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Efficacy of newer molecules against red spider mite, *Tetranychus urticae* in tomato under protected cultivation

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Abstract
A field experiment was conducted to study the efficacy of newer molecules against red spider mite, *Tetranychus urticae* Koch during *rabi* 2020-21 in tomato under protected cultivation at Hi-tech horticulture unit, UAS, Dharwad. The efficacy of nine newer combination products found to be significantly superior when compared with untreated control. Among the treatments, spirotetratmat 11.01 SC + imidacloprid 11.01 SC @ 1.0 ml/l found to be the best treatment in reducing the mite population (3.39 mites/3 leaflets) by recording the highest percent reduction of 78.35. This was followed by pyriproxyfen 5 EC + fenpropathrin 15 EC (72.19%), spinosad 45 SC + buprofezin 25 SC (65.81%) and buprofezin 25 SC (59.68%) The spinosad 45 SC and indoxacarb 14.5 SC + acetamiprid 7.7 SC recorded as least effective treatment with 11.52 and 14.20 percent reduction (13.91 and 13.50 mites/3 leaflets) over the untreated control.

Keywords: efficacy, leaflets, newer molecules, protected cultivation, red spider mite, tomato

Introduction
The globalization of trade and liberalization of Indian economy created an immense scope for export of high value vegetables from India. In addition to ensuring the vertical growth in productivity, modern technology is required. One such technology is "Protected cultivation" or Greenhouse technology". Protected cultivation is a technique for creating an environment suitable for the sustainable crop growth through management of biotic and abiotic factors. It is the most intensive method of crop production and protects plants from adverse environmental conditions. It also provides stable and congenial micro-climate favorable for the multiplication of mites and insect pests. This becomes one of the limiting factors for the successful crop production in protected cultivation (Sood, 2010) [14].

Among the vegetables, tomato is the preferred crop grown in greenhouses worldwide. It is one of the important and popular commercial vegetable crops. Cultivation of tomato in protected environment has gained importance in recent years due to export, off-season cultivation and potentiality of tomato. Tomato is one of the most popular solanaceous vegetable crops grown all over the world and ranks second after potato because of its special nutritive and medicinal value. Tomato ranks first among the processed vegetables. Tomato fruits are excellent source of vitamin A, B and C (Madhavi and Salunkhe, 1998) [7].

About 45 insect and mites pests associated with the crops under protected cultivation have been identified in India. Among them, red spider mite, *Tetranychus urticae* Koch is an important non-insect pest that causes economic damage to tomato crop under greenhouse conditions (Mehta, 2012) [8]. Spider mites (*Tetranychus urticae*) feed on the undrside of crop leaves. They penetrate cells containing chloroplasts, thereby reducing the leaf chlorophyll content (Sances *et al*., 1979) [11]. Spider mites are one of the challenging pests in greenhouses with tomato crops as their control is increasingly difficult due to resistance to pesticides and difficulties in biological control. The mites prefer young canopies on the outside of plants, resulting in canopy dmaage (Herrmann *et al*., 2017) [4]. Typical symptoms are small yellowish white spots on the upper side of the leaf due to chlorophyll depletion, which develop into irregularly shaped white or greyish colored spots, and yellowing and bronzing of leaves may result. The damage due to mites is reported up to an extent of 55 percent yield loss. The heavy incidence of mite and insect pests has been observed under protected cultivation due to congenial environmental condition.

It causes severe damage more particularly when the climatic conditions are hot and dry (Lal *et al*., 2004) [6]. Mites in polyhouse are not a serious pest in temperate countries but can be devastating in the tropical climate of India (Reddy and Kumar, 2006) [10]. To tackle this pest farmers are using number of insecticidal and acaricidal spray in tomato crop, which led to several problems like toxic residues, elimination of natural enemies, environmental disharmony and development of resistance. To overcome the latter constraints it is necessary to develop the suitable management practices for sucking pests, particularly the newer ready mix combination of molecules as these are having unique mode of action which effectively manage the mite pests. The objective of this paper is to assess the efficacy of newer molecules in managing red spider mite population in tomato under protected cultivation.

Materials and Methods

To carryout field efficacy studies, an experiment was laid out in randomized block design at Hi-tech Horticulture Unit, UAS, Dharwad with 10 treatments replicated thrice. Tomato seedlings were procured from Pattanshetty hi-tech nursery, Dharwad and the tomato hybrid, Durga was used for the trial during *rabi* 2020-21. The seedlings of 25-30 days old were transplanted on raised beds of 30 m length, 1m width and half meter path between beds in paired row system in protected cultivation with spacing of 60x45 cm. Each treatment consisted of three beds of four meter length and each bed consists two rows of tomato plants. Management practices were carried out by following all the recommended package of practices except the plant protection measures against red spider mite in tomato in protected cultivation. Treatments were imposed at vegetative stage, flowering stage and fruiting stage of tomato crop with the help of knapsack sprayer. The pest population was recorded on five randomly selected plants and was counted with the help of a hand lens (10X magnification). The three leaflets (one each from top, middle and bottom canopy) per plant were selected for recording the observation. The population counts were taken a day before spray and 3, 7 and 10 days after treatment imposition. The mean pest population recorded at weekly interval was worked out and expressed per plant basis.

The data was subjected to ANOVA. Further, obtained data was converted into percent reduction of pest population over control through following formula

$$\text{Percent reduction over control} = \frac{\text{Insect pest population in control- Insect pest population in treatment}}{\text{Insect pest population in control}} \times 100$$

Statistical analysis

The statistical analysis of data was done by using the analysis of variance (ANOVA) with Web Agri Stat Package (wasp-2) developed by ICAR, Central Coastal Agricultural Research Institute, Goa and OPISTAT. Data were transformed by square root transformation before subjecting to DMRT. The significance of the difference among the treatment combination means were determined by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Results and Discussion

The results obtained from the present investigation with relevant discussion have been summarized below:

The mite population ranged from 8.89 to 9.68 per 3 leaflets across the treatment plots before imposition of spray (First time) without any statistical difference. Among the treatments, the lower mite population of 2.01 per 3 leaflets was recorded in T_7 and this was followed by T_8 (2.56 mites/3 leaflets), T_3 (3.58 mites/3 leaflets) and T_2 (3.75 mites/3 leaflets) respectively after three days of first spray. At seven days of spray, T_7 recorded lower mite population of 2.15 per 3 leaflets and differed significantly with rest of treatments. The highest population of 9.19 mites per 3 leaflets was recorded in T_1 followed by T_9 (8.75 mites/3 leaflets) but was significantly superior to untreated check (10.72 mites/3 leaflets). The same trend of treatment difference was recorded at ten days after spray as observed at seven days of spray with a recovery in the mite population (3.01 to 11.46 mites/3 leaflets) across the treatments (Table 1).

Among the treatments, lower mite population of 3.84 per 3 leaflets was recorded in T_7 and followed by T_8 (4.89 mites/3 leaflets) after three days of spray for the second time. The treatment T_7 once again proved superior by recording minimum mite population of 4.84 per 3 leaflets, which was followed by T_8 (6.14 mites/3 leaflets) and differed significantly with rest of treatments at ten days after second spray. (Table 1).

The mite population ranged from 10.80 to 15.12 per 3 leaflets across the treatment plots a day before imposition of treatments during third spray. The mite population was statistically significant across the treatments and T_7 and T_8 recorded the lowest mite population of 3.19 and 4.22 per 3 leaflets respectively after three days of spray for the third time. The lower mite population of 4.19 and 5.47 per 3 leaflets was recorded in T_7 and T_8 treatment at ten days of spray. The highest recovery in mite population (16.90 and 16.55 mites/3 leaflets) was recorded in T_1 and T_9 over the untreated check (Table 1).

The pooled mean data indicates that, T_7 (Spirotetramat 11.01 SC + Imidacloprid 11.01 SC) stood significantly superior in reducing red spider mite population when compared with other chemicals including untreated check by recording a minimum mean population of 3.39 mites per 3 leaflets with 78.35 percent reduction in mite population. This was followed by T_8 treatment (Pyriproxyfen 5 EC + Fenpropathrin 15 EC) which recorded a mean population of 4.36 mites per 3 leaflets (72.19 percent reduction). The least effective treatment was T_1 spinosad 45 SC and T_9- chlorpyriphos 50 EC + cypermethrin 5 EC which recorded a highest mean population of 13.91 and 13.50 mites per 3 leaflets (11.52 and 14.20 percent reduction) but significantly superior over the untreated check (15.72 mites/3 leaflets) (Table 1).

Spirotetramat is a new keto-enol and reported to intervene and inhibit lipid biosynthesis. It is reported as a good systemic insecticide that penetrates the plant leaves when sprayed and is also stated to be ambimobile that gets transported in both upward and downward direction through vascular bundles. This affecting lipogenesis drastically reduces fecundity, growth and fertility of sucking pests and provides excellent long-term suppression of pest populations (Bruck *et al.*, 2009) [2]. Imidacloprid is a nicotinic acetylcholine receptor (nAChR) inhibitor and results in disruption of the insect's nervous system (Sheets, 2010) [12]. As a result of new combination having quick action of inhibition of sucking pests proves to be the promising agent in the reducing the red spider mite population under protected cultivation. The present findings are supported by findings of Patel and Sarkar (2019) [9] that spirotetramat + imidacloprid against red spider mite on tomato was effective at a dosage of 500 and 625 ml/ha. Gajalakshmi and Gunasekaran (2017) [3] assessed the efficacy of spirotetramat 150 OD (60, 75 and 90 g a.i. ha^{-1}) in comparison with thiamethoxam 25 WG (25 g a.i. ha^{-1}) and dicofol 18.5 EC (250 g a.i. ha^{-1}) against two spotted spider mite, *T. urticae* on brinjal revealed that foliar application of spirotetramat at 90 and 75 g a.i. ha^{-1} was highly effective followed by spirotetramat at 60 g a.i. ha^{-1}.

Pyriproxyfen was reported as juvenile hormone analogue and an insect growth regulator thus mimicking a natural hormone. The said chemistry also disrupts the growth of whiteflies, mostly the nymphs and also causes suppression of embryogenesis in adult females. Being photostable it causes sustained control of sucking pests for a prolonged period (Boina *et al*., 2010) [1]. Whereas, fenpropathrin plays a vital role as pyrethroid ester insecticide, when ingested/comes in contact with the insect leads to death by interfering with kinetics of voltage gated Na channel (Soderlund, 2010) [13]. Thus above combination reduced the mite population effectively due to predominant complementary action of these chemicals. The present findings are supported by findings of Kalyan and Kalyan (2022) [5] reported that Pyriproxyfen 5% + Fenpropathrin 15% EC @ 750 ml was effective in reducing mites (68.92%) in okra.

Table 1: Efficacy of newer molecules against red spider mite

Treatments	Number of mites per 3 leaflets												Pooled Mean of three sprays	Percent reduction over UTC
	First spray				Second spray				Third spray					
	DBS	3 DAS	7 DAS	10 DAS	DBS	3 DAS	7 DAS	10 DAS	DBS	3 DAS	7 DAS	10 DAS		
T_1	9.04 (3.09)a	8.22 (2.95)e	9.19 (3.11)e	11.02 (3.39)de	16.46 (4.12)b	15.64 (4.02)e	16.61 (4.14)e	18.44 (4.35)d	14.92 (3.93)b	14.10 (3.82)f	15.07 (3.95)e	16.90 (4.17)de	13.91	11.52
T_2	8.98 (3.08)a	3.75 (2.06)c	4.09 (2.15)c	5.02 (2.35)c	12.64 (3.62)a	7.24 (2.78)d	7.45 (2.82)c	8.68 (3.03)c	11.82 (3.51)a	6.42 (2.63)d	6.63 (2.67)c	7.86 (2.89)c	6.35	59.68
T_3	9.68 (3.19)a	3.58 (2.02)c	3.89 (2.09)b	4.32 (2.19)b	12.16 (3.56)a	6.23 (2.59)c	6.57 (2.65)b	6.80 (2.70)b	11.46 (3.46)a	5.53 (2.45)c	4.87 (2.32)b	6.10 (2.57)b	5.32	65.81
T_4	8.89 (3.06)a	7.83 (2.88)de	8.39 (2.98)e	10.11 (3.26)d	16.14 (4.08)b	14.79 (3.91)e	15.32 (3.98)de	17.18 (4.20)d	14.27 (3.84)b	13.21 (3.70)ef	13.77 (3.78)de	15.41 (3.99)d	12.86	18.04
T_5	9.46 (3.16)a	8.21 (2.95)e	8.42 (2.99)e	10.59 (3.33)de	16.36 (4.11)b	15.11 (3.95)e	15.35 (3.98)de	17.49 (4.24)d	15.42 (3.99)b	13.65 (3.76)ef	14.38 (3.86)e	16.42 (4.11)d	13.29	15.40
T_6	9.07 (3.09)a	7.23 (2.78)d	7.51 (2.83)d	10.03 (3.24)d	15.85 (4.04)b	14.30 (3.85)e	14.58 (3.88)d	16.99 (4.18)d	14.25 (3.84)b	12.41 (3.59)e	12.69 (3.63)d	15.29 (3.97)d	12.34	21.57
T_7	9.62 (3.18)a	2.01 (1.58)a	2.15 (1.63)a	3.01 (1.87)a	11.45 (3.46)a	3.84 (2.08)a	3.98 (2.12)a	4.84 (2.31)a	10.80 (3.36)a	3.19 (1.92)a	3.33 (1.96)a	4.19 (2.17)a	3.39	78.35
T_8	9.26 (3.12)a	2.56 (1.75)b	2.73 (1.80)b	3.81 (2.08)b	11.59 (3.48)a	4.89 (2.32)b	5.06 (2.36)b	6.14 (2.58)b	10.92 (3.38)a	4.22 (2.17)b	4.39 (2.21)b	5.47 (2.44)b	4.36	72.19
T_9	9.05 (3.09)a	7.92 (2.90)de	8.75 (3.04)e	10.69 (3.34)de	16.23 (4.09)b	15.15 (3.96)e	15.93 (4.05)de	17.87 (4.28)d	14.78 (3.91)b	14.17 (3.83)f	14.48 (3.87)e	16.55 (4.13)de	13.50	14.20
T_{10}	9.64 (3.18)a	10.06 (3.25)f	10.72 (3.35)f	11.46 (3.46)e	16.81 (4.16)b	17.55 (4.25)f	19.16 (4.43)f	20.98 (4.63)e	15.12 (3.95)b	15.78 (4.03)g	17.64 (4.26)f	18.12 (4.31)e	15.72	-
S.Em. ±	NS	0.16	0.17	0.19	0.26	0.23	0.24	0.25	0.25	0.21	0.22	0.23		
C.D. at 5%	NS	0.49	0.50	0.56	0.77	0.68	0.69	0.74	0.74	0.64	0.65	0.70		

Figures in the parentheses are $\sqrt{x+0.5}$ transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (P = 0.05); NS – Non-Significant; DBS – Day before spraying; DAS – Days after spraying

T_1 = Spinosad 45 SC (0.25 ml/l); T_2 = Buprofezin 25 SC (1.0 ml/l); T_3 = Spinosad 45 SC + Buprofezin 25 SC (0.25 ml/l + 1.0 ml/l); T_4 = Thiamethoxam 12.6 ZC + Lambdacyhalothrin 9.5 ZC (0.25 ml/l); T_5 = Indoxacarb 14.5 SC + Acetamiprid 7.7 SC (1.0 ml/l); T_6 = Chlorantraniliprole 8.8 SC + Thiamethoxam 17.5 SC (1.0 ml/l); T_7 = Spirotetramat 11.01 SC + Imidacloprid 11.01 SC (1 ml/l); T_8 = Pyriproxyfen 5 EC + Fenpropathrin 15 EC (1.5 ml/l); T_9 = Chlorpyrifos 50 EC + Cypermethrin 5 EC (2.0 ml/l); T_{10} =Untreated Check (UT

Conclusion

From the present study it was found that spirotetramat 11.01 SC + imidacloprid 11.01 SC followed by pyriproxyfen 5 EC + fenpropathrin 15 EC were the most effective combinations in reducing mite population. These ready mix combinations of treatments have unique mode of action making them suitable to include in management practices for reducing the mite population in tomato under protected cultivation.

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