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Irrigation, a potential tool for insect pest management in horticultural crops — a review

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ABSTRACT

Irrigation, probably more than any other single factor, has a greater role to enhance the production and productivity of horticultural crops. Different methods of irrigation systems are being followed for various horticultural crops. Apart from soddening the crops, irrigation can also play a pivotal role in insect pest management in so many horticultural crops. A light irrigation minimizes the termite infestation. The drip irrigation in perennial orchard helps maintain lower level of insect pests compared to flood irrigation; whereas drip irrigation maintains the incidence of tomato fruit borer to lower level in field instead of sprinkler irrigation. The paper illustrates this theory by reference to illustrates and discusses the ways in which insect pests menace can be minimized in horticultural crops.

Key Words: Irrigation, Horticultural crops, Insect pests management, Drip irrigation, Sprinkler irrigation

Stupendous efforts have been made to enhance the irrigated area through creation of a large number of surface irrigation projects and through ground water resources in India. Therefore, the irrigated area has increased by almost 250% from 1950-51 (Shankar *et al.*, 2015). Recently, microirrigation is being emphasized to increase the water use efficiency. In microirrigation, water is irrigated through special devices, *viz*. sprinklers, drippers, foggers and additional emitters on surface and subsurface of land. It has a potential role in insect pests management in horticultural crops. When a plant is stressed and weakened because of missing of vital nutrients, it becomes a soft-target for any pests or diseases. If watering for a plant is not appropriate, it can weaken a plant very quickly and the opportunistic pests are already waiting for the opportunity to attack crops (www.naturesseed.com). So, insect pest management thorough irrigation is a unique, distinct and eco-friendly cultural method with potential benefits. Unlike conventional chemical method of pest control which often has problems, such as resistance to pesticides, resurgence of target sucking insects and secondary pest outbreaks, in addition to widespread killing of beneficial non-target organisms (Halder and Rai, 2016; Halder *et al.*, 2015, 2021).

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Considering the adverse effects of these synthetic insecticides, this noble cultural method of pest control gives an opportunity to control the pests without no/little cost involvement. However, thorough knowledge of pest bio-ecology and seasonal incidence are paramount in this venture (Halder *et al.*, 2019, 2022). Different methods of irrigation such as surface irrigation; sub-surface irrigation; sprinkler irrigation and drip irrigation are widely used by farmers. The role of these irrigation methods has been reviewed and discussed in the light of insect pest management in horticultural ecosystems.

Irrigation methods in insect pest management

Flood irrigation: Incidence of red spider mites, *Tetranychus urticae* Koch. and *T. cinnabarinus* (Boisduval) on vegetables, *viz*. okra, brinjal, pumpkin, pointed gourd etc. are more in dry months. Frequent irrigations at 4-5 days intervals in clay-loam soils of Varanasi, Uttar Pradesh, India, substantially minimized its incidence in summer season, particularly during May-June (Rai *et al.*, 2014(a). Flooding and water stagnation for 2-3 days kill the over-wintering soil-inhabiting pupal stage of many Lepidopteran, Dipteran and Coleopteran pests of vegetables (Rai *et al.*, 2014(b).

Flooding of fields has been recommended for minimizing the attacks of those pest whose at least one

or more life-stages are passed in soil. Cutworms [*Agrotisipsilon* (Hufnagel)], army worms [*Spodoptera mauritia* (Boisduval)], red hairy caterpillar [*Amsactaalbistriga* (Fabricius), *A. mooreii* Butler], red pumpkin beetles (*Rhapidopalpa foveicollis* Lucas), cucurbit fruit fly [*Zeugodacus cucurbitae* (Coquillett)], termite [(*Odontotermesobesus* (Rambur)], white grubs [*Holotrichia consanguinea* Blanchard, *Holotrichia serratae* (Fabricius)] are few in the list. Due to flooding, water permeates the soil pores and soil inhabiting stages of insects get killed either due to asphyxiation or emerge out from the soil and finally devoured by the predatory fauna.

The performance of phytophagous insects in tomato (*Lycopersicon esculentum* Linn.) is minimized by water stress, depending on cultivars and other stress level (Inbar *et al.* 2001; Rivelli *et al.* 2013). This is in accordance with the earlier studies on synchronous effects of aphids and water stress on tomato crop growth under controlled conditions (Rivelli *et al.*, 2012). Colella *et al.*, 2014 recorded that incidence and population of phytophagous insects of tomato, *viz. Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae); *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae); *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae); and leafhoppers (unidentified species) was the maximum in plots where plants obtained the full restoration of crop evapotranspiration and the minimum in plots where crops had not receive any water except during transplanting.

So, water deficit also reduces the insect pest infestation rate under field conditions. Frequent irrigation and optimum soil moistures reduce the phytophagous mite population in horticultural crops (Rai *el al.,* 2014(b). In Chinese cabbage (*Brassica rapa* subsp. *pekinensis*), the mustard aphid population (*Lipaphisery simi* (Kalt.) increased significantly with the number of irrigation from three to six (Dhaliwal and Arora, 2002).

Drip and sprinkler irrigations

Drip and sprinkler irrigations are the improved version of irrigation methods with multiple advantages. Precise and adequate water supply at the root zone made these technologies highly acclaimed around the world. According to Kuhar *et al.* (2010) two drip applications of Chlorantraniliprole drastically reduced the tomatoes ravaged by tomato borer, *Helicoverpa zea* (Boddie), in comparison to that of using repeated foliar applications of insecticides. Taylor (1984) had observed that application of sprinkler irrigation during the larval emergence of cutworm was very effective in reducing infestations compared with pesticide treatment. They concluded that larvae dislodged from the foliage were unable to regain their position on the host plant as they are positively phototactic immediately (up to two days) after emergence.

Sprinkler irrigation on alternate days over the first 3-4 weeks for 5 minutes during dusk, and regular day thereafter, significantly reduced the diamondback moth (DBM), Plutellaxylostella Linn. on cabbage and increased the yield over drip irrigation control plots receiving an equal amount of water. The disruption of flying activity, oviposition, and to some extent wash-off of larvae and adults were from the plant surface seem to be the major causes of the observed effects (Talekar *et al.*, 1986). Sprinkler irrigation presumably drowns and washes away DBM larvae feeding on the leaf surface. Apart from disturbing the adult moths and forces them to fly upon which the water droplets wash them away.

Since, sprinkler irrigation was carried out close to dusk, when the DBM mate and start laying eggs (Harcourt, 1957), there seems a distinct possibility that this treatment disturbs mating and/or oviposition. Crucifer crops with overhead sprinkle irrigation tend to have fewer DBM larvae than drip or furrow-irrigated crops (Gautam *et al.*, 2018). In another study McHugh and Foster (1995) reported that irrigation water was applied to cabbage by Whiz head, Mini head, or Buckner head sprinklers, DBM infestations were reduced by 37.5-63.9% as compared to drip-irrigation. Sprinkler treatments applied between 1500 and 1700 hours continuously, 2000 and 2200 hours continuously, and 2000 and 2330 hours intermittently resulted on an average 53.7, 72.9, and 85.9% reduction in diamondback moth infestation, respectively.

However, the best results were obtained by intermittent daily application of overhead irrigation between 2000 and 2330 hours. In another study on watercress in Hawaii, Tabashnikand Mau (1986) determined that 70% of diamondback moth adult oviposition occurred between the hours of 1700 and 2300. Irrigation during that time was effective in suppressing diamondback moths on watercress by reducing the number of eggs laid per plant. Use of sprinkler irrigation reduced thrips population in chilli and ginger considerably compared to drip and surface irrigation.

The effects of overhead and drip tube irrigation on two spotted spider mite (*Tetranychus urticae* Koch) and its predatorymite (*Phytoseiulus persimilis* Athias-Henriot) populations were investigated on Impulse Orange (*Impatiens wallerana* Hook.f.) by Opit *et al.* (2006). Overhead watering significantly reduced *T. urticae* and *P. persimilis* populations as much as 68 and 1538-fold, respectively, compared to drip irrigation with micro tubes. They also concluded that spider mite infestations

and injury may be made by irrigation systems that wet plant foliage. Similar observations were also recorded by Hudson and Beirne (1970); Ranga *et al.* (1990).

Aldryhim and Al-Bukiri, 2003 showed that more infested date palm trees by the red palm weevil *Rhynchophorous ferrugineus* (Olivier), the most serious pest, were detected in plots with flood irrigation compared to drip irrigation. The number of infested trees in these plots represented 89% of the total infested trees. They also concluded that irrigation management and soil moisture are key factors in the dispersion of the red palm weevil infestation and could be used as one of the integrated pest management tools.

However, overhead or sprinkler irrigation wets the plant foliage that could be favorable for plant pathogens and subsequent disease development. Splashing water off the plant foliage often results in the movement of plant pathogens between the plants. Apart from the known benefits of overhead irrigation loss of water to evaporation and chance of disease incidence are greater threats in crop production.

High-pressure water spray

Use of high-pressure water spray to dislodge spider mites, aphids, small caterpillars and other pests from host plants has long been suggested as a "non-chemical" or "organic" method of pest control (Meyer and Stone, 1989). The water pressure (pressure of water coming out of the end of a hose) would be 90-100 pounds per square inch (https://extensionentomology.tamu.edu). Using ones' thumb on the end of the hose to produce a high pressure spray to dislodge the arthropods (insects and mites) from the plants has been widely used practice. Use of these devices would be compatible with biological control programmes to dislodge pests before natural enemies are released. In addition, water or soap water spray treatments may be capable of removing the sugary honey dew secreted by the sucking insects deposited on leaves and other plant parts as black sooty mold, hindering the normal photosynthesis of the plants (Halder *et al.,* 2010; Halder and Rai, 2018).

Chemigation

Chemigation is the process of applying an agricultural chemical (pesticides or fertilizers) to the soil or plant surface with an irrigation system by injecting the chemical into the irrigation water (https://hort.purdue.edu). Both the water and pesticides are homogeneously applied, resulting in excellent distribution of the water-pesticide mixture. Pesticides may also be applied when other approaches cannot be used due to humidity, extreme wind, equipment availability *etc.* Depending on the type of agricultural chemical being applied, chemigation may be referred to as herbigation, insectigation, fungigation, fertigation,

Table 1. Effect of different irrigation methods on insect pests management

Irrigation method	Crop(s)	Insect pest(s)	Effects (+ve /- ve) on target pest(s)	Place	References
Flooding followed by water stagnation for 2-3 days	Vegetables	Soil inhabiting stages of Lepidoptera, Coleoptera and Diptera	Negative	Varanasi, Uttar Pradesh	Rai *et al.,* 2014(b)
Sprinkler irrigation	Vegetables	Cutworm	Negative	Londan, U.K.	Taylor, 1984
Sprinkler irrigation	Cabbage	Diamondback moth, *Plutellaxylo stella* Linn.	Negative	Taiwan Ontario, Canada India West Lafayette, U.S.A.	Talekar *et al.,* 1986 Harcourt, 1957 Gautam *et al.,* 2018 McHugh and Foster, 1995
Overhead sprinkler irrigation	Impulse orange (*Impatiens wallerana* Hook. f.)	Two spotted spider mite (*Tetranychus urticae* Koch) and its predatorymite (*Phytoseiuluspers imilis* Athias-Henriot)	Negative	Kansas, U.S.A.	Opit *et al.,* 2006
Flood irrigation	Date palm	Red palm weevil *Rhynchophorous ferrugineus* (Oliver)	Positive		Aldryhim and Al-Bukiri, 2003

etc. Chemigation can be an effective application option for some labeled pesticides if the irrigation system can apply the chemical / water solution uniformly over the target area with the correct water depth.

However, accurate calibration of the irrigation system and the pesticide application rate is most important in this technology. Palumbo (2008) observed that two drip applications of Chlorantraniliprole during stand establishment provided excellent residual control of *Trichoplusiani* (Hübner), *Spodoptera exigua* (Hübner), and *Liriomyza* spp. in romaine lettuce (*Lactuca sativa* Linn. var. *longifolia*), with no significant marketable yield loss. Schuster *et al.* (2009) reported that a single or double drip application of Chlorantraniliprole effectively reduced both leafminer, Liriomyza trifolii (Burgess); and armyworm, *Spodoptera* spp., damage in tomato (*Solanum lycopersicum* L.).

Water management with other management practices

Water management in horicultural crops through irrigations is, in general, compatible with other pest management options, *viz*. physical, mechanical, cultural, biological and chemical pest control methods. In fact, frequent irrigations inflate the moistures / humidity in the crop field which further favour the biological pest control resorted through microbial organisms. Similarly, different physical methods of pest control such as light traps, pheromone traps, colored sticky traps are compatible with water management. However, sometimes, flood irrigation restricts the intercultural operations in the field for few days, depending on soil texture, due to muddy condition of soil. Foliar sprays of pesticides generally do not affect by ground irrigation, however, basal and root zone application of pesticides sometime restricted due to irrigation. Pesticides, particularly organo-phosphates, can move in solution with irrigation water. So, adequate precaution should be taken to prevent this unintended run-off through irrigation water.

CONCLUSION

Obviously, finding of above experiments will enable us to develop a sound Integrated Plant Health Management (IPHM) package and that will help growers to select ways to reduce overall pest load in their field and ensure that the management of pests is compatible with their other crop management inputs. Moreover, it is important that growers should realize that IPHM system is updated from time to time in response to biological changes that occur in their field and new techniques or technologies are introduced as soon as additional relevant information becomes available. Irrigation, the single most crucial factor in increasing horticultural production and productivity, also plays a pivotal role in insect and acarine pests problem. It is evident that at agricultural intensification, irrigation as a central feature can also minimize the impact of natural regulatory mechanisms on insect pest populations.

The examples selected above have been chosen to illustrate rather specifically the influence of irrigation on crop pest problems. The current trends in pest management that mostly emphasize the exploitation of biological and chemical components can also integrate irrigation management as a cultural realistic means of substituting for this crop losses. However, thorough knowledge of bio-ecology the target pest(s) and associated environment are imperative. Identifying the suitable method(s)of irrigation, their time of application, crop phenology, soil texture and its prevalent moisture level in relation to pest biology are the few in the catalogue.

REFERENCES

Aldryhim Y and Al-Bukiri S. 2003. Effect of irrigation on within-grove distribution of red palm weevil *Rhynchophorousferrugineus*. *Journal of Agricultural and Marine Sciences* **8**(1): 47-49.

Colella T, Candido V, Campanelli G, Camele I and Battaglia D. 2014. Effect of irrigation regimes and artificial mycorrhization on insect pest infestations and yield in tomato crop. *Phyto-parasitica* **42**: 235-46. DOI 10.1007/s12600-013-0356-3.

Dhaliwal G S and Arora R. 2002. *Integrated Pest Management: Concepts and Approaches*. Kalyani Publishers, Ludhiana, Punjab, India p. 121.

Gautam M P, Singh H, Kumar S, Kumar V, Singh G and Singh SN. 2018. Diamondback moth, *Plutella xylostella* (Linn.) (Insecta: Lepidoptera: Plutellidae) a major insect of cabbage in India: a review. *Journal of Entomology and Zoology Studies* **6**(4): 1394-99.

Halder J and Rai A B. 2016. Suitability of different prey aphids on the growth, development and reproduction of *Chrysoperla zastrowisillemi* (Esben-Petersen) (Chrysopidae: Neuroptera). *Proceedings of the Zoological Society* **69**(1): 89-95. DOI 10.1007/s12595-014-0131-6.

HalderJ, Majumder S and Rai A B. 2021. Compatibility and combined efficacy of entomopathogenic fungi and neonicotinoid insecticides against *Myzuspersicae* (Sulzer): An ecofriendly approach. *Entomologia Hellenica* **30**(1): 24-32. DOI.org/10.12681/eh.25417.

Halder J and Rai A B. 2018. Aphidicidal activity of some systemic insecticides and change in susceptibility level of *Myzuspersicae* Sulzer in vegetable ecosystem in Varanasi, India. *Pesticide Research Journal* **30**(2): 219-23.

Halder J, Srivastava C, Dhingra S and Dureja P. 2010. Bioactivity of some plant extracts against mustard aphid, *Lipaphiserysimi* (Kalt.) and its predator *Coccinella septempunctata* (Linn.). *Pesticide Research Journal* **22**(2): 174-76.

Halder J, Rai A B and Dey D. 2015. Occurrence of *Phenococcus solenopsis* (Tinsley) in vegetable ecosystem and host-mediated effects on its dominant parasitoid, *Aenasius*

bambawalei Hayat. Vegetable Science **42**(2): 30-33.

Halder J, Kushwaha D, Deb D and Rai A B. 2019. Abundance and distribution of sucking pests complex of okra in relation to meteorological parameters. *Journal of Agrometeorology* **21**(2): 227-29.

Halder J, Rai A Band Deb D. 2022. Distribution and abundance of cucurbit fruit fly *Zeugodacus* (Bactrocera) cucurbitae in relation to weather parameters. *Journal of Agrometeorology* **24**(2): 220-22. DOI:https://doi.org/10.54386/jam.v24i2.1643

Harcourt D G. 1957. Biology of the diamondback moth, *Plutellamaculipennis* (Curt.) (Lepidoptera: Plutellidae), in eastern Ontario. II. Life-history, behavior, and host relationship. *Canadian Entomology* **89**: 554-64.

https://extensionentomology.tamu.edu/publications/water-wands-high-pressure-water-spray-devices-for-insect-and-mite-control/ visited on 23/05/2021 at 07.30 pm

https://hort.purdue.edu/rhodcv/hort410/ID562003/ Chemigation.pdf accessed on 29/02/2020 at 10.45 am.

Hudson W B and Beirne B P. 1970. Effects of sprinkler irrigation on McDaniel and European red mites in apple orchards. *Journal of the Entomological Society of British Columbia* **67**: 8-13.

Inbar M, Doostdar H and Mayer R T. 2001.Suitability of stressed and vigorous plants to various insect herbivores. *Oikos* **94**: 228-35.

Kuhar T P, Walgenbach J F and Doughty H B. 2010. Control of Helicoverpazea in tomatoes with chlorantraniliprole applied through drip chemigation. Online. *Plant Health Progress* doi:10.1094/PHP-2009-040701-RS.

McHugh J J JR and FosterA E. 1995. Reduction of diamondback moth (Lepidoptera: Plutellidae) infestation in head cabbage by overhead irrigation. *Journal of Economic Entomology* **88**(1): 162-68.

Meyer Aand Stone P (Eds.). 1989. *The Healthy Garden Handbook.* A Fireside Book, Simon and Schuster Inc., New York. p. 192.

Opit G P, Fitch G K, Margolies D C, Nechols J R and Williana K A. 2006. Overhead and drip-tube irrigation affect two spotted spider mites and their biological control by a predatory mite on impatiens. *Hort. Science* **41**(3): 691-94.

Palumbo J C. 2008. Systemic efficacy of Coragen applied through drip irrigation on romaine lettuce, fall 2007. *Arthropod Management Tests* **33**: E24.

Rai A B, Halder J, Kodandaram M H. 2014(b). Emerging insect pest problems in vegetable crops and their management in India: An appraisal. *Pest Management in Horticultural Ecosystems* **20**(2): 113-22.

Rai A B, Loganathan M, Halder J, Venkataravanappa V and Naik P S. 2014(a). Eco-friendly approaches for sustainable management of vegetable pests. Technical Bulletin, ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh p. 104.

Rivelli A R, Toma I, Trotta V, Fanti P, De Maria S and Battaglia D. 2012. Combined effect of water stress and Macrosiphumeuphorbiae infestation on plant growth in tomato. ***In:*** F. Stoddard and P. Mäkelä, 12th Congress of the European Society for Agronomy (Helsinki, Finland) **1**: 334-35.

Rivelli A R, Trotta V, Toma I, Fanti P and Battaglia D. 2013. Relation between plant water status and *Macrosiphumeuphorbiae* (Hemiptera: Aphididae) population dynamics on three cultivars of tomato. *European Journal of Entomology* **110**: 617-25.

Schuster D J, Shurtleff A and Kalb S. 2009. Management of armyworms and leaf miners on fresh market tomatoes, fall 2007. *Arthropod Management Tests* **34**: E79.

Shankar M S, Ramanjaneyulu A V, Neelima T L and Das A. 2015. Sprinkler Irrigation - An Asset in Water Scarce and Undulating Areas. ***In:*** *Integrated Soil and Water Resource Management for Livelihood and Environmental Security.*

Rajkhowa D J, Das A, Ngachan S V, Sikka A K and Lyngdoh M. (Eds), pp 259-83. ICAR Research Complex for North Eastern Hill Region, Umiam 793 103, Meghalaya, India.

Tabashnik B E and Mau R F L. 1986. Suppression of diamond-back moth (Lepidoptera: Plutellidae) oviposition by overhead irrigation. *Journal of Economic Entomology* **79**: 189-91.

Talekar N S, Lee S T and Huang S W. 1986. Intercropping and modification of irrigation method for the control of diamondback moth pp. 145-51.

Taylor, C. G. 1984. 'An investigation of a predictive system developed to improve timing of control measures against cutworms in vegetables.' M.Sc thesis, University of London.

www.naturesseed.com/blog/irrigation-for-pest-control/ accessed on 29/02/2020 at 10.30 am.