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OPTIMISATION OF PLANT PROTECTION SCHEDULE FOR MANAGEMENT OF INSECT PESTS OF ONION

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Abstract

Field experiment was conducted at Main Agricultural Research Station, Raichur (Karnataka), India; during *Kharif* 2012-13 to develop a holistic approach and optimize plant protection schedule for management of insect pests of onion. Results revealed that T_4 consisting of seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed followed by one spray with fipronil 5 SC @ 1 ml/l and thiamethoxam 25 WG @ 0.2 g/l for sucking pests and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliators in main field recorded significantly lowest number of thrips (2.40 thrips/plant) and defoliators (0.30 larvae/plant) (table 2) followed by T_6 consisting of no seed treatment but one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l for sucking pests and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliator and these two treatments were superior to rest of the treatments. Maximum bulb yield of onion 24.44 t/ha was recorded by T_4 followed by T_6, which recoded (23.89 t/ ha) (table 2). Significantly lowest yield was obtained in T_8 (untreated control) (11.50 t/ ha).

Key words : Onion, thrips, plant protection schedule, plant protection schedule.

Introduction

Onion is an important vegetable crop and assumes significant role in national economy. Amongst the onion producing countries in the world India ranks second in area (1064 m. ha) and production (15117.7m.t) after China (Anonymous, 2011). The production of onion is curtailed by various biotic factors among them insect pests play a vital role. Among the insect pests, onion thrips, *Thrips tabaci* (Lindeman) is a most serious and persistent pest and can reduce bulb yield by 33% (Nault and Shelton, 2008). Likewise of late defoliators mainly *Spodoptera litura* (Fabricius) and *S. exigua* (Hubner) also affect the growth and yield of onion, which necessitates farmers to take up chemical spray repeatedly during growing season irrespective of pest load. In recent times, consumers are demanding higher quality and safer food and highly interested in organic products (Naik *et al*., 2014). Unfortunately very little information is available regarding plant protection schedule against insect pests of onion. In this regard, the present study was undertaken to develop holistically the plant protection schedule to manage all insect pests right from nursery stage; this would pay way for developing IPM strategy.

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Materials and Methods

Field experiment was laid out in a randomized block design (RBD) at Main Agricultural Research Station, Raichur (Karnata), India; during 2012-13 season having eight treatments with three replications. Onion variety, Delta N-53 was sown in nursery according to treatments and later one month old seedlings were transplanted in the main field. The crop was raised at a spacing of 30 x 15 cm in a plot size of 3 × 2 mts. Below mentioned different treatments were designed so as to take care of insect pests right from nursery stage till harvest either by seed treatment and or with spraying applications.

T_1- Seed treated with imidacloprid 60 FS @ 9 ml/kg of seed and sown in nursery later seedlings were transplanted and further no plant protection was followed in the main field.

T_2- Seed treated with imidacloprid 60 FS @ 9 ml/kg of seed followed by only one spray with fipronil 5 SC @ 1 ml/l at 20-25 days after transplanting in the main field for the control of sucking pests.

T_3- Seed treated with imidacloprid 60 FS @ 9 ml/kg of seed followed by one spray with fipronil 5 SC @ 1 ml/l at 20-25 days after transplanting for sucking pests

and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliators at 40-45 days after transplanting.

T_4- Seed treated with imidachlopid 60 FS @ 9 ml/kg of seed followed by one spray with fipronil 5 SC @ 1 ml/l at 20-25 days after transplanting for sucking pests followed by second spray with thiamethoxam 25 WG @ 0.2 g/l at 20 days after first spray and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l in the main field for defoliators.

T_5- No seed treatment but one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l (15-20 days old seedlings) followed by one spray with fipronil 5 SC @ 1 ml/l at 20-25 days after transplanting for sucking pests and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliators at 20 days after first spray in main field for defoliators.

T_6- No seed treatment but one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l (15-20 days old seedlings) followed by spray with fipronil 5 SC @ 1 ml/l at 20-25 days after transplanting and thiamethoxam @ 0.2 g/l after 20 days after first spray for sucking pestsand one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliators.

T_7- No seed treatment and no spray in nursery but two sprays with fipronil 5 SC @ 1 ml/l for sucking pests at 20-25 days after transplanting and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliators in main field.

T_8- Untreated control.

These treatments were imposed when thrips and defoliators mainly, *Spodoptera exigua* and *Spodoptera litura* population was noticed. Before imposing the treatments, pre-treatment observations on number of thrips and defoliators per plant were taken a day before application on five randomly selected plants in each plot. Similarly, post treatment observations on number of thrips and defoliators were also recorded on one, three, seven, ten and fifteen days after application.

Propiconazole @ 1 ml/l was sprayed as general fungicide for management of purple blotch to all the treatments including untreated control.

Results and Discussion

Management of onion thrips and defoliators

Data was registered on thrips and defoliators per plant separately but for discussion here it is included in following paragraph. Precount of thrips population varied from 12.20 to 20.67 thrips per plant (table 1) showed lot of variation in pest load across treatments, which was due to seed treatment done prior to nursery sowing which has reduced the pest load and carried further likewise spraying undertaken in nursery might have suppressed the initial population of thrips. However, the population of defoliators per plant registered a day before imposition of treatments across different treatments was uniform (table 2) and showed no significant difference.

The results of study on optimization of plant protection schedule for the management of thrips one day after spraying revealed that the **T_4** consisting of seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed followed by one spray with fipronil 5 SC @ 1 ml/l and thiamethoxam 25 WG @ 0.2 g/l for sucking pests and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliators in main field recorded significantly lowest number of thrips (2.40 thrips/plant) and defoliators(0.30 larvae/plant) (table 2) followed by **T_6** consisting of no seed treatment but one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l for sucking pests and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l for defoliator and these two treatments were superior to rest of the treatments. Untreated control suffered with more number of thrips (20.18 thrips/plant) and defoliators (1.14 larvae/plant).

T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed and sown in nursery and later such seedlings were transplanted and no plant protection was followed in the main field) and **T_2** (Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed followed by only one spray with fipronil 5 SC @ 1 ml/l at 20-25 days after transplanting in the main field) recorded higher defoliators population of 1.17 and 1.10 larvae per plant, respectively because no spray was undertaken to manage defoliators. The same trend was recorded after 3,5,10 and 15 days after spraying. Treatments like **T_4** and **T_6** were on par with each other and afforded good control of thrips upto fifteen days after spraying and were superior to all other treatments.

The results of study on optimization of plant protection schedule for the management of thrips revealed that the **T_4** (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l in nursery followed by thiamethoxam 25 WG @ 0.2 g/l + and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l in main field) and **T_6** (no seed treatment, but one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l) afforded good control of thrips upto fifteen days after spraying and were superior to all other treatments.

Table 1 : Optimization of plant protection schedule for the management of *Thrips tabaci* on onion (Pooled data of two sprays).

Treatment details	Number of thrips/plant						Yield (t/ha)
	1 DBS	1 DAS	3 DAS	5 DAS	10 DAS	15 DAS	
T_1 : Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	12.20 (3.56)[a]	15.52 (3.99)	18.21 (4.32)	21.25 (4.65)	24.02 (4.95)	27.35 (5.27)	18.20
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	12.33 (3.58)[ab]	10.16 (3.22)	10.10 (3.13)	10.43 (3.06)	11.16 (3.09)	12.40 (3.23)	21.94
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	12.30 (3.58)[ab]	10.02(3.19)	9.37 (3.02)	9.42 (2.92)	10.22 (2.95)	11.12 (3.08)	21.67
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l.	12.47 (3.60)[abc]	2.40 (1.69)	1.24 (1.32)	0.65 (1.06)	0.49 (0.98)	0.63 (1.05)	24.44
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l	15.40 (3.99)[de]	11.13 (3.38)	11.07 (3.32)	11.54 (3.27)	12.27 (3.3)	13.15 (3.4)	22.78
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	15.27 (3.97)[d]	3.88 (2.05)	2.12 (1.61)	1.25 (1.32)	0.99 (1.21)	1.21 (1.30)	23.89
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	19.83 (4.51)[f]	9.0 (3.03)	5.92 (2.50)	3.77 (2.04)	3.1 (1.87)	3.24 (1.91)	20.27
T_8: Untreated control.	20.67 (4.59)[fg]	20.18 (4.54)	23.06 (4.85)	25.8 (5.10)	27.88 (5.32)	31.00 (5.6)	11.50
S.Em±	**0.09**	**0.08**	**0.07**	**0.06**	**0.09**	**0.07**	**0.72**
CD @ 5%	**0.26**	**0.24**	**0.21**	**0.17**	**0.27**	**0.22**	**2.20**
CV	**9.38**	**9.52**	**8.69**	**8.55**	**9.61**	**11.5**	**8.5**

DBS – Day before spray **DAS –** Days after spray

Mean followed by the same letters in a column do not differ significantly,

*Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

Table 2 : Optimization of plant protection schedule for the management of defoliators on onion.

Treatment details	Number of defoliators/plant					
	1 DBS	1 DAS	3 DAS	5 DAS	10 DAS	15 DAS
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	1.13 (1.28)a	1.17 (1.29)^{c}	1.21 (1.31)c	1.24 (1.32)^{d}	1.26 (1.33)^{c}	1.30 (1.34)^{b}
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	1.10 (1.26)a	1.10 (1.27)c	1.16 (1.29)c	1.20 (1.30)^{d}	1.24 (1.32)c	1.27 (1.33)^{b}
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	1.14 (1.28)a	0.40 (0.95)^{ab}	0.22 (0.85)b	0.10 (0.77)b	0.12 (0.79)a	0.13 (0.80)^{a}
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l.	1.17 (1.29)a	0.30 (0.89)a	0.00 (0.71)a	0.00 (0.71)a	0.10 (0.77)^{a}	0.12 (0.79)^{a}
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l	1.10 (1.26)a	0.42 (0.96)^{ab}	0.23 (0.85)b	0.12 (0.79)^{b}	0.14 (0.80)^{a}	0.17 (0.82)^{a}
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	1.18 (1.29)a	0.32 (0.91)^{a}	0.00 (0.71)a	0.00 (0.71)^{a}	0.12 (0.79)^{a}	0.14 (0.80)^{a}
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	1.13 (1.28)a	0.40 (0.95)^{ab}	0.25 (0.87)^{b}	0.15 (0.81)bc	0.16 (0.81)^{ab}	0.18 (0.82)^{a}
T_8: Untreated control.	1.10 (1.26)a	1.14 (1.28)^{c}	1.13 (1.28)c	1.23 (1.31)d	1.25 (1.32)c	1.31 (1.35)^{b}
S.Em ±	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**
CD @ 5%	**NS**	**0.05**	**0.03**	**0.03**	**0.03**	**0.03**
CV (%)	**9.35**	**10.76**	**8.18**	**9.50**	**8.74**	**8.90**

DBS-Day before spray, **DAS-**Days after spray. Mean followed by the same letters in a column do not differ significantly. *Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

Superiority of these two treatments is mainly due to complete protection of all insect pests right from nursery to the main field.

Lot of research work has been conducted with respect to screening of chemicals for thrips individually. But no much efforts were made to use them consecutively to formulate IPM schedule However, such studies pertaining to optimization of plant protection schedule is needed for onion growers. The present findings are comparable with the findings of Gupta *et al.* (2011) also evaluated the efficacy of different contact and systemic insecticides against thrips and found that sequential spray of deltamethrin @ 0.092 per cent, carbosulfan 25 EC @ 0.2 per cent, fipronil @ 0.1 per cent and thiomethoxam 25 WG @ 0.2 per cent at 15 days interval performed better in reducing thrips population.

Farman *et al.* (2010) reported that the insecticides like endosulfon, imidacloprid and spinosad were effective against thrips (*Thrips tabaci*) on onion. Hosmani *et al.* (2012) reported that fipronil 80 WG @ 60 g a.i./ha was effective in reducing the thrips population with increased yield of onion. Similarly, Ibrahim and Adesiyun (2010) evaluated two factors consisting of transplanting date and insecticide frequency and found that transplanting of onion early in the season *i.e.*, November combined with two sprays with lambda cyhalothrin 5EC gave better control of thrips with increased yield of onion compared to three to four rounds of application of insecticides.

Table 3 : Effect of plant protection schedule on the population of spiders on onion (first and second spray).

Treatment details	Number of spiders/plant							
	First spray				Second spray			
	1 DBS	5 DAS	10 DAS	15 DAS	1 DBS	5 DAS	10 DAS	15 DAS
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	0.36(0.93)^{a}	1.00 (1.22)^{b}	1.36(1.37)^{a}	1.70 (1.48)^{a}	1.66 (1.46)^{a}	1.81 (1.52)^{a}	2.10(1.61)^{a}	2.46 (1.72)^{a}
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	0.34(0.92)^{a}	0.42(0.96)^{c}	0.50(1.00)^{b}	0.74(1.11)^{b}	1.60(1.45)^{a}	1.70(1.48)^{a}	1.85(1.53)^{ab}	2.13(1.62)^{ab}
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.35(0.92)^{a}	0.44(0.97)^{c}	0.52(1.01)^{b}	0.67(1.08)^{b}	01.65(1.47)^{a}	1.71(1.49)^{a}	1.83(1.53)^{ab}	2.00(1.58)^{abc}
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.37(0.93)^{a}	0.43(0.96)^{c}	0.50(1.00)^{b}	0.70(1.10)^{b}	1.62(1.45)^{a}	0.52(1.01)^{c}	0.67(1.08)^{d}	0.81(1.14)^{e}
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l	0.30(0.89)^{b}	0.36(0.93)^{cde}	0.48(0.99)^{bc}	0.65 (1.07)^{b}	1.66 (1.47)^{a}	1.78(1.51)^{a}	1.90(1.55)^{ab}	2.15(1.63)^{ab}
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.32(0.91)^{a}	0.38(0.94)^{cd}	0.51(1.01)^{b}	0.75(1.12)^{b}	1.60(1.45)^{a}	0.60(1.05)^{c}	0.73(1.11)^{d}	0.73(1.11)^{e}
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.32(0.91)^{a}	0.47(0.98)^{c}	0.60(1.05)^{b}	0.81(1.14)^{b}	1.66(1.47)^{a}	0.80(1.14)^{b}	0.94(1.20)^{c}	1.20(1.31)^{d}
T_8: Untreated control.	0.40(0.95)^{a}	1.23 (1.32)^{a}	1.43(1.39)^{a}	1.73(1.49)^{a}	1.70 (1.48)^{a}	1.83 (1.52)^{a}	2.23(1.65)^{a}	2.52(1.73)^{a}
S.Em±	**0.01**	**0.01**	**0.02**	**0.02**	**0.03**	**0.02**	**0.03**	**0.03**
CD @ 5%	**0.04**	**0.04**	**0.05**	**0.07**	**NS**	**0.06**	**0.08**	**0.09**
CV (%)	**11.15**	**8.98**	**10.68**	**10.86**	**9.70**	**8.05**	**9.55**	**10.16**

DBS – Day before spray **DAS –** Days after spray

Mean followed by the same letters in a column do not differ significantly,

*Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

Table 4 : Effect of plant protection schedule on population of coccinellids on onion (first and second spray).

Treatment details	Number of coccinellids/plant							
	First spray				Second spray			
	1 DBS	5 DAS	10 DAS	15 DAS	1 DBS	5 DAS	10 DAS	15 DAS
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	0.13(0.79)^{a}	0.18(0.82)^{a}	0.24 (0.86)^{a}	0.25 (0.87)^{a}	0.30 (0.89)^{a}	0.40 (0.95)^{a}	0.44 (0.97)^{b}	0.48 (0.99)^{a}
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	0.10 (0.77)^{b}	0.00 (0.71)^{c}	0.07 (0.75)^{c}	0.10 (0.77)^{b}	0.15 (0.81)^{ab}	0.15 (0.81)^{c}	0.17 (0.82)^{c}	0.20 (0.84)^{b}
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.13 (0.79)^{a}	0.01 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.12 (0.79)^{ab}	0.14 (0.80)^{d}	0.18 (0.82)^{c}	0.22 (0.85)^{b}
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.13 (0.79)^{a}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.10 (0.77)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.10 (0.77)^{b}
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l	0.14 0.80)^{a}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.12 (0.79)^{ab}	0.15 (0.80)^{c}	0.17 (0.82)^{d}	0.19 (0.83)^{b}
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.12 (0.79)^{a}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.14 (0.80)^{ab}	0.00 (0.71)^{e}	0.00 (0.77)^{e}	0.12 (0.79^{b}
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	0.12 (0.79)^{a}	0.01 (0.71)^{c}	0.07 (0.75)^{c}	0.09 (0.77)^{b}	0.15 (0.81)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.08 (0.76)^{bc}
T_8: Untreated control.	0.13(0.79)^{a}	0.20 (0.84)^{a}	0.26 (0.87)^{a}	0.30 (0.89)^{a}	0.40 (0.94)^{a}	0.44 (0.97)^{a}	0.48 (0.99)^{a}	0.51 (1.00)^{a}
S.Em±	**0.01**	**0.00**	**0.00**	**0.02**	**0.03**	**0.01**	**0.00**	**0 .01**
CD @ 5%	**0.02**	**0.01**	**0.01**	**0.06**	**0.08**	**0.02**	**0.01**	**0.02**

DBS – Day before spray **DAS – Days after spray**

Mean followed by the same letters in a column do not differ significantly, *Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

Table 5 : Economics of management of pests of onion.

Treatment details	Yield (t/ha)	Common cost of cultivation /ha	Cost of treatments/ha	Total cost/ha	Gross returns /ha	Net returns /ha	B:C Ratio
T_1: Seed treatment with imidacloprid 60 FS @ 9ml/kg of seed.	18.20	35000	458	35458	364000	328542	1:10.27
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	21.94	35000	1112	36112	438800	402688	1:12.15
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	21.67	35000	1862	36862	433400	396538	1:11.76
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l.	24.44	35000	2147	37147	488800	451653	1:13.16
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l	22.78	35000	1652	36652	455600	418948	1:12.43
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	23.89	35000	1937	36937	477800	440863	1:12.94
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l.	20.27	35000	1742	.36742	405400	368658	1:11.03
T_8: Untreated control	11.50	35000	-	35000	230000	195000	1:6.57

Price of onion :Rs 20000/Ton

The present findings on screening of chemicals for defoliators are in line with the findings of Sreenivas *et al*. (2013) evaluated eleven treatments comprising of organic and inorganic treatments and revealed that among all treatments chlorantriliniprole 18.5 SC was found to be better treatment followed by lufenuron 5 EC and spinosad 48 SC.

Influence of insecticide on natural enemies

The spider and coccinellids population was significantly higher in T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/l/kg of seed) and T_8 (untreated control), since here no chemical spray was made. Hence, there was no significant difference in population of spiders and coccinellids in all other treatments (tables 3 & 4).

Yield

Maximum bulb yield of onion 24.44 t/ha was recorded by T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/ kg of seed followed by two sprays with thiamethoxam 25 WG @ 0.2 g/l and fipronil 5 SC @ 1 ml/l for sucking pests and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l) for defoliators followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/ l and thiamethoxam @ 0.2 g/l and one sprays with chlorantriliniprole 18.5 SC @ 0.15 ml/l) which recoded (23.89 t/ ha) (table 2). Next treatment in the order of merit is T_1 and T_2, which managed thrips and defoliators satisfactorily. Significantly lowest yield was obtained in T_8 (untreated control) (11.50 t/ha).

Economics of management of pests of onion

Economics of optimisation of plant protection revealed that highest benefits: costs ratio of 1:13 was obtained in the $\mathbf{T_4}$ (seed treatment with imidacloprid 60 FS @ 9 ml/ kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantriliniprole 18.5 SC @ 0.15 ml/l), this was followed $\mathbf{T_6}$ (no seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantriliniprole 18.5 SC @ 0.15 ml/l) which was recorded 1:12. Thus proving their superiority compared to other treatments (table 5). Next best treatments which recorded better B:C ratio were $\mathbf{T_1}$ and $\mathbf{T_2}$.

Onion insect pests can be completely managed by effective and sequential plant protection schedule, comprising seed treatment with imidacloprid 60FS@ 9ml/ Kg of seed (is inevitable) for managing thrips in the nursery stage followed by two systemic insecticide spray application (fipronil 5 EC or thiomethoxam 25 WG) followed by one application for defoliator management is the best schedule. If seed treatment is not followed spray with systemic insecticide in the nursery followed by two applications with systemic insecticides for sucking pests and one application for defoliator would also be a good option. This trend of plant protection schedule will pay way for formulation of IPM for onion insect pests.

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