

Annual Chrysanthemum: A potential bio-remedy for nematode control

Annual chrysanthemum has emerged as a valuable horticultural crop with expanding significance beyond ornamental cultivation. The species offers considerable potential for promoting environmentally sustainable crop production owing to its wider adaptability, multifunctional utility and compatibility with low-input farming systems. The availability of genetically diverse genotypes possessing attractive floral traits and stress tolerance further enhances its suitability for commercial floriculture, landscape horticulture and sustainable agricultural practices. Moreover, its utility in biologically based pest management highlights the increasing shift toward safer, plant-derived alternatives in horticulture. The crop also offers significant opportunities for developing eco-friendly production systems that effectively integrate aesthetic appeal with agricultural sustainability. With growing emphasis on climate-resilient agriculture and reduced dependence on synthetic chemicals, annual chrysanthemum is likely to become an important component of future sustainable horticultural systems and green agricultural technologies in India.

Keywords: Annual Chrysanthemum, Bio-Nematicide, Botanical extracts, Pyrethrin, Root-knot nematodes, Sustainability

INDIA'S horticulture sector has witnessed remarkable growth in recent decades; however, the productivity of horticultural crops continues to be severely constrained by various biotic stresses. Among these, soil-borne pests, particularly root-knot nematodes (*Meloidogyne incognita*) are highly destructive. These microscopic plant parasite nematodes infect plant root systems and induce gall formation, thereby disrupting water and nutrient uptake. As a result, infected plants exhibit stunted growth, chlorosis, poor flowering, reduced fruiting and substantial yield loss. Since nematode infestations are often detected only at advanced stages of crop growth, significant economic damage frequently occurs before effective management interventions are implemented. Although synthetic nematicides are commonly used for nematode control, their prolonged and indiscriminate application leads to environmental pollution, health hazards, destruction of beneficial soil microorganisms and the development of resistance in target pest populations. Consequently, increasing emphasis is being placed on sustainable and eco-friendly alternatives. In this context, plant-based approaches involving annual

chrysanthemum (*Chrysanthemum coronarium* L.) have gained considerable importance due to their nematicidal and nematode suppressive properties. Such approaches offer an environmentally safe and sustainable alternative that is comparatively safer for both human health and ecological systems.

Annual chrysanthemum as a bio-nematicide: In the search for sustainable alternatives to synthetic nematicides, annual chrysanthemum (*Chrysanthemum coronarium* L.), a member of Asteraceae family, commonly known as Crown daisy, has emerged as a promising ornamental crop with additional potential as a bio-nematicidal plant. The species contains several bioactive compounds that exhibit significant activity against root-knot nematodes (*Meloidogyne incognita*), highlighting its potential role in sustainable nematode management strategies. The crop is

highly valued for its profuse flowering, attractive blooms, extended flowering duration and suitability for loose flower production as well as landscape beautification. Its adaptability to marginal lands, low water requirement and compatibility with low-input cultivation practices further enhances its suitability for commercial



Pusa Swarna



Pusa Dhaval



Pusa Ivory

cultivation and home gardening. Generally, the crop is raised through transplanting of approximately one-month-old seedlings at a spacing of 30 × 30 cm.

Bioactive compounds of annual chrysanthemum with strong nematicidal potential, includes: pyrethrins, cinerins, jasmolins, flavonoids and phenolic compounds. These constituents interfere with nematode metabolism and nervous system activity, ultimately leading to paralysis and mortality. Among these, pyrethrins are regarded as the most potent compounds, rapidly disrupting nervous system function and inducing paralysis in nematodes. Cinerins and jasmolins further enhance and prolong this nematicidal action, while flavonoids contribute by interfering with nematode growth, metabolism and infectivity. Advanced phytochemical analyses have additionally identified compounds such as luteolin, quercetin, myricetin and pyrethrin derivatives, which possess well known pesticidal, antioxidant and protective properties. Collectively, these bioactive constituents act through multiple mechanisms, thereby increasing the effectiveness of annual chrysanthemum against nematodes while reducing the likelihood of resistance development.

Improved annual chrysanthemum genotypes developed by ICAR-IARI, New Delhi

Promising genotypes identified at institute level: Indian Agricultural Research Institute, New Delhi has developed improved annual chrysanthemum genotypes through purification, sib mating and rigorous selection from heterogeneous populations. The breeding programme was primarily focused on developing hardy genotypes with attractive flower colours, higher flower yield and suitability for loose flower production as well as garden display.

- Pusa Dhaval is a white- double flowered annual chrysanthemum genotype characterised by profuse flowering, hardiness and excellent ornamental value. The plants produces approximately 162 flowers/plant and well suited for loose flower use and garden decoration. This genotype performs satisfactorily under low-management practices and is comparatively less prone to major pests and diseases.
- Pusa Ivory is a cream-coloured genotype possessing attractive double flowers with compact plant growth habit. It produces about 137 flowers/plant and performs well under minimal crop management practices. Its elegant blooms and profuse branching habit make it highly suitable for ornamental gardening and landscape planting.
- Pusa Swarna is a vigorous yellow-flowered genotype with high flower production potential. It produces

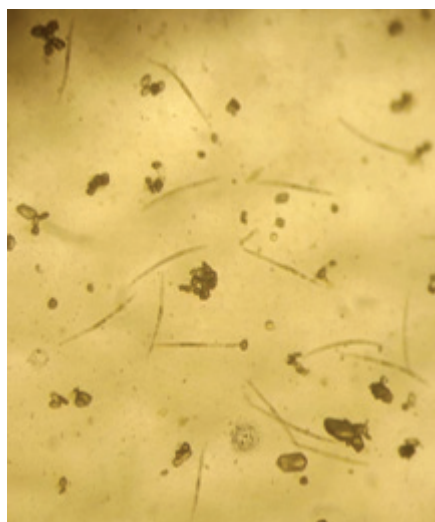
nearly 190–195 attractive flowers/plant, making the genotype highly suitable for loose flower markets and landscape purposes. Its high flower yield coupled with bright, attractive blooms makes it a promising genotype for commercial cultivation.

Factors influencing nematicidal activity of plant extracts: The novelty of this approach lies in the integration of ornamental horticulture with eco-friendly crop protection strategies. Biomass and plant extracts of annual chrysanthemum can be effectively utilised as components of integrated nematode management programmes. The nematicidal potential varies among these annual chrysanthemum genotypes. Amongst them, the white-flowered genotype, Pusa Dhaval, exhibits comparatively higher nematicidal activity against root-knot nematodes followed by the Pusa Ivory and Pusa Swarna. This indicates that fresh leaf extracts, particularly from white-flowered genotypes, possess strong nematicidal potential and may serve as an effective plant-based alternative for sustainable nematode management.

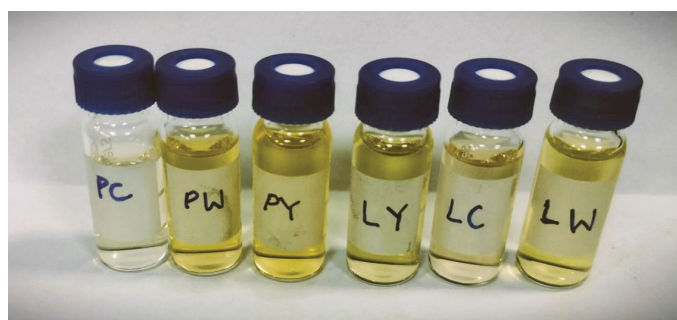
- All parts of the plant are not equally effective. Fresh leaves show the strongest nematicidal activity, followed by fresh flowers and dried leaves. Whereas, dried flowers are the least effective. The greater efficacy of fresh plant material may be attributed to the higher concentration of active volatile compounds.
- The nematicidal efficacy of annual chrysanthemum extracts increases with increasing extract concentration. At lower concentrations, the extracts cause only temporary immobilisation of nematodes, and many individuals recover after transfer to fresh water, indicating a nematostatic effect. In contrast, higher concentrations, particularly full-strength extracts, cause irreversible damage and result in complete nematode mortality.
- The effectiveness of the extracts increases with longer exposure duration. Nematode mortality progressively increases over time, with the maximum effect after 96 hours of exposure. This indicates that the bioactive compounds requires sufficient contact time to penetrate the nematodes and disrupt their metabolic and physiological functions, ultimately leading to mortality.
- Although botanical extracts may require comparatively longer exposure periods than synthetic nematicides to achieve maximum effectiveness, their eco-friendly nature, lower environmental risk and compatibility with sustainable farming systems makes them highly valuable components of integrated nematode management strategies.



Galls and egg masses induced by *Meloidogyne incognita* infected roots of tomato cv. Pusa Ruby.



Plant extracts showing nematicidal effect under *in-vitro*



LC-MS/UPLC-ToF-MS-based extraction of chemical constituents from annual chrysanthemum for nematicidal activity

Advantages of annual chrysanthemum-based management: Annual chrysanthemum offers considerable potential as an eco-friendly alternative to synthetic nematicides, as plant-based extracts help to reduce dependence on hazardous chemicals and minimise environmental contamination. The crop performs well under low fertility and minimal management conditions, thereby lowering cultivation costs

and making it suitable for low-input farming systems. In addition to its ornamental value, annual chrysanthemum possesses multi-purpose utility by providing attractive flowers along with bioactive compounds that contribute to pest suppression. Furthermore, the presence of multiple bioactive constituents acting through different mechanisms reduces the likelihood of nematode resistance development, enhancing its potential as a sustainable component of integrated nematode management strategies.

Sustainable utilisation: Annual chrysanthemum can be effectively integrated into sustainable agricultural systems through practices such as intercropping, crop rotation, green manuring and the application of botanical extracts. Its cultivation not only provides ornamental and economic benefits but also contributes to the natural suppression of root-knot nematode populations. Incorporation of annual chrysanthemum herbage into the soil through ploughing and mixing of fresh biomass helps to suppress plant-parasitic nematodes due to the release of bioactive compounds during decomposition, while simultaneously improving soil health and organic matter. In addition, extracts derived from different plant parts offer an eco-friendly alternative to synthetic nematicides. Thus, annual chrysanthemum serves as a multifunctional crop that supports sustainable pest management, soil health improvement and eco-friendly horticultural production systems.

The future prospects of annual chrysanthemum appear highly promising. With the increasing emphasis on sustainable horticulture, eco-friendly pest management and ornamental landscaping, the crop has the potential to play multiple roles in Indian agriculture. Integration of annual chrysanthemum-based management practices with other environmentally safe approaches may further enhance its effectiveness in sustainable crop protection systems. Moreover, further refinement and standardisation of extraction techniques under diverse field conditions could strengthen the commercial viability of bio-nematicidal formulations derived from this crop.

The newly developed genotypes from ICAR- Indian Agricultural Research Institute, New Delhi, namely Pusa Dhaval, Pusa Ivory and Pusa Swarna, possess varied flower colours, profuse blooming habit and adaptability to marginal lands, making them highly suitable for commercial cultivation as well as public and home gardens. Simultaneously, the bioactive potential of these genotypes provides significant opportunities for the development of plant-based nematicidal formulations, thereby contributing to sustainable and environmentally resilient horticultural systems.

SUMMARY

Annual chrysanthemum is no longer an ornamental flower crop, it is gradually emerging as a multifunctional species with aesthetic, ecological and agricultural importance. The improved genotypes combine attractive flower colours, profuse flowering, hardiness and adaptability under low-input cultivation conditions. Simultaneously, the presence of naturally occurring bioactive compounds makes the crop a promising eco-friendly alternative for the management of root-

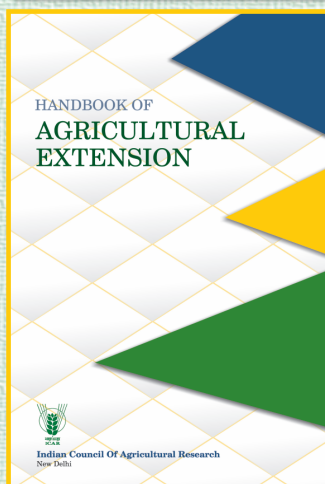
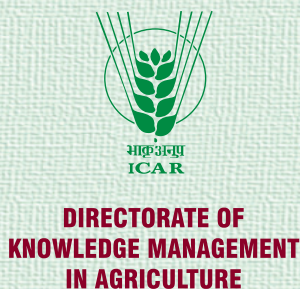
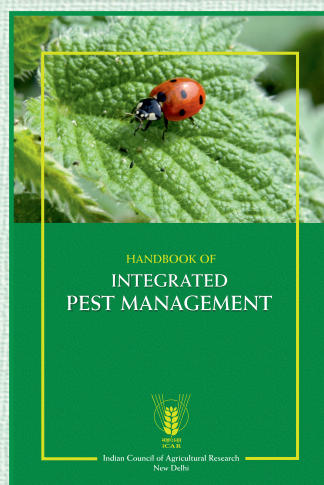
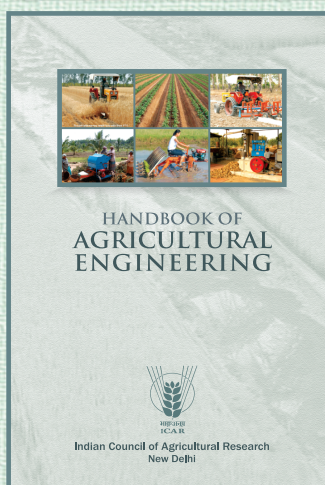
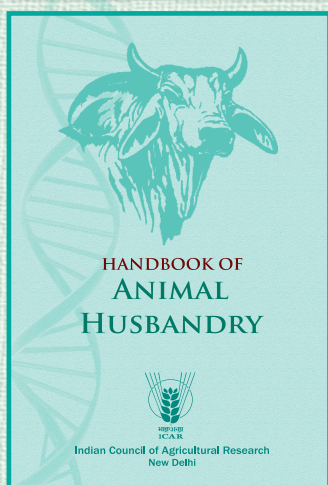
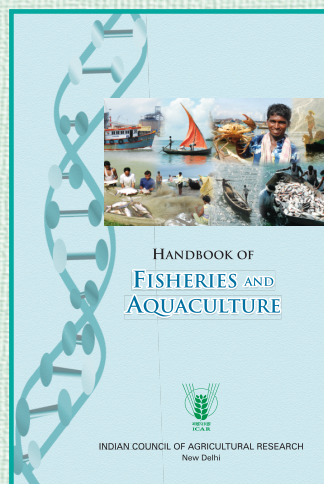
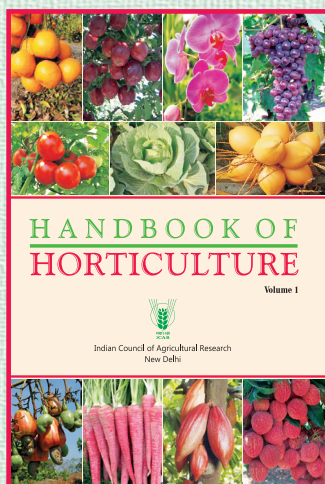
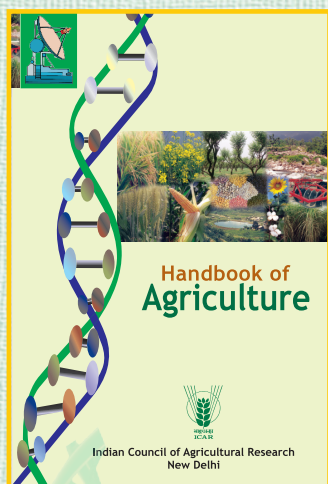
knot nematodes. Therefore, the integration of annual chrysanthemum into sustainable farming systems through ornamental cultivation, intercropping, crop rotation and the use of botanical extracts may help to reduce the dependence on synthetic chemicals while improving environmental health and agricultural sustainability. With further research, refinement and field-level validation, annual chrysanthemum has the potential to become an

important component of climate-resilient and sustainable horticultural systems in India.

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