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RESEARCH ARTICLE

Integrated Pest and Disease Management (IPDM) Module for Major Insect Pest Thrips and Diseases of Onion (*Allium cepa var. aggregatum)*

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ABSTRACT

In the validation of IPDM module (Seed treatment with thiophanate methyl) @ 2.5 g kg^{-1} seed, soil application of *Bacillus subtilis* @ 1.25 kg ha^{-1} + *Trichoderma asperellum* @ 1.25 kg ha^{-1} + VAM fungi @ 12.5kg ha^{-1} + Azophos @ 4kg ha^{-1} + neem cake @ 250 kg ha^{-1} + blue sticky traps (20 traps per 0.4 ha at 30 cm height above the onion plant) + need based application of tebuconazole @ 1.5 mL l^{-1} for purple blotch disease management + need based application of (3.3% mefenoxam + 33.1% chlorothalonil SC 0.1 %) followed by 23.4% mandipropamid SC 0.1% for downy mildew management + fipronil 5% SC @ 1.0 mL l^{-1} for thrips) against thrips and major diseases of onion revealed significant reduction of purple blotch (10.7 PDI) downy mildew (6.1 PDI), twister blight (11.1 PDI) and thrips population (1.76 nos leaf $^{-1}$) as against 25.0, 24.2,11.3 and 4.6 respectively in control. In the farmer's practice, the disease, severity, and thrips population recorded were 16.9 PDI, 8.7 PDI, 16.6 PDI, and 3.28 nos leaf $^{-1}$, which emphasizes the effectiveness of the IPDM module. The reduction of the disease severity and thrips population over control in the IPDM module was 57.20%, 46.01%, 54.13 %, and 61.73 %, recording an economic return of 1:3.12. Hence, the validated IPDM module may be recommended to manage thrips, purple blotch, downy mildew and twister blight in onion to reduce the use of chemical pesticides.

Keywords: *IPDM, Twister blight, Purple blotch, Downy mildew, Thrips.*

INTRODUCTION

Onion, *Allium cepa var. aggregatum* (Alliaceae) is one of the most important commercial lucrative and high value vegetable-spice crops in India, cultivated in an area of 756,000 ha. Two main types of onions, bulb onion (*Allium cepa* var. cepa) and shallot or multiplier onion/small onion (*Allium cepa* var. *aggregatum*), are cultivated in India with the production and productivity of 12.16 million tonnes and 16.10 tonnes/ha, respectively (www.nhb.gov.in). Both types are inevitable ingredients in Indian cuisine in general and with special reference to south Indian preparations. Small onion is famous for its characteristics flavour and is widely used to increase the taste of foods like gravies, soups, stew stuffing, fried fish, and meat (Rashid *et al.,* 2016; Jegadeeswari *et al*., 2021).

The small onion is the common type of onion cultivated in Tamil Nadu in an area of 30,255 ha with a production of 286,000 tonnes and it is customarily propagated through bulbs. The average productivity of small onion in Tamil Nadu is 9.45 tonnes/ha (www.tn.gov.in). However, the crop is highly sensitive to several diseases *viz*., twister blight - *Colletotrichum gloeosporioides*, purple blotch *Alternaria porri* (Ellis) and powdery mildew - *Peronospora destructor* and the major insect pest recorded being thrips (Thrips *tabaci*) (McKenzie *et al*., 1993; Iglesias *et al*., 2021). The biotic stress caused by this insect pest and diseases reduces the production and productivity of onion in Tamil Nadu (Bharathi *et al*.,2017). Thrips is considered as a pest of national importance in India, causing an annual yield loss of 10-15 per cent in onions through direct feeding damage and indirectly

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through predisposing onion plants to purple blotch and transmitting viral diseases as well (McKenzie *et al*., 1993; Gupta *et al*., 1994;, Bharathi *et al*., 2017; Randhawa *et al*., 2022). Though chemical management would be the first and most effective and promising approach to be used for managing insect pests and diseases, the negative effects such as resistance, resurgence, and residue are the major concerns. Therefore, the development of novel management ways like IPDM to address the losses and to improve the onion production has been of great interest. Hence, this study was conducted with a holistic combination of strategies like seed treatment, basal application of bio-control agents and organic amendments, traps for sucking insect pest thrips, and need-based application of pesticides as a last resort.

MATERIAL AND METHODS

Validation of IPDM in Onion

A field experiment was laid out during 2020-21 in farmer's field at Anaipatti village (*9 °N lattitude and 77 °E longitude)* of Chinnamanur Block in Theni district, Tamil Nadu. The details of the treatments imposed were T_1- IPDM package (Seed treatment with thiophanate methyl @ 2.5 g kg^{-1} seed, soil application of *Bacillus subtilis* @ 1.25 kg ha^{-1} + *Trichoderma asperellum* @ 1.25 kg ha^{-1} + VAM fungi @ 12.5kg ha^{-1} + Azophos @ 4kg ha^{-1} + neem cake @ 250 kg ha^{-1} + blue sticky traps (20 traps per 0.4 ha at 30 cm height above the onion plant) + need based application of tebuconazole @ 1.5 mL l^{-1} for purple blotch disease management + need based application of (3.3% mefenoxam + 33.1% chlorothalonil SC 0.1 %) followed by 23.4% mandipropamid SC 0.1% for downy mildew management + fipronil 5% SC @ 1.0 mL l^{-1} for thrips. T_2 – Farmers practice (application of profenophos @ 4 mL l^{-1} of water from 30 days after sowing at 8 days interval for thrips and application of mancozeb 0.2 % or copper oxychloride 0.25 % or chlorothalonil 0.2 % for disease management). T_3 - Untreated control. The treatments were replicated seven times in a Randomized Block Design for the management of thrips and diseases.

Sampling and observations

Five micro plots of 20 square meters were chosen to record observations on purple blotch, twister blight, downy mildew and thrips incidence. In each micro plot, thrips population was counted from 10 randomly selected plants. Disease severity of purple blotch was assessed by selecting ten plants randomly from each plot and using a 0 - 5 scale (Ravichandran *et al*.,2017).

Grade scale used to assess purple blotch disease severity

Grade	Description
0	no disease symptoms
1	a few spots towards the tip, covering less than 10% leaf area
2	several dark purplish-brown patches covering less than 20% leaf area
3	several patches with paler outer zone, covering up to 40% leaf area
4	long streaks covering up to 75% leaf area or breaking of leaves/stems from the center
5	complete drying of the leaves/stems or breaking of the leaves/stems from the base

Similarly, twister blight disease severity was recorded based on 0 - 5 grade detailed below (Ramakrishnan et al., 2022) and PDI (percent disease index) was calculated.

Grade scale used to assess twister blight disease severity

Grade	Description
0	No Symptom
1	Upto 10% Curling and chlorosis of leaves
2	11 to 20% Abnormal elongation of leaves and neck
3	21 to 40% Leaf-sheath showing cluster of acervuli concentric rings
4	41 to 60% Elongated neck slender bulbs leaves show dieback symptoms
5	>60% Severe dieback, rotten bulbs, root system underdeveloped with discoloured roots

Downy mildew disease severity was recorded based on 1 - 9 grade (Abkhoo, 2012).

Grade scale used to assess downy mildew disease severity

Grade	Description
1	No symptoms
2	Only few leaves affected
3	Less than half of the plants affected
4	Most of the plants affected, attack is restricted to one leaf per plant
5	All plants affected, attack restricted to one or two leaves
6	Three to four leaves of each plant affected, crop looks fairly green
7	All leaves affected, crop gives blighted appearance
8	All leaves severely affected, greenness restricted to central shoot only
9	Foliage completely blighted

Per cent Disease Index (PDI) for all the three diseases was calculated by using the formula proposed by (Mckinney, 1923).

$$PDI = \frac{\text{Sum of all individual disease ratings X 100}}{\text{Total No. of plants observed X Maximum disease grade}}$$

The data was analyzed to find out the significant difference between the treatments by using OPSTAT (Sheoran *et al*., 1998). Yield data per plot was recorded and extrapolated to one ha for calculating the economic returns.

RESULTS AND DISCUSSION

In India, the purple blotch (*A. porri*) is a major devastating and widespread disease and causes severe yield reduction (Ahmed and Goyal, 1988). The disease attacks all the foliar parts. The leaves express circular to oval water soaked areas, which later on, became oblong with a fresh zone of discoloured tissue around the spots. Initially spots are white, but later produce pinkish or purple concentric rings. The older leaves are more susceptible than younger leaves and with increasing susceptible towards bulb maturity. Similar lesions formed on seed stalks, leading to girdling and destruction of the stalk, producing shriveled seeds. Results of the present study indicate that the adoption of IPDM module reduced the purple blotch severity to the tune of 10.7 PDI as against 16.9 PDI and 25.0 PDI in farmer's practice and control plot respectively. The reduction in the purple blotch severity over control 52.20 % might be due to the action of neem cake applied as basal. In line with these findings, purple blotch disease reduction was recorded in garlic by the application of neem cake rather than other organic amendments like goat manure, farm yard manure (FYM), and vermicompost (Prajapati *et al*., 2019). Akter *et al*., (2022) reported that reduction in purple blotch in garlic was due to the effect of *Trichoderma harzianum* from 45 to 60 DAS. Shubham *et al*., 2021 also documented that the application of T. viride found to be the most effective in inhibiting the percent disease intensity by upto 73.60% inhibition of purple blotch of garlic, followed by Neem oil. In the present study also, it was witnessed that the IPDM, comprising the *T. asperellum,* may be responsible for the reduction of disease severity.

Downy mildew caused by *P. destructor* is one of the most severe diseases of onions, if control measures are not taken at the right time especially under cool and humid weather. The disease initiates as slightly pale spots, becoming light brown or purplish in colour. Lesions expand to the successive leaves leading to drooping, until the only youngest ones remain (Abkhoo 2012). Plants are not killed immediately, but leads to development of immature, poor quality bulbs with sponginess. If the crop is raised for seed purposes, such lesions spread to the seed stems, weakening and breaking the stem, eventually leading to shriveling of seed. Under extended periods of high humidity, downy growth of the fungus becomes visible in the affected parts may lead to heavy economic loss to the farmer if effective management is not undertaken. Hence, the integrated approach with need based application of (3.3 % mefenoxam + 33.1 % chlorothalonil SC 0.1 %) followed by 23.4 % mandipropamid SC 0.1 % for downy mildew management (T_1) was designed. As expected the downy mildew severity was very less (6.1 PDI) in T_1 as against control (11.3 PDI) with the reduction over control was 46.01 % (Table 1).

The disease twister blight (*C. gloeosporioides*) is one of the most common problems in onion production which is currently an economic threat to the cultivation. Twister blight is initially visualized by white or pale-yellow water-soaked oval depressed lesions on leaf blades. Curling, chlorosis, abnormal elongation of leaves with cluster of acervuli in concentric rings on the leaf-sheath leading to die back, elongated neck, underdeveloped root system

with discoloured roots producing slender and rotten bulb are the other characteristic symptoms (Ramakrishan *et al*., 2022; Dutta *et al*., 2022). Owing to the serious nature of the disease, it requires combined mode of action by using biocontrol agents and need based application of fungicides which has been attempted in this study. The results of this trial indicate that the IPDM module combining *T. asperrellum*, neem cake, VAM and need based application of fungicide (T_1) is effective in reducing the twister blight severity to 54.13 % compared to the control. Manthesha et al., (2022) has reported that the application of carbendazim 12% + mancozeb 63% 75 WP at 2.5g l^{-1}, *Trichoderma* + *Pseudomonas* mixture at 10 g l^{-1} concentration and propiconazole 25 EC at 1 mL l^{-1} recorded less PDI of 16.59, 17.26 and 18.54 respectively.

Onion thrips *T. tabaci* L. is an important pest of onion causing 25-50% reduction in bulb yield (Muhammad *et al*., 2018). Both adults and larvae feed on young leaves in the inner necks of onion plants and feeding on leaves may aid in the development of purple blotch disease (Randhawa *et al*., 2022). Onion thrips are small insects and live in curled leaves, which lead to omitting them easily during monitoring. Hence, in the IPDM module blue sticky traps were included as mechanical component and found that the IPDM imposed plot recorded less thrips population (1.76 $leaf^{-1}$) as against 4.6 $leaf^{-1}$ in control plot. The reduction in thrips population over control in IPDM module-imposed plot was 61.73 % (Table 1). In addition, the thrips population caught in the blue sticky trap ranged from 5.32 to 8.52 $square\ inch^{-1}$ area of blue sticky trap from 7th day after installation (DAI) to 42nd DAI (Figure 1). Based on the trap catches, application of fipronil @ 1.0 mL l^{-1} was imposed to reduce the thrips population. Randhawa *et al*., (2022) recorded the reduction of thrips population 72.78% over control through the application of fipronil 80 WG @100 gm a.i ha^{-1}. Thrips can infest onion at all the phenological stages of crop growth but their population increases from bulb initiation and remain high till bulb development and maturity. Thrips is a regular and potential pest of onion and cause considerable losses as high as 90 % in quality and yield (Gupta *et al*., 1984, Devi and Roy, 2017). Blue sticky trap is highly useful for relative estimate of *T. tabaci* population and also for monitoring and mass trapping as a component of IPM programme.

With regard to yield, the highest yield of 12.82 t ha^{-1} was registered in IPDM module imposed plot against 9.71 t ha^{-1} in control. In farmers practice, yield of 11.03 t ha^{-1} was observed. All the treatments differed significantly from each other in terms of yield and the maximum benefit-cost ratio of 1:3.12 was recorded in IPDM module imposed plot (Table.1). Hence, adoption of IPDM packages in onion recorded lowest incidence of twister blight, purple blotch and downy mildew and highest yield and ultimately the economic return (1:3.12).

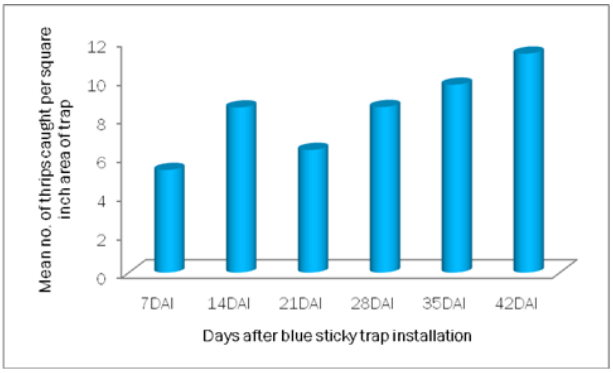

Figure 1. Thrips population caught in blue sticky trap installed in IPDM module plot

CONCLUSION

It could be inferred that the adaptation of IPDM module comprising of seed treatment, bio-control agent, organic amendments and blue sticky trap and need based application of fungicides would reduce the onion thrips population and disease severity of purple blotch, twister blight and downy mildew in onion. Hence, in onion growing area the IPDM module may be adopted to avoid **marketable** yield loss due to major insect pests and diseases. Moreover, the actuality is that the indiscriminate use of pesticides leads to the development of resistance and resurgence in insect **pests** and pathogens.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

This is entirely original work; any work or words of others have been appropriately cited.

Table 1. IPDM module for the management of thrips and major diseases of onion (var.Local)

Treatments	Per cent Disease Index (PDI)			(No of thrips leaf^{-1})	Per cent Reduction Over Control				Yield (t ha^{-1})	BC ratio
	Purple blotch	Downy mildew	Twister blight	Thrips	Purple blotch	Downy mildew	Twister blight	Thrips		
T_1- IPDM package	10.7 (19.11)	6.1 (14.28)	11.1 (19.46)	1.76 1.66)	57.20	46.01	54.13	61.73	12.82	3.12
T_2-Farmers practice	16.9 24.33)	8.7 (17.17)	16.6 (24.08)	3.28 (2.06)	32.40	23.00	31.40	28.69	11.03	2.43
T_3-Control	25.0 30.00)	11.3 (19.65)	24.2 (29.50)	4.6 (2.47)	-	-	-	-	9.71	1.91
SEd	0.64	0.38	0.82	0.057	-	-	-	-	0.64	-
CD (p=0.05)	1.40	0.83	1.7	0.126	-	-	-	-	1.22	-
CV (%)	4.92	4.2	7.3	5.181	-	-	-	-	12.94	-

Values are mean of seven replications. Figures in parenthesis are arcsine transformed values.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There was no conflict of interest in the publication of this content.

Data availability

All the data of this manuscript is included in the MS. No separate external data source is required.

Author contributions

Research fund – MAIN,HC&RI,TNAU, Periyakulam,

Idea conceptualization – PI, AV and RV. Experiment – PI and RV, Guidance - RV, Writing original draft – PI and AV, Writing reviewing & editing – RV.

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