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MK Pathak
Technical Officer (Entomology) RRS, National Horticultural Research and Development Foundation, Karnal, Haryana, India

PK Gupta
Director, National Horticultural research and Development Foundation, New Delhi, India

S Pandey
Assistant Director (Entomology) RRS, National Horticultural Research and Development Foundation, Nashik, Maharashtra, India

MK Pandey
Technical Officer (Plant Pathology) RRS, National Horticultural Research and Development Foundation, Nashik, Maharashtra, India

S Purshottaman
Senior Technical Officer (Plant Pathology) RRS, National Horticultural Research and Development Foundation, Karnal, Haryana, India

RC Gupta
Assistant Director (Plant Pathology) RRS, National Horticultural Research and Development Foundation, Nashik, Maharashtra, India

Corresponding Author:
MK Pathak
Technical officer (Entomology) RRS, National Horticultural Research and Development Foundation, Karnal, Haryana, India

A review of onion thrips (*Thrips tabaci* Lindeman) management options and importance

MK Pathak, PK Gupta, S Pandey, MK Pandey, S Purshottaman and RC Gupta

Abstract
Thrips (*Thrips tabaci* Lindeman) is a major pest of onion and cause considerable losses in yield. The nymph and adult of thrips feed leaves by piercing and rasping the leaf tissues and causes lengthwise, silvery stippling or blotching on the onion leaves, resulting in the loss of chlorophyll and reduced photosynthetic efficiency. Thrips attack onion at all the stages of crop growth but their count increases from bulb initiation and remain high up to bulb development and maturity. Onion thrips can also transmit several plant pathogens in onion crop that reduced onion bulb size and quality. Therefore, the objective of this review was undertaken to evaluate previous work on the management of onion thrips.

Keywords: *Allium cepa, Thrips tabaci,* management options

Introduction
Onion (*Allium cepa* L.) is an important vegetable or spices crop cultivated in almost all the states of the country. In India onion is cultivated in 3 seasons ie, *rabi, kharif* and *late kharif* seasons and maximum area under cultivation is being covered in *rabi* season (about 60-65%). Thrips (*Thrips tabaci* Lindeman) is a regular and potential pest of onion and cause considerable losses as high as 90% in quality and yield (Gupta *et al.*, 1984) [19]. Srinivas and Lawande (2004) [72] reported that *Thrips tabaci* could cause yield loss in the range of 46-87% in onion. Waiganjo *et al.*, (2008) [79] estimated the foliage damage of crop around 40-60% which can led to yield losses 10-20% in the crop. Shibru and Negeri. (2014) [70] reported that onion thrips cause damage on yield 23-85%. Onion thrips are an important vector also for several plant viruses such as tomato spotted wilt virus (Kritzman *et al.*, 2002) [30]. Failure to control this pest by timely and effective means causes considerable damage and result in immense economic loss by remarkably reduced yield (Anonymous. 2000, + [3]. Insecticides are a major tool for thrips control, but this strategy is inadequate and unsustainable (Maniania *et al.*, 2003) [41] because thrips have developed resistance towards various group of insecticides (Lebedev *et al.*, 2013) [34].
The farmers have intensively used particularly those insecticides which are used to control this pest and repeated application of the same group of insecticide could have led to the development of resistance to insecticides (Shitole *et al.*, 2002, Alston & Drost 2008) [69, 4]. Pathak *et al.*, (2018) [57, 64] reported that lowest thrips population and highest onion seed yield was recorded with application of fipronil insecticides. Tirkey *and* Kumar (2017) [77], Kurbett *et al.*, (2015) [28] reported that thiamethoxam was proved to be the most effective for thrips control. Asgar *et al.*, (2018) [82] suggested that the insecticides reduced thrips population compared to control and highest yield was obtained by the use of Dimathoate. Kumar and Singh (2011) [29], Das *et al.*, (2017) [15] reported that spry of Imidaclorprid given at 15 days interval recorded lowest thrips population and gave highest gross yield. Pandey *et al.*, (2013) [56] reported that lowest thrips population and highest bulb yield was obtained by applying fipronil.

Origin of onion thrips
Thrips tabaci was first reported by Russian Entomologist *Karl Eduard Lindeman* based on specimens collected in Bessarabia, Russia, that caused severe damage to tobacco plants (Lindeman 1889) [40].

Geographic distribution of onion thrips

The onion thrips is global pest of onion grown between see level and 2000 (Lewis 1973) [39]. Onion thrips is a native of the Mediterranean region but has become a major pest of agricultural crops throughout most of the world (Mount and Walker 1982, Mound 1977) [51, 50].

Biology of onion thrips

Thrips life cycle deepened environmental condition, like temperature, humidity and nutrient quality of their food source. Stage in developmental life cycle is the egg, first larval stage, second larval stage, pre pupa, pupa and adult .Because of their small size, this pest species like other thrips connote readily be identified to species even with a hand lens. Adult specimens are usually needed to make species identification under high microscope magnification (Morse *et al.*, 2005) [59]. Brain A.N. 2006 mentioned that the biology of onion thrips was as followed the entire life cycle (egg to adult) required about 19 days. Large population are able to develop quickly under dry weather condition where there are many overlapping generations throughout year. Females have a saw -like structure that help to make an incision in plant tissue for egg laying. Eggs are placed singly just under the epidermis of succulent leaf, flower, stem or bulb tissue. Eggs are elliptical, approximately 0.2 mm in length. They are whitish at deposition and change to an orange tint as development conditions. Hatching occurs in 4-5 days. Larvae are whitish to yellowish. There are two larval stages and besides the adults they are the only damaging stages. Larval development is completed in about 9-10 days.

There are two non-feeding stages called the prepupa and pupa does not feed and occur primarily in the soil. Combined prepupal and pupal development in completed in 4-6 days. Adult are about 1 mm in length their body colour ranges from pale yellow to dark brown, wings are un banded and dirty gray. The males are wingless and exceedingly rare while the female have long, narrow fringed wings. Female live for 12-30 days and lay 50-60 kidney shaped eggs singly inside leaf tissue with a sharpe ovipositor.

Economic importance

Thrips is a serious pest on a wide range of fruit, vegetable, flower and Agronomics crops. Thrips are members of the order Thysanoptera, which contains a number of genera and species. Among species of thrips that attack onion are onion thrips (*Thrips tabaci*). Onion thrips incidence was a major problem due to the damage caused by feeding on vegetative parts which caused discoloration, deformities and reduced marketability the crop thrips may also serve as vectors for plant diseases such as tospovirus (Nault LR 1997) [52]. These enveloped viruses are considered among some of the most damaging of emerging plant pathogen around the world. Thrips damage is usually measured as an overall reduction in bulb size and weight of bulb.

Damage symptoms

Thrips tabaci is considered an in direct pest of dry bulb onion because it feeds on leaves rather than the marketable portion of the crop. Thrips feeding on onion leaves causes slivery leaf spot that turn in to white blotches along the leaves due to removal of cellular content followed by the development of silvery patches and curling of leaves (Bailey 1938) [13]. *Thrips tabaci* causes significant yield loss despite decades of research on control strategies worldwide (Lewis 1997b) [35]. *T. tabci* feeding can reduce onion bulb weight (Kendall and Capinera 1987, Fournier *et al.*, 1995, Rueda *et al.*, 2007, Diaz-Monato *et al.*, 2010, Waiganjo *et al.,* 2008 [31, 18, 66, 16, 79] and cause up to 60% yield loss. In addition to injury by feeding *T.tabaci* transmits IYSV and is the only confirmed vector of this pathogen (Pozzer *et al.*, 1994, Kritzman *et al.*, 2001) [54, 32]. IYSV was first identified on onion in southern Brazil in 1981 (Pozzer *et al.*, 1994) [54] and was confirmed in the United states in 1989 and worldwide (Gent *et al.*, 2006) [24]. IYSV symptoms on leaves appear as lesions (i.e., straw colour to white, dry, and sometimes elongate) along the edges (Gent *et al.*, 2004) [23] indicated that IYSV infection can reduced bulb size. The IYSV infects onion plants early in the growing season, onion yield losses may increase (Diaz-Montano *et al.*, 2010) [16].

Weather factors on outbreak of onion Thrips

Relatively high temperatures and lack of rainfall have been associated with increase in onion thrips population, while high relative humidity and rainfall reduce thrips population (Hamdy, M.K. and Salem M *et al.*, 1994) [26]. In addition to their effect on thrips activity, temperature and relative humidity further influence the intrinsic rate of natural increase of the thrips (Murai T. 2000) [57]. The rate of development of *Thrips tabaci* is positively affected by increased temperature and decreased by increased relative humidity (Hamdy, M.K. and Salem M *et al.*, 1994) [26]. The hot and dry weather promotes the increase of *T.tabaci* populations (Bailey 1934, Rueda *et al.*, 2007) [14] and the severity of thrips injury (Lewis 1973) [39] Additionally water stress may impact the nutritional quality of onion plants and also increases the attractiveness of the plants to thrips.

Management options of onion thrips

Cultural practice

The cultural practices such as remove of weeds around the fields crop rotation, date of planting, intercropping, spacing of plant to plant and row to row, does of fertilizers, Irrigation and mulching, etc are important factors decrees or increasing of thrips populations in onion crops.

Field sanitation

Plant health adherence thought the removal of volunteer onion plants and weeds around the cultivated fields and crop rotation would be useful in minimizing thrips population in an onion field (Waiganjo *et al.*, 2008) [79]. Removal of volunteer onion plants is also important because they are one of the few sources of primary inoculam of IYSV (Gent *et al.*, 2006) [24]. *Thrips tabaci* also has been found colonizing different weeds species late in the fall (Larentzaki *et al.*, 2007, Smith 2010) [38, 73].

Effect of planting date on thrips population

Pandey Sujay *et al.*, (2018) [60] conducted an experiment at NHRDF, Karnal, Haryana, India, during rabi, 2011-12, 2012-13 and 2013-14 as result show that lowest mean thrips population (4.71 nymphs/plant) with highest gross yield (113.39 q/ha) were recorded in 1st October planted crop, which was found at par (7.74 nymphs/plant) with gross yield (111.21 q/ha) were recorded 15th October planted crop. While highest mean thrips population (13.73) nymphs/plant with lowest gross yield (42.04 q/ha) was recorded in 15th

December planted crop. The similar trend was also found by Sujay and Giraddi (2014) [74] that late planted crop was liable for heavy infestation by insect pests. Dharmatti *et al.*, (2013) [17] conducted an experiment at university of Agriculture Sciences, Dharwad, Karnataka, India, to find out the thrips population attacking onion sown at different dates to determine the optimum dates of sowing. Result indicated that in 2009-2010, November 1st transplanted crop had a peak population of onion thrips in protected (8.95 nymphs/plant) as well as in unprotected plots (53.30 nymphs/plant). Where in 2010-11 and 2011-12, December 1st transplanted crop had a peak population of thrips (10.75 nymphs/plant) in protected plot and (55.49 nymphs/plant) in unprotected plots 2010-11) and 11.58 nymphs/plant in protected plot and 57.83 nymphs/plant in unprotected plot 2011-12 therefore the finding of the work revealed that thrips population had peak in *rabi* season compared to *kharif* season. Time of transplanting onion influences the intensity of thrips the results of this study are in agreement with Rahim (1988) [67]. Date of transplanting is one of the crop habitat diversifications that are to be looked in to minimize the incidence of thrips on onion crop so that its yield can be enhanced.

Spacing plant to plant and row to row effect on thrips

Malik *et al.*, (2003) [43] recommended 30 cm row to row and 20 cm plant to plant distance, most suitable thrips suppression and also produce a better yield. The increase in bulb weight with an increase in plant spacing. Increase plant spacing provided more space to the bulb for expression and reduce competition for nutrient and light Saud *et al.*, (2013) [75], affect food searching and laying behaviour of insect pests and reduced pest damage with an increased in plant spacing (Anyium 2002) [9]. Regarding thrips population they said two treatments got an optimum number of thrips per plant. Since the farmer are much interested in the outcome thus 30 cm row to row with 20 cm plant to plant distance is recommended for commercial farming of onion (Muhammad *et al.*, 2003) [48].

Effect of Intercropping on thrips

Intercropping has a wide range of benefits including suppression of weeds, improvement of soil fertility and conservation of natural predatory fauna and higher production. When the onion was intercropped with cotton, the thrips population moved towards cotton seedlings. Cotton seedlings are more susceptible to thrips attack. So cotton can be used as a trap crop in onion and when thrips populations reached a certain level, the trap crop should be sprayed with insecticides (Alston and Drost, 2008) [4]. Gachu *et al.*, (2012) [22] reported that carrot (*Daucus carota*), spider plant (Ceome gynandra) and French bean (Phaseolus vulgaris) effectiveness of intercropping with onion in the management of onion thrips. The similar trend was also found Hossain *et al.*, (2015) [25] and Abdul *et al.*, (2016) [6] reported that intercropping of carrot, tomato and French bean with onion effectiveness for the management of onion thrips.

Effect of fertilizers on thrips

Fertilizers i.e. nitrogen (N), phosphorous (P) and potassium (K) play an important role that promote growth and productivity of onion crop. Phosphorous is required for root growth and development of plant (Uchida, 2000) [78]. The recommendation is to apply 100-120 Kg of nitrogen per hectare, but there is a wide range in the amount of nitrogen added to the crop. Some growers apply nitrogen at planting and supplement with foliar applications during the season. However, recent work has shown that foliar-applied nitrogen will not improve bulb size or yield (Warncke 2008) [81]. Westerveld *et al.* (2002) [80] reported that onion yield did not differ between a conventional nitrogen treatment and one that received twice the amount of nitrogen. The Vegetative growth of onion plants and minerals uptake increased with increasing nutrients like P_2O5 and N that affect the infestation of *Thrips tabacai* (Malik *et al.*, 2009) [42] Bandi and Sivasubramanian, 2012) [10].

A positive correlation between onion thrips and nitrogen fertilizer has been observed. Cultural practices, e.g., crop fertilization can affect susceptibility of plants to insect pest by altering plant tissue nutrient levels (Altieri and Nicholls, 2003) [2]. However; they reported that excessive use of chemical fertilizers can cause nutrient imbalances and lower pest resistance. Recommended rate of N, P, and K, three times of the recommended rate of organic fertilizer, and control without fertilizer application were similar in relation to density of thrips (Goncalves and Sousa, 2004) [20]. Furthermore, six rates of N, low (50 kg N/ha) and optimum (150 kg N/ha) were applied to soil, but they did not affect on the abundance of *T. tabaci* on onions, although the density of thrips (7.6 thrips/plant) was decreased in 150kg N/ha (Malik *et al.*, 2009) [42]. They also reported that a total of 13 thrips/plant were observed with application of higher rate of N (200 and 250 kg/ha), which increased the population of thrips up to73.90%.However, it is confirmed by (Bandi and Sivasubramanian, 2012) [10] that agronomic and N-fertilizer factor affected the susceptibility of onion bulbs to onion thrips. Combination of NPK + FYM + bio-fertilizers + neem cake recorded the lowest incidence of *T. tabaci* on compared to the treatments receiving inorganic NPK alone. Patel and Patel (2012) [55] found that 100kg N/ha recorded significantly lowest thrips (9.23 thrips/plant) density compared to 50 kg N /ha (10.13 thrips /plant), but the infestation was minimum when the crop served with 50 kg N/ha on compared to 150 kg N/ha. Onion yield was also increased as a result of P_2O_5 compared to N and K fertilizer (Goncalves *et al.*, 2009) [21]. Similarly, Malik *et al.*, (2009) [42] reported that yield of onion was increased with 200 kg N/ha. Whereas, the highest bulb yield (19.50 t/ha) was recorded with a recommended doses of inorganic nutrients along with farm yard manure, bio-fertilizers, and neem cake (Bandi and Sivasubramanian, 2012) [10]. Patel and Patel (2012) [55] suggested that the yield of onion bulb was significantly highest (60.74 t /ha) with 150 Kg N/ha, and it was at par with treatment of 100 kg N/ha which yield 57.80 t /ha onion bulb as compared to 50 kg N/ha, However, Malik *et al.*, (2009) [42] suggested that a rapid decrease in the yield was obtained with 200-250 kg/ha, Pathak M.K. *et al.* (2018) [57, 64] reported that the lowest thrips population was recorded without application of Nitrogen fertilizer, that an excessive dose of nitrogen fertilizer may produce lush green plants, which will attract pest infestation, moreover higher dose of fertilizer also affect the crop maturity and heavy attack of sucking pests.

Irrigation management

Drought stress increases the susceptibility of onion to thrips damage. Adequate irrigation throughout the growing season is a critical factor in minimizing damage (Fournier *et al.*, 1995) [18].

Mulching

The thrips are colour sensitive that coloured mulches may be effective control for thrips, (Quarles 1990) [65] reported that whether aluminium- coated mulch would repeal the pest. Antignus (1996) [8] reported that the reflective mulch repelled 33 to 68% of thrips ultraviolet absorbing effective in protecting crop from western flower thrips. Ludger and Jean (2005) reported that mulching with wood shaving can be used as a strategy to improve onion yield and bulb size under the agro-ecological settings of the area of Mersan.

Mechanical method for control of thrips

The sticky trap helps to minimize the use of chemical insecticides for the control of onion thrips. The use of sticky trap for early monitoring of thrips could be an important component of IPM Maniani *et al.*, (2003) [41]. Liu and Chu (2004) [36] and Maimom *et al.*, (2017) [44] reported that the blue traps were more attractive for *Thrips tabaci* than the white traps. Atkan and Canhilal (2004) [1], suggested that yellow sticky traps were significantly attractive for the western flower thrips on cotton. The colour sticky trap can also be used for mass trapping and monitoring of insect in horticultural crop ecosystem (Shridhar V *et al.*, 2015) [68]. Malik *et al.*, (2012) [45] reported highest attraction of yellow colour trap followed by green trap in okra thrips. Mir (2019) [46] also reported that yellow colored sticky trap attracted more number of thrips over the crop growth period which was installed at 75 cm in height above the ground.

Biological control of thrips

Hoffmann *et al.*, (1996) [27] reported that many beneficial organism prey to harm onion thrips. Some of these include ladybird beetles, minute pirate bugs, ground beetle, lacewings, hover flies, predatory mites and spiders. Bateman *et al.*, (1993) [11] reported that entomopathogenic fungi are currently being investigated for the control of many important insect pests on various crops around the world, and some commercially available. Bio pesticides for used integrated pest management (IPM), as they combine host specificity with proven safety. Neil *et al.*, (2004) [53] reported *Beauveria* infection can kill the insect from 3to 7days, leaving a while mass of spores which can spread to other insects. Some authors observed that the effect of *Beauveria bassiana* against the onion thrips was significantly increased after 3 days whereas the effect of *Metarhizium* against the onion thrips was prolongated unlikely decreasing trend unsatisfactory control of the pest. *B. bassiana* was most effective when used early at the economic threshold level before large thrips populations have built up. The influence of temperature on the infection process is very important according to Shiberu *et al.*, (2013) [71] temperature at which *Metarhizium* infecting adult thrips is about 23 °C and decreases in temperature of 3 to 5 °C increase the time to death of the insect about a day. *Beauveria* is used as contact myco insecticides but survives a relative short period of time when exposed on leaf surface. The killing capacity of this fungus at 3rd, 5th, and 7th day was 46.18, 54.31 and 60.67%. Pandey *et al.*, (2014) [59] reported that *B. bassiana* @10^{13} spores /ha for effective of control onion thrips.

Botanical methods for control of onion thrtips

Pandey *et al.*, (2007) [58] develop an Integrated Pest Management package for thrips in onion at Nashik and Karnal. The pooled analysis of data revealed that two sprays of spinosad 45% SC @ 1 ml/L, neem oil @ 2 ml/L, Acetamiprid 10 WP @ 1 ml/L at fortnightly intervals proved effective in controlling thrips population giving higher yield at both the place. Abdul *et al.*, (2014) [7] reported that three botanical insecticides (Neem, Datura and bitter apple) 60% control of thrips population. Tadele and Mulugeta (2014) [76] reported that *Azadirachta indica* L. and *Dodon aeangustifolia* L.). Pandey *et al.*, (2013) [56] reported that Neem based formulations are seen less effective compared to chemicals for thrips management. Khosho *et al.*, (2017) [33] reported that the use of botanical especially, Neem can be used as front line management tool for controlling onion thrips at early stage.

Chemical control of thrips

Chemical are the most common practices for onion thrips management. Despite their ease of use and availability of numerous classes or modes of action, rapid development of resistance to insecticides has been a key problem. Patil and Patil (2018) [61] reported that fipronil was the most effective for control of onion thripa and recording highest yield, Pathak *et al.*, (2018) [57, 64] reported that lowest thrips population and highest seed yield was recorded with application of fipronil insecticides. Tirkey and Kumar (2017) [77] and Kurbett *et al.*, (2015) [28] reported that thiamethoxam was proved to be the most effective for thrips control. Asgar *et al.* (2018) [82] suggested that the insecticides reduced thrips population compared to control and highest yield was obtained by the use of Dimathoate. Kumar and Singh (2011) [29] and Das *et al.*, (2017) [15] reported that spry of Imidaclorprid given at 15 days interval recorded lowest thrips population and gave highest gross yield. Pandey *et al.*, (2013) [56] reported that lowest thrips population and highest bulb yield was obtained by applying fipronil. Pathak *et al.*, (2020) [62] reported that spray of spinosad @ 0.3 ml/L at 10 days interval effective for management of thrips in onion during *rabi* season. Pathak *et al.*, (2021) [63] suggested that spray of Fipronil @ 1.0 ml/L alongwith silica based surfactant @ 0.5 ml/L control the thrips population as well as increased the yield of onion bulbs and insecticides efficiency was increased by addition of silica based surfactant.

Conclusion

Thrips are major insect pest of onion crop, reduce the yield potential. Management of bulb crops pests relies on insecticide use at planting. But insecticide resistance can cause control failure that threaten the long-term viability of this strategy. IPM strategies minimize the loss and increase the marketable value of bulb crops. Thrips population was positively correlated with temperature and negatively with relative humidity and rainfall. Cultural practice such as intercropping with carrot, tomato spider plant, mixed cropping, time of planting, spacing, balance nitrogenous fertilizer dose, irrigation application, coloured sticky traps, bio-pesticides, *B. bassiana*, neem oil, basil oil, geranium oil, datura and neem products can also be used for effective control of thrips and some insecticides fipronil, thiamethoxam, dimathoate, imidachlorprid, spinosad, acetamiprid are can also be used for effective control of onion thrips. Keeping in view the above facts that the present research review was initiated to review the past research work was not solved the challenges. Still now the problem of this particular insect pest is existing. Therefore, it needs to focus on the future the management aspects of onion thrips is need attention to the researchers. It's important to develop resistant varieties, use of entomopathogenic fungi, mass rearing and release of natural enemies, use selective different classes of insecticides within a season to avoid resistance and use all available cultural practices. In addition to these it is necessary to develop alternative tactics that are practical to implement.

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