



Effect of Fipronil + Isoprothiolane against Onion Thrips and Purple Blotch Disease and Its Effect on Parasites and Predators

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Authors' contributions

This work was carried out in collaboration among all authors. Author MRR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TG and GRR managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Onion (*Allium cepa* L.) is one of the important vegetable cum condiment crop grown throughout the world. Onion crop is infested by various insect pests and diseases right from seedling to harvesting stage. The experiment was conducted in farmer's fields of Ranebennur (Haveri-District) to evaluate the bio-efficacy and Phytotoxicity of Fipronil + Isoprothiolane against Thrips and Purple Blotch disease in onion and its effect on parasites and predators during *khari*-2018 and *rabi*-2019 seasons. Amongst the treatments, the formulation Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha was excellent in controlling thrips (2.47/trifoliate leaf) and showed the least severity of purple blotch (3.02% PDI) followed by Fipronil 5% + Isoprothiolane 28% EC@ 1250 ml/ha (2.85 and 3.25)1000 ml/ha (2.99 and 3.67 % PDI) respectively. The results revealed that amongst the

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treatments, Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml recorded the highest bulb yield (21.52 t/ha) which was on par with the 1250 and 1000 ml/ha. The formulation Fipronil 5% + Isoprothiolane 28% EC @ 1000 ml/ha was found to be cost effective followed by treatment of Fipronil 5% + Isoprothiolane 28% EC @ 1250ml /ha for control of thrips and prevention of Purple Blotch disease hence which is recommended for control of thrips and Purple Blotch disease in onion.

Keywords: Fungicides; onion; purple blotch; thrips; predators.

1. INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetables grown in India and the world. It belongs to the family Amaryllidaceae (Alliaceae). India is the second largest onion producing country in the world, next to china. India contributes 12 per cent of onion produced in the world with a production of 215 lakh tones in an area of 13 lakh ha. Major onion producing states in India are Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Rajasthan, Tamil Nadu and Haryana. In Karnataka, onion occupies an area of 2 lakh ha with a production of 28 lakh tones (productivity of 14 tonnes /ha). The major districts in Karnataka are Dharwad, Chitradurga, Vijayapur, Bellary, Haveri and Gulbarga. Onion crop is subjected to attack by various insect pests and diseases right from seedling to harvesting stage which reduces yield and quality of bulbs [1]. The important ones are onion thrips (*Thrips tabaci* Lindeman) and purple blotch (*Alternaria porri*).

Onion thrips are recorded mainly in cabbage, cotton, carnation, garlic, and wheat. Both nymphs and adults are damaging stages which feed on leaves and other tender tissues of plants and suck the sap, as a result, it causes silver patches and streaks on leaves. Besides direct damage to foliage, it can indirectly aggravate the incidence of purple blotch. It is also a vector for "Iris Yellow Spot Virus", tospovirus causing adverse effect on bulb and seed yield of onion crop in India. Use of insecticides is one of the most common practices for control of thrips in onion crop.

The purple blotch (*A. porri*) destructs the leaf tissue which destroys the stimulus for bulb initiation and delays bulbing and maturation. Severe attack on flowering alliums can completely girdle flower stalks with necrotic tissues causing their collapse and total loss of

seed production capacity. Further, seed infection causes more severe economic loss in seed production.

Chemicals need to be used wisely in control or management of onion thrips and purple blotch with due consideration of cost economics and environmental safety. With this background the experiment was conducted to evaluate the efficacy and phytotoxicity of chemicals against thrips and purple blotch disease in onion.

2. MATERIALS AND METHODS

The experiment was conducted in farmer's field of Ranebennur taluk in Haveri district to evaluate the bio-efficacy and Phytotoxicity of Fipronil 5% + Isoprothiolane 28% EC against Thrips and Purple Blotch disease in onion and its effect on parasites and predators during *khariif*-2018 and *rabi*-2019 seasons. The experimental plot was laid out with Randomized Block Design (RBD) involving eight treatments replicated thrice. The Onion variety used was Nasik Red. Recommended doses of major fertilizers (nitrogen, phosphorus and potassium) were applied in the field along with well rotten FYM (Before sowing) with a spacing of 15 x 10 cm. The plot size for each treatment was 25 m², weed management and other agronomic practices were followed properly in the experimental plots to ensure the uniformity of treatments. In first season (*khariif*-2018), the onion was transplanted during third week of July 2018 and in the second season (*rabi*-2019) during first week of September 2019. The treatments were imposed to respective plots with defined dosages at 50-60 days after transplanting depending on the pest and disease occurrence. Knap sack sprayer fitted with flood jet nozzle was used for spraying and applied to all vegetative parts of onion crop at 10 -15 days intervals. Chemicals were sprayed twice during the crop growth period.

2.1 Treatment Details

Treatments	Doses (ml/g)/ha
T ₁ Fipronil 5% + Isoprothiolane 28%EC	750 ml/ha
T ₂ Fipronil 5% + Isoprothiolane 28%EC	1000 ml/ha
T ₃ Fipronil 5% + Isoprothiolane 28%EC	1250 ml/ha
T ₄ Fipronil 5% + Isoprothiolane 28%EC	1500 ml/ha
T ₅ Fipronil 80% WG @ 75 g/ha	75 g/ha
T ₆ Tebuconazole 25.9% EC	750 ml/ha
T ₇ Untreated Control	-

The observations on population of thrips before and after spraying of chemical was recorded. Per cent reduction in thrips population and Disease index (PDI), Phytotoxicity, population density of natural enemies and Bulb yield (q/ha). The Cost Benefit Ratio was worked out by taking in to account the existing costs.

The data on target pests was recorded from five plants which were selected randomly in each treatment and replication. An observation on total thrips population was recorded from five top young leaves from each plant per plot. But, in case of Purple blotch Per cent Disease index (PDI) was recorded.

Grading of disease was done on 0-5 scale and disease intensity was calculated by following formula [2].

2.3 Phyto-toxicity Grades

Percentage of damage	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Grade	1	2	3	4	5	6	7	8	9	10

2.4 Observations on Natural Enemies

To see the impact of toxicity of test insecticide at different doses on naturally occurring predator and parasites in Onion ecosystem, the observations on numbers of natural enemies were recorded on 5 randomly selected plants in each replication in different treatments at 3, 7 and 10 days after each spray. All the treatments recorded non significant effect on predators and parasites.

3. RESULTS AND DISCUSSION

The results of the experiment are presented here under different headings and are discussed as below.

3.1 Efficacy of Fipronil 5% + Isoprothiolane 28% EC against thrips

Thrips are the most common important insect pests of onion causing widespread damage, wherever onions are grown in Karnataka. The results of trial conducted at farmer's field of Ranebennur taluk in Haveri district were evaluated on the basis of comparative study of formulation at different days interval of 5, 10 and 15 days of First and Second spray, followed by calculating mean population and % reduction over control (% ROC) of thrips. The values and figures in parenthesis were further transformed into Square Root Analysis before statistical analysis.

Disease intensity = (Sum of all numerical ratings / Total no. of leaves graded X Maximum grade) X 100

The data is subjected to analysis after making necessary transformation and expressed as Per cent Disease Intensity. The Onion yield (t/ha) from each plot was recorded and analyzed statistically. Based on these observations, mean insect population was worked out and statistically analyzed after transforming them. The per cent reduction in insect population over untreated control was worked out treatment-wise using the formula [3].

2.2 Observations on Phyto-toxicity

The phytotoxicity test was carried out with test chemical Fipronil 5% + Isoprothiolane 28% EC at different doses such as 1000, 2000 and 4000 ml/ha & along with control. For Purple blotch, the crop was observed after 1st and 2nd spray for Percent Disease Incidence. Observations on phytotoxicity (wilting, necrosis, vein clearing, epinasty and hyponasty.) were counted on every alternate day starting from 1st day till 15th day after spraying of chemical and were converted into percentage. Phyto-toxicity was assessed using a scale of different degree on plant growth effect. When there was no phyto-toxicity effect on plant, it was recorded as zero grade.

Season-1 (Kharif-2018): The test chemical Fipronil 5% + Isoprothiolane 28% EC was evaluated at four doses ie.750, 1000, 1250 and 1500 ml/ha with standard pesticides against thrips.

After second spray, the formulation Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha was excellent in controlling the pest population (2.47) followed by Fipronil 5% + Isoprothiolane 28% EC @ 1250 and 1000 ml/ha (2.85 and 2.99/trifoliolate leaf) respectively. The control recorded the maximum thrips population (17.82/trifoliolate leaves). The highest per cent reduction in thrips population was recorded in T4, the combination at 1500 ml (86.13) followed by treatments T3 the combination at 1250 ml (84.00) & T2 the combination at 1000 ml (83.22) (Table 1). The present findings are in line [4] who reported that lowest mean of thrips population was recorded in onion.

Season-2 (Rabi 2019) : After second spray, the formulation Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha was excellent in controlling the pest population (3.51) followed by Fipronil 5% + Isoprothiolane 28% EC@ 1250 and 1000 ml/ha (4.02 and 4.57/trifoliolate leaf) respectively (Table 2). The control recorded the maximum thrips population (22.47/trifoliolate leaves). The highest per cent reduction in thrips population was recorded in T4 (84.37) followed by treatments T3 (2.09) & T2 (79.66). Similar results were also obtained in management of rose thrips [5]. The chemical Fipronil 5% + Isoprothiolane 28% EC is a new molecule having combination of insecticide and fungicide helped in contro of thrips infestation to greater extent.

3.2 Efficacy of Fipronil 5% + Isoprothiolane 28% EC against Purple Blotch

Purple blotch is fairly common foliar disease of onion causing widespread damage. The results of trial conducted in farmer's field were evaluated for Percent Disease Index (PDI) before and after first and second spray. The Mean and % Reduction over control (% ROC) were also calculated.

Season 1 (Kharif-2018): The test chemical Fipronil 5% + Isoprothiolane 28% EC was evaluated at four doses ie.750, 1000, 1250 and 1500 ml/ha with standard pesticides against purple blotch disease incidence.

After second spray, the formulation Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha was excellent in controlling the purple blotch disease incidence (3.02) followed by Fipronil 5% + Isoprothiolane 28% EC@ 1250 and 1000 ml/ha (3.25 and 3.67(PDI) respectively. The control recorded maximum disease incidence of 18.59 (PDI). The highest per cent disease reduction was recorded in T4 (83.75) followed by treatments T3 (82.51) & T2 (80.25) (Table 3). Similar results are also obtained in onion [6].

Season-2 (rabi 2019): After second spray, the formulation Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha was excellent in controlling the purple blotch disease incidence (4.39) followed by Fipronil 5% + Isoprothiolane 28% EC@ 1250 and 1000 ml/ha (4.96 and 5.25 (PDI) respectively (Table 4). The control recorded maximum disease incidence of 28.98 (PDI). The highest per cent disease reduction was recorded in T4 (84.85) followed by treatments T3 (82.88) & T2 (81.88) [1]. As Fipronil 5% + Isoprothiolane 28% EC is a combi product it does take care of purple blotch of onion to the maximum extent.The similar results are also obtained in onion [7].

3.3 Effect of Fipronil 5% + Isoprothiolane 28% EC against Natural Enemies (Predators and Parasites)

Different coleopteran predators' viz.; *Coccinella* spp. and *Spider* were found to be prevalent in onion eco-system. Attempts were also made to observe the relative toxicity of Fipronil 5% + Isoprothiolane 28% EC against these natural enemies (Table 5 and Table 6). The results showed that, Fipronil 5% + Isoprothiolane 28% EC at all the dosages were absolutely having no effect on naturally occurring predators and parasites. It may be due to the development of resistance to thrips as reported by [8].

3.4 Effect of Fipronil 5% + Isoprothiolane 28% EC on Onion Crop (Phyto toxicity)

No phytotoxic symptoms were observed in any of the treated plots with respect to Fipronil 5% + Isoprothiolane 28% EC @ 1000, 2000 and 4000 ml/ha during both the seasons [9] (Tables 7 & 8).

3.5 Yield Parameters

The *Kharif* -2018 crop was harvested during the last week of November 2018 and the *rabi*- 2019 crop was harvested during the first week of January 2020.

Table 1. Bio-efficacy of Fipronil 5% and Isoprothiolane 28% EC against thrips of onion (Kharif- 2018)

Treatments	Dose gm/ml/ha	Before Spray	1 st spray				2 nd spray				Corrected % Thrips population reduction	
			5DAS	10DAS	15DAS	Mean	5DAS	10DAS	15DAS	Mean	1 st Spray	2 nd Spray
T ₁	750	10.21 (3.27)	4.62 (2.26)	3.40 (1.97)	4.13 (2.15)	4.05	4.83 (2.30)	3.77 (2.06)	4.41 (2.21)	4.33	70.75	75.70
T ₂	1000	11.77 (3.50)	3.72 (2.05)	2.60 (1.76)	3.44 (1.98)	3.25	3.45 (1.98)	2.48 (1.72)	3.05 (1.88)	2.99	76.53	83.22
T ₃	1250	10.40 (3.30)	3.13 (1.90)	2.20 (1.64)	3.04 (1.88)	2.79	3.01 (1.87)	2.70 (1.78)	2.85 (1.83)	2.85	78.05	84.00
T ₄	1500	11.33 (3.43)	3.00 (1.87)	2.08 (1.60)	2.90 (1.84)	2.66	2.93 (1.85)	1.70 (1.48)	2.80 (1.81)	2.47	80.79	86.13
T ₅	75	11.80 (3.50)	6.41 (2.62)	5.30 (2.40)	6.10 (2.56)	5.93	7.64 (2.85)	6.40 (2.62)	7.25 (2.78)	7.09	57.18	60.21
T ₆	750	10.70 (3.34)	7.55 (2.83)	6.40 (2.62)	7.02 (2.74)	6.99	8.09 (2.93)	7.48 (2.82)	7.81 (2.88)	7.93	49.53	55.49
T ₇	--	10.05 (3.24)	12.08 (3.54)	14.10 (3.82)	15.39 (3.98)	13.85	16.04 (4.06)	17.72 (4.26)	19.70 (4.49)	17.82	0.00	0.00
CD at 5%		NS	1.97	1.88	1.52	-	2.80	1.86	1.57	-	-	-
SEm ±		0.09	0.74	0.67	0.56	-	0.83	0.62	0.58	-	-	-

✓ Figures in parentheses arc sine transformed values

Table 2. Bio-efficacy of Fipronil 5% and Isoprothiolane 28% EC against thrips of onion (Rabi- 2018)

Treatments	Dose gm/ml/ha	Before Spray	1 st spray				2 nd spray				Corrected % Thrips population reduction	
			5DAS	10DAS	15DAS	Mean	5DAS	10DAS	15DAS	Mean	1 st Spray	2 nd Spray
T ₁	750	11.00 (3.39)	6.00 (2.54)	5.03 (2.35)	5.81 (2.51)	5.61	5.75 (2.5)	4.25 (2.17)	5.42 (2.43)	5.14	67.15	77.12
T ₂	1000	12.70 (3.63)	4.78 (2.29)	3.10 (1.89)	4.13 (2.15)	4.00	5.04 (2.35)	4.11 (2.14)	4.56 (2.24)	4.57	76.58	79.66
T ₃	1250	11.77 (3.50)	4.30 (2.19)	3.05 (1.88)	3.75 (2.06)	3.70	4.62 (2.26)	3.44 (1.98)	4.00 (2.12)	4.02	78.33	82.09

Treatments	Dose gm/ml/ha	Before Spray	1 st spray				2 nd spray				Corrected % Thrips population reduction	
			5DAS	10DAS	15DAS	Mean	5DAS	10DAS	15DAS	Mean	1 st Spray	2 nd Spray
T ₄	1500	11.92 (3.52)	3.41 (1.97)	2.60 (1.76)	3.10 (1.89)	3.03	4.17 (2.16)	3.05 (1.88)	3.32 (1.95)	3.51	82.25	84.37
T ₅	75	12.40 (3.59)	6.80 (2.70)	5.50 (2.44)	6.33 (2.61)	6.21	7.80 (2.88)	6.30 (2.60)	7.58 (2.84)	7.22	63.64	67.86
T ₆	750	12.27 (3.57)	7.68 (2.86)	6.15 (2.57)	7.24 (2.78)	7.02	8.69 (3.03)	7.35 (2.80)	8.09 (2.93)	8.04	58.89	64.21
T ₇	--	12.01 (3.53)	14.04 (3.81)	17.52 (4.24)	19.70 (4.49)	17.08	20.02 (4.52)	22.33 (4.77)	25.07 (5.05)	22.47	-	--
CD at 5%		NS	1.73	1.75	2.02	-	2.07	2.24	2.07	-	-	-
S.E.m ±		0.12	0.64	0.69	0.75	-	0.72	0.75	0.75	-	-	-

✓ Figures in parentheses arc sine transformed values

Table 3. Bio-efficacy of Fipronil 5% and Isoprothiolane 28% EC against Purple blotch disease of onion (Kharif- 2018)

Tr. No.	Treatment	Dose gm/ml/ha (Formulation)	Before Spray	Disease incidence (PDI) (per cent)		Mean	Reduction %
				After 1 st Spray	After 2 nd Spray		
T ₁	Fipronil 5 % + Isoprothiolane 28 % EC	750	2.04 (8.21)	4.02 (11.57)	4.77 (12.62)	4.39	76.38
T ₂	Fipronil 5 % + Isoprothiolane 28 % EC	1000	2.19 (8.51)	3.28 (10.43)	4.06 (11.62)	3.67	80.25
T ₃	Fipronil 5 % + Isoprothiolane 28 % EC	1250	2.02 (8.17)	2.93 (9.86)	3.57 (10.89)	3.25	82.51
T ₄	Fipronil 5 % + Isoprothiolane 28 % EC	1500	2.11 (8.35)	2.63 (9.33)	3.42 (10.66)	3.02	83.75
T ₅	Standard Fipronil 80 % WG	75	2.74 (9.53)	5.41 (13.45)	7.30 (15.68)	6.35	65.84
T ₆	Standard Tebuconazole 25.9% EC	750	3.14 (10.21)	6.55 (14.83)	7.40 (15.79)	6.95	62.14
T ₇	Control (Untreated)	-	3.20 (10.20)	13.08 (21.20)	24.10	18.59	
S.E.m±			NS	2.78	2.71		
CD at 5%			0.53	0.96	0.99		

✓ Figures in parentheses arc sine transformed values

Table 4: Bio-efficacy of Fipronil 5% and Isoprothiolane 28% EC against Purple blotch disease of onion (Rabi- 2018)

Tr. No.	Treatment	Dose gm/ml/ha (Formulation)	Before Spray	Disease incidence (PDI) (per cent)		Mean	Reduction %
				After 1 st Spray	After 2 nd Spray		
T ₁	Fipronil 5 % + Isoprothiolane 28 % EC	750	05.22 (13.21)	5.85 (14.00)	6.11 (14.31)	5.98	79.36
T ₂	Fipronil 5 % + Isoprothiolane 28 % EC	1000	04.10 (11.68)	4.93 (12.83)	5.57 (13.65)	5.25	81.88
T ₃	Fipronil 5 % + Isoprothiolane 28 % EC	1250	04.07 (11.64)	4.63 (12.43)	5.30 (13.31)	4.96	82.88
T ₄	Fipronil 5 % + Isoprothiolane 28 % EC	1500	03.82 (11.27)	4.18 (11.80)	4.60 (12.38)	4.39	84.85
T ₅	Standard Fipronil 80 % WG	75	04.49 (12.23)	6.21 (14.43)	8.54 (16.99)	7.37	74.56
T ₆	Standard Tebuconazole 25.9% EC	750	05.44 (13.49)	6.77 (15.08)	9.46 (17.91)	8.11	72.01
T ₇	Control (Untreated)	-	04.70 (12.52)	23.18 (28.78)	34.79 (36.14)	28.98	
S.Em+			NS	2.55	2.67		
CD at 5%			0.67	0.85	0.89		

✓ Figures in parentheses arc sine transformed values

Table 5. Effect of Different dose of Fipronil 5% and Isoprothiolane 28% Econ Natural Enemies population in onion (Kharif-2018)

Treatments	Coccinelids/5 plants					Chrysoperla /5 plants				
	B.S.	3 DAS	7 DAS	10 DAS	14 DAS	B.S.	3 DAS	7 DAS	10 DAS	14 DAS
T1: Fipronil 5% + Isoprothiolane 28%EC @ 750 ml/ha	4.00	2.36 (2.04)	2.98 (1.95)	3.47 (1.99)	3.29 (1.95)	4.23 (2.25)	3.12 (1.96)	5.67 (2.48)	4.13 (2.14)	4.00 (2.12)
T2: Fipronil 5% + Isoprothiolane 28%EC @ 1000 ml/ha	4.23	3.32 (1.93)	2.56 (1.87)	3.17 (1.92)	3.00 (1.87)	4.11 (2.19)	3.71 (1.94)	6.33 (2.61)	3.64 (2.02)	5.33 (2.41)
T3: Fipronil 5% + Isoprothiolane 28%EC @ 1250 ml/ha	4.50	3.02 (1.76)	3.65 (1.65)	2.67 (1.78)	2.23 (1.65)	5.32 (2.47)	4.11 (2.14)	4.33 (2.19)	4.23 (2.19)	3.33 (1.95)
T4: Fipronil 5% + Isoprothiolane 28%EC @ 1500 ml/ha	4.37	3.12 (1.69)	2.12 (1.57)	2.00 (1.58)	1.97 (1.57)	5.21 (2.36)	5.05 (2.14)	6.00 (2.54)	5.26 (2.38)	5.00 (2.34)

Treatments	Coccinelids/5 plants					Chrysoperla /5 plants				
	B.S.	3 DAS	7 DAS	10 DAS	14 DAS	B.S.	3 DAS	7 DAS	10 DAS	14 DAS
T5: Standard Fipronil 80% WG @ 75 g/ha	4.00	2.89 (1.85)	2.01 (1.74)	2.97 (1.86)	2.53 (1.74)	6.45 (2.57)	5.28 (2.38)	4.67 (2.27)	5.21 (2.46)	3.67 (2.04)
T6: Standard Tebuconazole 25.9% EC@ 750 ml/ha	4.20	1.65 (1.47)	2.11 (1.64)	2.47 (1.72)	2.19 (1.64)	5.67 (2.34)	5.93 (2.40)	5.00 (2.34)	5.70 (2.50)	5.20 (2.36)
T7: Control	4.67	6.60 (2.66)	5.15 (2.39)	4.93 (2.33)	5.23 (2.39)	5.43 (2.36)	5.04 (2.34)	5.00 (2.34)	5.03 (2.34)	5.20 (2.36)
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

✓ Figures in parentheses arc sine transformed values

Table 6. Effect of Different dose of Fipronil 5%and Isoprothiolane 28% ECon Natural Enemies population in onion (Rabi-2019)

Treatments	Coccinelids/5 plants					Chrysoperla /5 plants				
	B.S.	3 DAS	7 DAS	10 DAS	14 DAS	B.S.	3 DAS	7 DAS	10 DAS	14 DAS
T1: Fipronil 5% + Isoprothiolane 28%EC @ 750 ml/ha	3.89	3.67 (2.04)	3.79 (2.07)	3.23 (2.04)	3.29 (1.95)	5.01 (2.34)	4.65 (2.48)	3.12 (1.96)	4.76 (2.19)	3.89 (2.10)
T2: Fipronil 5% + Isoprothiolane 28%EC @ 1000 ml/ha	3.67	3.23 (1.93)	3.47 (1.99)	2.65 (1.93)	3.00 (1.87)	6.22 (2.54)	7.25 (2.61)	3.71 (1.94)	5.82 (2.48)	3.67 (2.04)
T3: Fipronil 5% + Isoprothiolane 28%EC @ 1250 ml/ha	3.00	2.59 (1.76)	2.67 (1.78)	2.66 (1.76)	2.23 (1.65)	4.11 (2.12)	4.33 (2.19)	4.11 (2.14)	3.54 (2.04)	3.00 (1.87)
T4: Fipronil 5% + Isoprothiolane 28%EC @ 1500 ml/ha	2.79	2.37 (1.69)	2.43 (1.71)	2.39 (1.69)	1.97 (1.57)	5.67 (2.48)	6.00 (2.54)	5.05 (2.14)	5.65 (2.41)	2.79 (1.81)
T5: Standard Fipronil 80% WG @ 75 g/ha	3.23	2.93 (1.85)	3.17 (1.92)	2.96 (1.85)	2.53 (1.74)	4.33 (2.19)	4.67 (2.27)	5.28 (2.38)	4.78 (2.12)	2.43 (1.71)
T6: Standard Tebuconazole 25.9% EC@ 750 ml/ha	2.43	1.67 (1.47)	1.89 (1.55)	1.69 (1.47)	2.19 (1.64)	5.05 (2.35)	5.00 (2.34)	5.93 (2.40)	5.52 (2.37)	2.37 (1.69)
T7: Control	6.00	6.59 (2.66)	6.79 (2.70)	6.12 (2.66)	5.23 (2.39)	6.67 (2.67)	5.00 (2.34)	5.04 (2.34)	6.60 (2.54)	6.00 (2.55)
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

✓ Figures in parentheses arc sine transformed values

Table 7. Effect of Fipronil 5%+ Isoprothiolane 28% ECon onion crop (phytotoxicity)during kharif – 2018

Treatments	Phytotoxicity parameters (mean observations recorded 1, 3, 5, 7 and 10 days after first spray)*																													
	Vein clearing					Necrosis					Epinasty					Leaf injury on tips / surface					Wilting					Hyponasty				
	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10
Fipronil 5%+ Isoprothiolane 28% EC@ 1000 ml/ha	0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fipronil 5%+ Isoprothiolane 28% EC@ 2000 ml/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fipronil 5%+ Isoprothiolane 28% EC@ 4000 ml/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Spray volume of 500lts/ha.

** Scale 0=Healthy, 1=0-10%, 2 =11-20 %, 3=21-30%, 4=31-40 %, 5=41-50%, 6 =51-60%, 7=61-70%, 8=71-80%, 9=81-90% and 10=91-100%.

Table 8. Effect of Fipronil 5%+ Isoprothiolane 28% ECon onion crop (phytotoxicity)during Rabi- 2019

Treatments	Phytotoxicity parameters (mean observations recorded 1, 3, 5, 7 and 10 days after first spray)*																													
	Vein clearing					Necrosis					Epinasty					Leaf injury on tips / surface					Wilting					Hyponasty				
	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10	1	3	5	7	10
Fipronil 5%+ Isoprothiolane 28% EC@ 1000 ml/ha	0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fipronil 5%+ Isoprothiolane 28% EC@ 2000 ml/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fipronil 5%+ Isoprothiolane 28% EC@ 4000 ml/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Spray volume of 500lts/ha.

** Scale 0=Healthy, 1=0-10%, 2 =11-20 %, 3=21-30%, 4=31-40 %, 5=41-50%, 6 =51-60%, 7=61-70%, 8=71-80%, 9=81-90% and 10=91-100%

Table 9. Yield of onion (*Kharif- 2018 and Rabi-2019*)

Treatments	Yield (t/ha)		Mean yield (t/ha)	% increase in yield over control
	<i>Kharif 2018</i>	<i>Rabi 2019</i>		
T1: Fipronil 5% + Isoprothiolane 28%EC @ 750 ml/ha	17.11	15.98	16.54	52.44
T2: Fipronil 5% + Isoprothiolane 28%EC @ 1000 ml/ha	22.45	18.23	20.34	87.46
T3: Fipronil 5% + Isoprothiolane 28%EC @ 1250 ml/ha	23.66	17.32	20.49	88.84
T4: Fipronil 5% + Isoprothiolane 28%EC @ 1500 ml/ha	24.69	18.35	21.52	98.34
T5: Standard Fipronil 80% WG @ 75 g/ha	14.23	14.11	14.17	30.59
T6: Standard Tebuconazole 25.9% EC@ 750 ml/ha	15.98	14.88	15.43	42.21
T7: Control	11.60	10.11	10.85	-
CD (p=0.05)	26.89	18.67		
SEm ±	8.98	6.32		

Table 10. Economics (Benefit: Cost Ratio) of Fipronil 5% + Isoprothiolane 28% ECon Onion crop (*kharif-2018 & Rabi- 2019*)

Sr. No	Treatments	Dose (ml/ha) (1)	Cost of Chemical/ kg/l (₹) & (2)	Cost of Chemical/ha For 2 spray (₹) (3)	Cost of Cultivation /ha (₹) (4)	Total Cost (₹) (5=3+4)	Total yield (Kg/ha) (6)	Gross Return @ ₹ 10/Kg (7)	Net Returns (₹) (8=7-5)	BC Ratio (9=8/5)
1	T1: Fipronil 5% + Isoprothiolane 28%EC	750	3600	5400	40000	45400	16540	132320	86920	1.91
2	T2: Fipronil 5% + Isoprothiolane 28%EC	1000	3600	7200	40000	47200	20340	162720	115520	2.45
3	T3: Fipronil 5% + Isoprothiolane 28%EC	1250	3600	9000	40000	49000	20490	163920	114920	2.35
4	T4: Fipronil 5% + Isoprothiolane 28%EC	1500	3600	10800	40000	50800	21520	172160	121360	2.39
5	T5: Standard Fipronil 80% WG	75	20600	3090	40000	43090	14170	113360	70270	1.63
6	T6: Standard Tebuconazole 25.9% EC@ 750 ml/ha	750	1700	2550	40000	42550	15430	123440	80890	1.90
9	T7: Control	Control	0	0	40000	40000	10850	86800	46800	1.17

Supporting information for calculation of economics:

Particulars	Cost (Rs.)
Fipronil 5% + Isoprothiolane 28%EC	Rs.3600/Kg
Fipronil 80% WG	Rs .20600/Kg
Tebuconazole 25.9% EC	Rs. 1700/L
Harvesting Charges	Rs. 5.50/Kg
Spraying Charges	Rs. 500/ha
Onion rate	Rs. 10.0/Kg

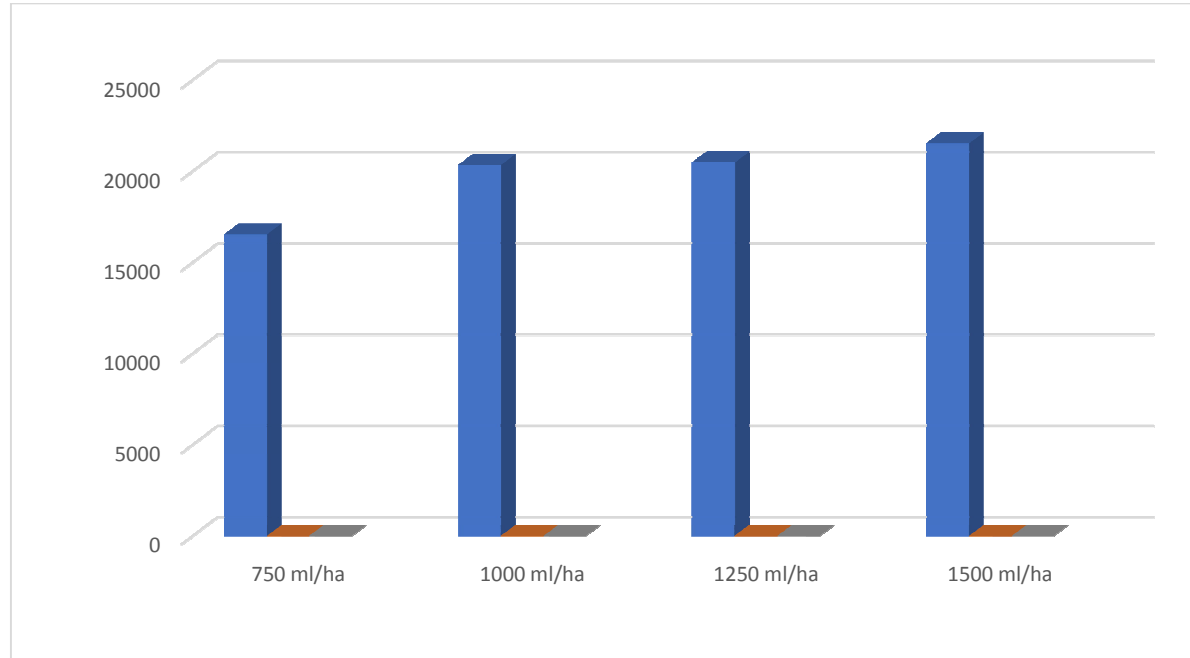


Fig. 1. Increase in bulb yield of onion as influenced by Fipronil 5% + Isoprothiolane 28% EC@ different doses

The pooled data of two seasons revealed that Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha recorded the maximum bulb yield (21.52 t/ha) followed by Fipronil 5% + Isoprothiolane 28% EC @ 1250 and 1000 ml/ha (20.49 and 20.34 t/ha respectively) whereas, the untreated control recorded the lowest bulb yield of 10.85 t/ha..The highest per cent increase in bulb yield over control is recorded in treatment T4 (98.34) followed by T3 (88.84) and T2 (87.46) (Table 9). The highest garlic yield (172.49q/ha) was also recorded when the crop was sprayed with Imidacloprid @ 0.5 ml per litre [10].

3.6 Economics

The highest gross returns (Rs. 1,72,160/ha) was obtained in treatment T4 followed by T3 (Rs.1,63,920/ha) and T2 (Rs.1,62,720 /ha) respectively. Whereas, the control recorded Rs.86, 800 per hectare. The Highest net returns was recorded in T4 (1,21,360 /ha) followed by T3 (Rs. 1,14,920/ha). The highest B:C ratio was recorded in T2 (2.45) followed by T4 (2.39) and T3 (2.35) respectively compared to control (1.17). The treatment T2 recorded 2.39 B:C ratio because of increased cost of chemical (Table 10). The present findings are in close agreement with findings of Nirgude (2017) who reported that Thiamethoxam 25 WG and Imidacloprid 70 WG were significantly superior among the chemicals tested and recorded higher B: C ratio.

The formulation Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha (T4) recorded the lowest thrips population (2.47 and 3.51) and purple blotch disease incidence (3.02 and 4.39), the highest yield (21.52 t/ha), Gross returns (Rs.1,72,160/ha) and Net returns (Rs.1,21,360/ha). The formulation doesn't recorded the phytotoxicity effect on onion crop. It was also safe to natural predators and parasites in onion ecosystem. The formulation Fipronil 5% + Isoprothiolane 28% EC@ 1000 ml/ha (T2)was found to be on par with T3 and T4 with respect to control of thrips, purple blotch disease incidence and yield. The treatment T2 is cost effective & having highest Benefit: Cost ratio (2.45) compared to all the treatments. So is recommended for adoption.

4. CONCLUSION

Treatment with Fipronil 5% + Isoprothiolane 28% EC @ 1500 ml/ha has effectively controlled purple blotch disease and thrips infestation in onion. But, economically the treatment with

Fipronil 5% + Isoprothiolane 28% EC @ 1000 ml/ha found superior over other treatments and recorded highest benefit:cost ratio followed by Fipronil 5% + Isoprothiolane 28% EC @ 1250 ml/ha

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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