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Developing economic threshold level for thrips (*Thrips tabaci* L.) in onion bulb crop

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ABSTRACT

Thrips (Thrips tabaci. L) are considered to be one of the major pests of onion. Seasonal abundance and effect on onion bulb yield were studied for onion thrips during two consecutive years (Rabi, 2019-20 and 2020-21) to develop economic thresholds (ET) at the Regional Research Station, Nashik (Maharashtra). On the basis of means of two years results revealed that, the economic injury level (EIL) of thrips in onion bulb crop was found to be 17.39 thrips/plant. The economic threshold level (ETL) of thrips in the onion bulb crop was worked out as 13 thrips/plant. Economic Thresholds were calculated with best yield infestation relationship which was found at 50 days after transplanting and control expenditure required for six insecticide sprays. The market price of onion was taken at Rs. 1152/= per quintal, which was an average of two years. Farmers are applying calendar-based application of different pesticides for management of insect pests.

Keywords: *Thrips tabaci. Thrips population. Gain Threshold, Economic Threshold Level. Economic Injury Level. yield infestation relation. Regression coefficient.*

Introduction

Onion (*Allium cepa* L.) is the most important commercial bulb crop grown all over the world and consumed in various forms. It is generally used fresh, spices, as important elements of the Mediterranean diet and as medicines (*Mishra et al*., 2014)[6]. The onion thrips, *T. tabaci* feeds directly on leaves, causing silver blotches and premature senescence as well as distorted and undersized bulbs that reduce yield by 30-50% (*Diaz et al*., 2011[2]; *Shiberu and Mohammed*, *2014*[11]; *Nault et al*., *2012*)[8] and is considered as a limiting factor for the bulb yield as well as reducing its quality (*Jenser and Szenasi, 2004*[4]*; Eltez and Karasavuran, 2006*[3]*; Mahmoud, 2008*)[5].

The knowledge of the economic threshold level (ETL) helps to determine whether an insect is to be classified as a pest or not. ETL is the pest density at which control measures should be applied to prevent an increasing pest population from reaching the economic injury level (EIL). Control measures are taken at this stage so that this pest does not exceed the economic injury level. The ideas expressed by *Pierce (1934)* [10] with regard to the assessment of insect damage and the initiation of control measures became one incentive for the development of a concept of economic injury level. In the later years, *Stern et al. (1959)* [12] who formally proposed the concept of economic threshold levels as the number of insects (density or intensity) when management action should be taken to prevent the increasing pest population from reaching economic injury level. The action threshold is one of the most important decision-making elements in integrated pest management (*Nault and Shelton, 2010*) [7].

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So, many authors tend to determine the damage threshold level and concluded that the levels were varied as the host plant and host growth stage (*Bird et al., 2004*) [1]. The application of insecticides at an economic threshold not only reduces the thrips infestation but also increases the bulb yield and quality of onion (*Tripathy et al., 2014*) [14]. So, this study aimed to assess of economic threshold and injury levels of onion thrips on onion plants.

Materials and Methods

The field experiment was conducted at Regional Research Station, Nashik during *rabi*, 2019-20 and 2020-21 seasons. Seedlings of onion variety NHRDF Red-4 were transplanted in a bed having the size of 3.0m x 1.2m at 15cm x 10cm spacing. The treatment was replicated three times and arranged in a completely randomized block design. Seven treatments for thrips number (nymphs/plant) were maintained by spraying the insecticide fipronil 5% SC @ 1.0 ml/L. In the first treatment spray of fipronil @ 1.0 ml/L was given when more than 5 thrips (nymphs/plant) appeared. In the second treatment spray of fipronil @ 1.0 ml/L was given when more than 10 thrips (nymphs/plant) appeared. In the third treatment spray of fipronil @ 1.0 ml/L was given when more than 15 thrips (nymphs/plant) appeared. In the fourth treatment spray of fipronil @ 1.0 ml/L was given when more than 20 thrips (nymphs/plant) appeared. In the fifth treatment spray of fipronil @ 1.0 ml/L was given when more than 25 thrips (nymphs/plant) appeared. In the sixth treatment spray of fipronil @ 1.0 ml/L was given when more than 35 thrips (nymphs/plant) appeared. In the seventh treatment, no sprays were given and it was treated as a control plot. A total of 6 sprays were given to maintain a thrips population below 5 thrips (nymphs/plant) in the first treatment, 5 sprays were given to maintain thrips population below 10 and 15 thrips (nymphs/plant) in second and third treatment, 4 sprays were given to maintain thrips population below 20 and 25 thrips

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(nymphs/plant) in fourth and fifth treatments, 3 sprays were given to maintain thrips population below 35 thrips (nymphs/plant) in sixth treatment and no spray was given in control for comparing the loss of bulb yield in different treatments. The data on thrips (nymph/plant) number (using hand lens 10X) were counted at the inner-most leaves in 10 plants marked randomly in each treatment before each spray at 10-day intervals. All other agronomical practices were performed as needed in all the treatments. The crop was harvested after attaining the maturity. The data from two consecutive years were pooled, analyzed statistically, and presented in Tables- 1, 2, and 3.

The yield infestation relation and regression coefficients were computed to clear the significance of the relationship between the mean number of onion thrips and the obtained mean bulb yield. The treatment cost of the number of insecticide sprays and the market price of the onion bulb were considered for calculating the gain threshold (GT). Economic injury level (EIL) was computed by dividing the gain threshold from the regression coefficient. The economic injury level of onion thrips was determined by *Stone and Pedigo (1972)* [13], while the economic threshold level as per *Pedigo (1991)* [9]. The mathematical procedures and steps for calculating economic injury level are given below:

$$\text{Gain threshold (Kg/ha)} = \frac{\text{Cost of treatment (Rs. /ha)}}{\text{Market price (Rs. /q)}}$$

Regression equation between thrips population (x) and bulb yield (y) of onion (kg/ha) (y) **:** y = (a±bx)

a = pure constant

b = regression coefficient

$$\text{Calculated EIL} = \frac{\text{Gain threshold (kg/ha)}}{\text{Regression coefficient (b)}}$$

Actual EIL = EIL (Cal.) + UTI

Whereas, UAI = Unavoidable thrips intensity (thrips/plant)

Results and Discussion

***Rabi,* 2019-20:**

Data presented in Table-1 and figure-1 revealed that before 1st spray (30 DAT), data did not differ significantly, however significantly lowest average mean thrips number (4.87 nymphs/plant) were recorded in T_1 (when more than 5 nymphs/plant appeared spray of fipronil @ 1.0 ml/L) due to minimum exposure period having 3 number of sprays. The thrips number under the minimum exposure period is considered as the unavoidable thrips number. The thrips number increased with the increase in exposure to thrips and significantly higher average mean thrips number (46.53 nymphs/plant) was observed when crop was under maximum exposure period having no insecticide spray. The data further revealed that bulb yield decreased with increase in thrips number. Significantly highest marketable yield (340.12 q/ha) was obtained in first treatment having minimum exposure period and maximum number of sprays.

Yield Infestation Relaion:

At 30 DAT, yield infestation relation was non-significant, however at 40, 50, 60, 70 & 80 DAT, yield infestation relation was significant.

At 40 Days (y_{40}) = 363.5 – 3.469 X (R^2 = 0.50)

At 50 Days (y_{50}) = 322.8 – 1.855 X (R^2 = 0.82)

At 60 Days (y_{60}) = 306.0 – 1.418 X (R^2 = 0.51)

At 70 Days (y_{70}) = 320.0 – 1.362 X (R^2 = 0.59)

At 80 Days (y_{80}) = 312.1 – 1.053 X (R^2 = 0.77)

The best relationship was found at 50 DAT followed by 80 DAT.

Y = Spray days after transplanting

R^2 = Regression coefficient

DAT = Days after transplanting

Gain Threshold:

Yield obtained with 3 sprays was significantly more than that with two sprays at various stages. It means that 3 sprays were essential for protecting onion from thrips. Therefore, EIL was calculated with best yield infestation relationship which was found at 50 DAT and control expenditure required for three sprays. Market price of onion was taken Rs 950/= per quintal.

Gain Threshold (kg/ha) = Control Expenditure (Rs. /ha) / Market price (Rs. /q)

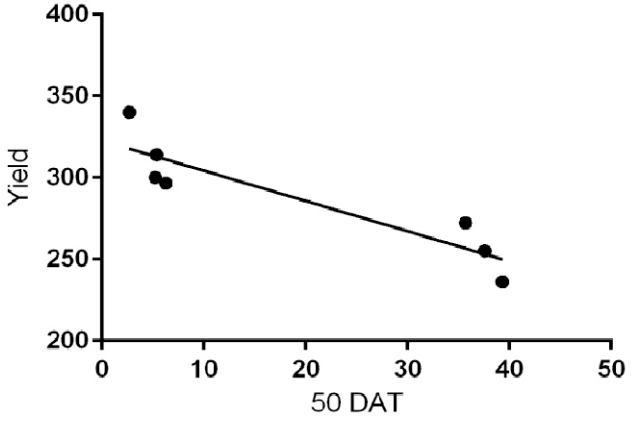
= 11700/950 = 12.31

Economic injury level (EIL) (calculated) = Gain Threshold (GT)/Regression coefficient (B)

= 12.31/1.83 = 6.72 Nymphs/plant

Actual EIL = Calculated EIL + Unavoidable thrips population= 6.72 + 4.87 = 11.59 nymphs/plant

So EIL was found to be 8.69 thrips/plant. ETL was work out = 9 thrips/plant (75% of EIL).



R^2 = 0.82; F = 24.15; df = 1; 5; P > 0.01; n = 7

Deviation from horizontal = Significant

Equation Y = -1.855*X + 322.8

Figure: 1: Relationship between thrips population and marketable yield of onion bulb during rabi, 2019-20

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Table-1 Developing Economic Threshold Level for onion thrips during rabi, 2019-20

Treatments	Thrips population (Nymphs/plant)							Marketable yield (q/ha)
	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	Average mean thrips number	
T_1	8.57	5.33	2.70	1.63	8.77	2.20	4.87	340.12
T_2	7.63	22.60	5.40	4.70	12.77	1.47	9.09	314.15
T_3	9.53	24.63	5.27	5.87	15.60	4.30	10.87	300.15
T_4	8.93	24.97	6.30	8.73	20.23	8.90	13.01	296.56
T_5	8.60	24.27	35.67	7.97	18.63	25.63	20.13	272.19
T_6	7.73	25.67	37.57	7.53	21.00	35.17	22.44	255.13
T_7	9.13	25.23	39.33	53.27	68.37	83.83	46.53	236.27
S.Em±	**1.63**	**0.99**	**1.42**	**1.00**	**2.07**	**1.53**	**0.54**	**7.52**
CD at 5%	**NS**	**2.16**	**3.09**	**2.18**	**4.51**	**3.33**	**1.18**	**16.38**
CV %	**23.28**	**5.55**	**9.22**	**9.60**	**10.75**	**8.15**	**3.62**	**3.20**

***Rabi,* 2020-21:**

Data presented in Table-2 and figure-2 revealed that before 1st spray (at 30 DAT), data did not differ significantly, however significantly lowest average mean thrips number (3.59 nymphs/plant) were recorded in T_1 (when more than 5 nymphs/plant appeared spray of fipronil @ 1.0 ml/L) due to minimum exposure period having 6 number of sprays. The thrips number under the minimum exposure period is considered as the unavoidable thrips number. The thrips number increased with the increase in exposure to thrips and significantly higher average mean thrips number (42.28 nymphs/plant) was observed when crop was under maximum exposure period having no insecticide spray. The data further revealed that bulb yield decreased with increase in thrips number. Significantly highest marketable yield (362.78 q/ha) was obtained in T_1 having minimum exposure period and maximum sprays.

Yield Infestation Relaion:

At 30 DAT, 40 DAT and 80 DAT, yield infestation relation was non-significant, however at 50, 60 & 70 DAT, yield infestation relation was significant.

At 50 Days (y_{50}) = 347.4 – 1.510 X (R^2 = 0.77)

At 60 Days (y_{60}) = 358.4 – 1.763 X (R^2 = 0.83)

At 70 Days (y_{70}) = 344.2 – 0.663 X (R^2 = 0.70)

The best relationship was found at 60 DAT followed by 50 DAT.

Y= Spray days after transplanting

R^2= Regression coefficient

Gain Threshold:

Yield obtained with 6 sprays was significantly more than that with other sprays at various stages. It means that 6 sprays were essential for protecting onion from thrips.

Therefore, EIL was calculated with best yield infestation relationship which was found at 60 DAT and control expenditure required for 6 sprays. Market price of onion was taken Rs 1547/= per quintal.

Gain Threshold (kg/ha) = Control Expenditure (Rs. /ha) / Market price (Rs. /q)

= 12744/1547 = 8.23

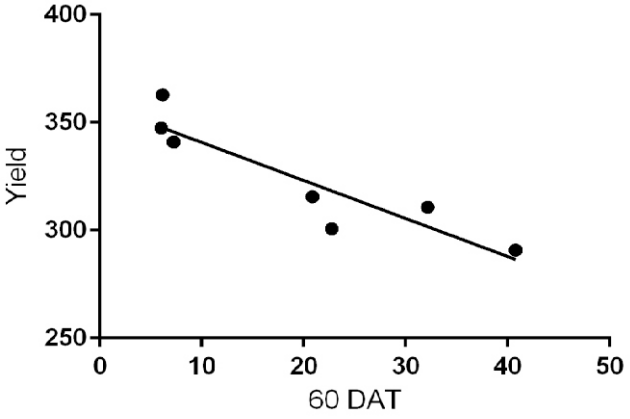
Economic injury level (EIL) (Calculated) = Gain Threshold (GT) / Regression coefficient (B)

= 8.23/0.83 = 9.91 Nymphs/plant

Actual EIL = Calculated EIL + Unavoidable thrips population

= 9.91 + 3.59 = 13.5 nymphs/plant

So, EIL was found to be 13.5 thrips/plant. ETL was work out = 10 thrips/plant (75% of EIL).



R^2= 0.83; F = 25.12; df = 1; 5; P > 0.01; n = 7

Deviation from horizontal = Significant

Equation Y = -1.763*X + 358.4

Figure: 2. Relationship between thrips population and marketable yield of onion bulb during rabi, 2020-21

Table-2 Developing Economic Threshold Level for onion thrips during rabi, 2020-21

Treatments	Thrips population (Nymphs/plant)						Average Mean thrips number	Marketable Yield (q/ha)
	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT		
T_1	5.00	0.63	1.57	6.17	1.77	6.40	3.59	362.78
T_2	4.47	16.90	2.87	6.03	5.33	11.90	7.92	347.40
T_3	4.83	17.53	3.93	7.27	5.47	11.93	8.49	340.92
T_4	4.60	19.47	5.53	20.87	4.07	17.27	11.97	315.55
T_5	5.33	18.87	26.87	22.77	52.87	4.90	21.93	300.65
T_6	4.40	19.03	27.67	32.17	61.10	4.87	24.87	310.74
T_7	5.57	19.53	39.37	40.80	81.50	66.93	42.28	290.83
S.Em±	**0.64**	**0.58**	**0.73**	**2.07**	**4.88**	**1.50**	**0.84**	**7.69**
CD at 5%	**NS**	**1.26**	**1.59**	**4.51**	**10.63**	**3.27**	**1.83**	**16.76**
CV %	**16.14**	**4.42**	**5.84**	**13.07**	**19.72**	**10.35**	**5.95**	**2.91**

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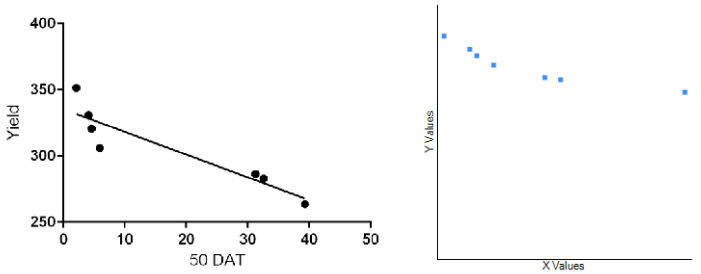
Combined results (*rabi*, 2019-20 and 2020-21):
Data presented in Table-3 and figure-3 revealed that the significantly lowest average mean thrips number (4.23 nymphs/plant) was recorded in T_1 (when more than 5 nymphs/plant appeared spray of fipronil @ 1.0 ml/L) due to minimum exposure period having 6 number of sprays. The thrips number under the minimum exposure period is considered as the unavoidable thrips number. The thrips number increased with the increase in exposure to thrips and a significantly higher average mean thrips number (44.40 nymphs/plant) was observed when crop was under maximum exposure period having no insecticide spray. The data further revealed that bulb yield decreased with increase in thrips number. Significantly highest marketable yield (351.45 q/ha) was obtained in T_1 having minimum exposure period and maximum sprays.

Yield infestation relation: (Combined *rabi*, 2019-20 and 2020-21)
At 30 DAT and 40 DAT, yield infestation relation was non-significant, however at 50, 60, 70 & 80 DAT, yield infestation relation was significant.
At 50 Days (y_{50}) = 335.4 – 1.717 X (R^2 = 0.84)
At 60 Days (y_{60}) = 334.4 – 1.766 X (R^2 = 0.73)
At 70 Days (y_{70}) = 335.3 – 1.090 X (R^2 = 0.81)
At 80 Days (y_{80}) = 325.1 – 0.939 X (R^2 = 0.58)
The best relationship was found at 50 DAT followed by 70 DAT.
Y= Spray days after transplanting
R^2= Regression coefficient

Gain threshold: -
Yield obtained with 6 sprays was significantly more than that with other sprays at various stages. It means that 6 sprays were essential for protecting onion from thrips. Therefore, EIL was calculated with the best yield infestation relationship which was found at 50 DAT, and control expenditure required for 6 sprays. The market price of onion was taken Rs 1152/= per quintal, which was an average of two years.
Gain Threshold (kg/ha) = Control Expenditure (Rs. /ha) / Market price (Rs. /q)
= 12744/1152 = 11.06
Economic injury level (EIL) (Calculated) = Gain Threshold (GT) / Regression coefficient (B)
= 11.06/0.84 = 13.16 Nymphs/plant
Actual EIL = calculated EIL + Unavoidable thrips population
= 13.16 + 4.23 = 17.39 nymphs/plant
So EIL was found to be 17.39 thrips/plant. ETL was worked out = 13 thrips/plant (75% of EIL).

Economic Injury Level of onion thrips (EIL):
Highly significant negative relationship (r = -0.91) existed between the thrips population and bulb yield. The gain threshold (GT) value is calculated as (11.06 kg/ha). The linear regression equation is formed as y = -1.717*X 335.4 and economic injury level (EIL) was calculated to be 13.16 thrips/plant, but there were 4.23 thrips per plant as unavoidable thrips number during the experiment period. So, the actual EIL will be sum of the calculated EIL and unavoidable thrips number which is 17.39 thrips/plant.

Economic Threshold Level of onion thrips (ETL):
Economic threshold level (ETL) indicates the pest population density at which control measures should be initiated to check the further increase of pest population reaching the EIL. According to the *Pedigo* (1991) the ETL is set as 75% of EIL. Accordingly, in the present study, economic threshold values are determined from economic injury level as 13 thrips (nymphs)/plant. These results are in harmony with those of *Bird et al.* (2004) who concluded that the economic threshold level of *T. tabaci* was ranged from 4–10 and 10–15 nymphs/plant is recommended for onion plant stages of 2–6 leaves and 6 leaves to maturity, respectively. Also, *Mishra et al.* (2014) found that the threshold of *T. tabaci* was 3 nymphs/green leaves.



R^2 = 0.84; F = 27.46; df = 1; 5; P > 0.01; n = 7 Correlation coefficient (R) = -0.91
Deviation from horizontal = Significant
Equation Y = -1.717*X + 335.4

Figure: 3. Relationship between thrips population and marketable yield of onion bulb (Combined rabi, 2019-20 & 2020-21)

Table 3: Developing Economic Threshold Level for onion thrips (combined rabi, 2019-20 & 2020-21)

Treatments	Thrips population (Nymphs/plant)						Average Mean thrips number	Marketable yield (q/ha)
	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT		
T1	6.78	2.98	2.13	3.90	5.27	4.30	4.23	351.45
T2	6.05	19.75	4.13	5.37	9.05	6.68	8.51	330.78
T3	7.18	21.08	4.60	6.57	10.53	8.12	9.68	320.54
T4	6.77	22.22	5.92	14.80	12.15	13.08	12.49	306.06
T5	6.97	21.57	31.27	15.37	35.75	15.27	21.03	286.42
T6	6.07	22.35	32.62	19.85	41.05	20.02	23.66	282.94
T7	7.35	22.38	39.35	47.03	74.93	75.38	44.40	263.55
S.Em±	**0.88**	**0.57**	**0.80**	**1.15**	**2.65**	**1.07**	**0.50**	**5.38**
CD at 5%	**1.81**	**1.18**	**1.65**	**2.38**	**5.47**	**2.21**	**1.03**	**11.10**

Table 4: Economic Threshold Level based on bulb yield and thrips population in Onion (Combined rabi, 2019-20 and 2020-21)

Gain threshold (Kg/ha)	Regression coefficient (b)	Correlation coefficient (r)	Unavoidable thrips population (nymphs/plant)	EIL		ETL
				Calculated	Actual	
11.06	0.84	-0.91	4.23	13.16	17.39	13

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Table: 5. Economic analysis of thrips management in onion bulb crop and benefit cost ratio. (Combined rabi, 2019-20 and 2020-21)

Treatments	No. of sprays	Mean yield of onion bulb (q/ha)	Yield increases over control		Cost of plant protection (₹/ha)			Net return (₹/ha)	B:C ratio
			(q/ha)	(₹/ha)	Cost of insecticide	Spraying and wedges	Total cost of protection		
T_1	6	351.45	87.90	101260.80	3444.00	9300.00	12744.00	88516.80	6.94:1
T_2	5	330.78	67.23	77448.96	2870.00	7750.00	10620.00	66828.96	6.29:1
T_3	5	320.54	56.99	65652.48	2870.00	7750.00	10620.00	55032.48	5.18:1
T_4	4	306.06	42.51	48971.52	2296.00	6200.00	8496.00	40475.52	4.76:1
T_5	4	286.42	22.87	26346.24	2296.00	6200.00	8496.00	17850.24	2.10:1
T_6	3	282.94	19.39	22337.28	1722.00	4650.00	6372.00	15965.28	2.50:1
T_7	0	263.55	-	-	-	-	-	-	-

Cost of labour @ ₹310/labour/day, cost of fipronil @ ₹1148/L. (0.5 L. fipronil/ha/spray) and average model price of onion bulb @ ₹1152/Q (average model rate of two year)

This research shows that the use of an ETL as a decision tool for timing insecticide applications is better than the most common current practice of calendar applications. For onions grown under favourable climatic conditions, thrips population under 13 nymphs/plant do not affect yield in Nashik district of Maharashtra (India).

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Conflicts of Interests: This research paper is for honestly reporting research results and useful for farmers, students and researchers of onion crop.

Future Scope of Study: More studies on new formulations of insecticides on controlling thrips should be done.

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