firm consistency, which does not deform when pressed.

Concrete structures are designed and manufactured in order to meet a set of functional requirements for a long length of time, without involving high costs of maintenance and overhaul. This period of time, representing the designed service length is provided by a good initial quality. When degradation due to unforeseen factors is observed, the need to intervene becomes compulsory.

According to the type of deterioration, to its position and location, there are various methods of overhaul.

One of these procedures is achieved with a special device for placing the designed mixture by using compressed air.

The tests conducted in laboratories to measure the quantity of the components, and on site to observe the quality of the jet of gunited material showed an improved quality of concrete homogeneity.

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Inhibitory effects of vermicompost produced from agro-waste of medicinal and aromatic plants on egg hatching in *Meloidogyne incognita* (Kofoid and White) Chitwood

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Experiments were conducted to determine the efficacy of various vermicomposts produced from agro- and distillation-waste of medicinal and aromatic crops on hatching of eggs of *Meloidogyne incognita* (Kofoid and White) Chitwood and root-knot disease development in tomato. Results revealed that considerable inhibition in hatching of eggs occurs in the aqueous extracts of vermicompost produced from wastes of menthol mint (*Mentha arvensis*), chamomile (*Matricaria recutita*), geranium (*Pelargonium graveolens*), qinghao (*Artemisia annua*) followed by pyrethrum (*Chrysanthemum cinerariaefolium*), isabgol (*Plantago ovata*), African marigold (*Tagetes minuta*), Boerhavia (*Boerhavia diffusa*), mustard (*Brassica compestris*), lemongrass (*Cymbopogon flexuosus*) and garden mint (*Mentha viridis*). In a pot experiment, vermicomposts of menthol mint, African marigold, qinghao, isabgol and pyrethrum effectively reduced the root-knot infection in tomato.

Keywords: Hatching, medicinal and aromatic plants, *Meloidogyne incognita*, vermicompost.

PLANT parasitic nematodes are important plant pests causing enormous loss to agricultural crop productivity and it is difficult to manage them even with chemical nematicides. Adverse effects of chemical nematicides on environment, human health and non-target organisms, restrict their use in nematode management. There are several alternate methods for managing plant parasitic nematodes[1–3] but none provides a satisfactory control. Closer examination of life cycle of damaging phytonematodes has opened up the possibilities to manage these nematodes by inhibiting their reproduction by creating an environment unfavourable for nematodes to survive, lay eggs or hatch. Crop residues and other agro-waste from medicinal and aromatic plants (MAPs) have been found to be effective soil supplements in reducing intensity of root-knot nematode infection[1]. Further, a technology has been developed at our institute where crop waste from medicinal and aromatic plants has been utilized for production of vermicompost rich in macro- and micronutrients (US Patent no. 6488733)[4]. Application of

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vermicompost has been shown to reduce the severity and population of plant parasitic nematodes[5,6]. Keeping this in mind, an experiment was carried out to determine the efficiency of aqueous extract of various vermicomposts produced from agro-wastes of MAPs on egg hatching of root-knot nematode *Meloidogyne incognita* (Kofoid and White) Chitwood, a causative agent of root-knot disease in many crops.

Vermicompost produced by utilizing straw of Boerhavia (*Boerhavia diffusa*), pyrethrum (*Chrysanthemum cinerariaefolium*), henbane (*Hyoscyamus muticus*), fennel (*Foeniculum vulgare* Mill.), chamomile (*Matricaria recutita*), opium poppy (*Papaver somniferum*), coriander (*Coriandrum sativum*), linseed (*Linum usitatissimum*), mustard (*Brassica campestris*), isabgol (*Plantago ovata*), marc of qinghao (*Artemisia annua*) and distillation waste of geranium (*Pelargonium graveolens*), menthol mint (*Mentha arvensis*), Bergamot mint (*Mentha cardiaca*), peppermint (*Mentha piperita*), spearmint (*Mentha spicata*), garden mint (*Mentha viridis*), lemon grass (*Cymbopogon flexuosus*), citronella (*Cymbopogon winterianus*) and African marigold (*Tagetes minuta*) were obtained from the vermicomposting unit of Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow.

Ten grams of these vermicomposts was taken and suspended in 100 ml of distilled water. After 24 h, it was filtered through Whatmann filter paper no. 1. About 400 eggs of *M. incognita* were placed in 10 cm petri dishes containing aqueous extracts from various vermicomposts. The total number of juveniles was counted after 120 h. Hatched juveniles in distilled water served as control. Each treatment was replicated five times.

A glasshouse experiment was then carried out to establish the role of vermicomposts found useful in reducing the hatching of eggs, on the severity of root-knot nematode infection in tomato. The experiment was carried out in 15 cm diameter earthen pots containing 2.5 kg autoclaved soil. Egg hatching inhibitory vermicomposts of pyrethrum, qinghao, marigold, menthol mint, lemon grass and geranium were added at 30 g/kg soil, two weeks before transplanting. Three-week-old healthy seedlings of tomato (*Lycopersicon esculentum* Mill.) were used in the present study. Untreated–uninoculated and untreated–inoculated pots along with carbofuran (1 g/kg soil) treated pots served as controls. After three days of transplantation, plants were inoculated with 1000 eggs of *M. incognita*. There were five replicates of each treatment including untreated–uninoculated and untreated–inoculated control. The experiment was terminated after three months when the plants were uprooted, washed and plant growth parameters were determined by measuring fresh/dry root and shoot weight. Fruit numbers and their weight were also determined. The degree of root-knot index (RKI) was recorded on the 0–5 scale[7].

It was found that different vermicomposts showed variability in their egg hatching inhibitory activity towards the nematode. Maximum inhibition in hatching was obtained in the aqueous vermicompost extracts of *M. arvensis* (90.6%), followed by *P. graveolens* (89.8%), *M. recutita* (89.2%), *A. annua* (88.5%), *C. cinerariaefolium* (82.6%), *P. ovata* (83.9%), *T. minuta* (81.8%), *B. diffusa* (81.8%), *C. flexuosus* (80.9%), *B. compestris* (78.5%) and *M. viridis* (73.2%) (Figure 1).

Encouraging results were obtained when some of the effective vermicomposts were tested for reducing root-knot severity. As observed in the egg hatching experiment, maximum reduction in root galling was also observed in plants treated with vermicomposts of menthol mint followed by vermicompost produced from marigold, isabgol and qinghao (Table 1). Most of the vermicompost treatments provided control at par or better than the protection provided by most common chemical nematicide carbofuran. Among the vermicomposts tested, the vermicompost produced from distillation waste of menthol mint and straw of isabgol significantly enhanced the total weight (fresh and dry) of tomato plants as compared to carbofuran-treated plants. This was also indicated in terms of fruit yield (both number and weight). Interestingly, the growth and yields of menthol mint vermicompost-treated plants was at par with untreated–uninoculated control signifying the efficacy of such compost in reducing the nematode infestation and losses caused by them.

With no effective chemical nematicides available and *M. incognita* being a polyphagus pest, it is nearly impossible to eradicate this pest from agricultural soils. It was therefore thought worthwhile to explore possibilities of reducing its populations in soil and roots; one such important blockage/obstruction would be inhibiting the egg hatching. This study revealed a drastic reduction in hatching of eggs by aqueous extracts of several vermicomposts and significant reduction in RKI and increase in total weight of the plant with the vermicomposts produced from distillation waste of menthol mint and straw of isabgol. A few reports of nematode inhibition through application of vermicompost made from recycled paper and supermarket food waste already exist[5]. Reducing hatching of *M. incognita* eggs with vermicomposts will help to a great extent in delay of population buildup of *M. incognita* to a level that may cause economic damage to crops. This way of managing nematode population will reduce the risk of selection pressure on nematodes and will avoid the development of more virulent pathotypes. The drastic reduction in population of *M. incognita* might be because of some nematode inhibitory compounds present in the MAPs[3,8] or because of high population of antagonistic microbes including actinomycetes present in such vermicomposts[4].

Our study emphasizes the use of vermicompost produced from agro-waste of MAPs which apart from pro-

Table 1. Effect of different vermicomposts on fresh/dry root and shoot weight, fruit yield and root-knot indices in tomato*

Treatments	Fresh weight (g)			Dry weight (g)			Fruit yield		
	Root	Shoot	Total	Root	Shoot	Total	No.	Weight (g)	RKI
Untreated–uninoculated	53.2	13.1	66.3	11.7	3.6	15.3	12.2	64.5	–
Untreated–inoculated**	24.6	7.4	32.0 (51.7)***	5.1	2.0	7.1 (53.6)***	5.6	38.7	4.33
Carbofuran**	40.4	10.6	51.0 (23.1)	8.2	2.8	11.0 (28.1)	8.4	45.6	2.66
Pyrethrum**	41.8	11.0	52.8 (20.4)	8.6	2.9	11.5 (24.8)	9.1	48.5	2.00
Qinghao**	42.6	11.4	54.0 (18.6)	8.8	3.2	12.0 (21.6)	9.6	51.4	1.81
Marigold**	44.0	11.7	55.7 (15.9)	9.0	3.5	12.5 (18.3)	10.2	52.5	1.66
Menthol mint**	50.4	12.5	62.9 (5.1)	10.2	3.8	14.0 (8.5)	10.7	61.4	1.33
Isabgol**	44.5	11.8	56.3 (15.1)	9.1	3.6	12.7 (16.9)	10.2	53.0	1.66
Geranium**	38.5	10.0	48.5 (26.8)	7.8	2.5	10.3 (32.7)	8.0	43.6	2.80
LSD (P = 0.05)	2.81	2.02	5.71	1.43	1.21	1.53	1.21	3.45	0.76

*Each value is an average of five replicates. **Inoculated with 1000 eggs of *Meloidogyne incognita*/plant. ***Percentage of reduction over untreated–uninoculated control.

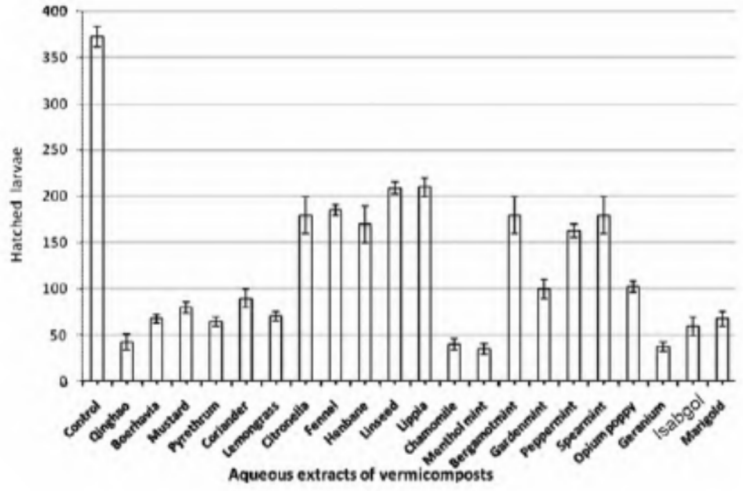

Figure 1. Effect of extracts of different vermicomposts on hatching of eggs of root-knot nematode, *Meloidogyne incognita*. Bar indicates the STDEV value (n = 5).

viding benefits of supplementing higher amount of macro- and micronutrients supporting better growth/health of plants also reduces losses from phytonematode infestation in crop plants. This strategy will be particularly useful to farmers growing MAPs who can economically utilize their crop waste, which otherwise have no economic value. Present findings assume potential importance in developing new vermicompost-based nematode management programme in the era of organic farming.

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