Evaluation of Integrated pest management modules for the management of leafhopper *Empoasca flavescens*(Fab.,) on castor *Ricinus communis*.

Abstract

Castor is an important oilseed crop. The castor bean contains about 50-55% oil. Among vegetable oils, castor oil is distinguished by its high content (over 85%) of ricinoleic acid. No other vegetable oil contains so high proportion of fatty hydroxy acids. Castor oil's unsaturated bond, high molecular weight (298), low melting point (5°C) and very low solidification point (-12°C to -18°C) makes it industrially useful, most of all for the highest and most stable viscosity of any vegetable oil. The castor plant has a substantial taproot with many lateral branches which can reach a great depth enabling them to withstand drought and most harsh weather conditions. Leaves of castor plants are large, glossy and green with pointed lobes and prominent veins; However, the castor leaf for many years has often been attacked by the leafhopper and in most cases leads to the destruction of the plant. The leafhopper causes hopperburn which renders the attacked leaves dry, uneven, curl downward in the shape of an inverted boat, margins turn brown and eventually death of the plant. Among the eight treatments, the lowest leafhopper/plant recorded by The T4 quinolphos and T6 Neem oil 2% recorded as best treatments over rest of the treatments. Significantly highest grain yield @3730.00 kg and 3627.63 kg recorded by T6 Neem oil 2% and T7 Pongamia oil 2% followed by T5 Mahuva oil recorded yield @ 3283.30kg. However the chemical treatments viz., T3 Profenophos 50 EC @0.03% and T4 quinolphos 25 EC @ 0.05% recorded yield @ 2956.66 and 2936.00 kg/ha both at par with each other. Where as untreated control recorded the lowest yield @2426.03 kg/ha.

Keywords

Castor (Ricinus communis); Hopperburn; Leafhopper (*Empoasca flavescens*); Wax bloom

Introduction: Castor is one of the industrially important non-edible oil seed crops of the world. India ranks first among the major castor producing countries [Brazil and China] in the world occupying 68% of area and 85% of castor seed production [Anonymous, 2019]. In India, castor production of 10.82 lakh MT during 2019-20 and is grown in an area of 9.92 lakh ha and mainly cultivated in Gujarat, Rajasthan, Andhra Pradesh and Karnataka. Gujarat occupies about

65% of the total share in area and contributes 75% share in production, while Karnataka occupies 9,527 ha in area with a production of 4,722 MT [Mohan Kumar and Yamanura, 2019].

Although there are about 20 species of insect pests were associated with castor in reality extremely irregular in nature of incidence and their occurrence over the years, distributed in patches with less infestation causing no remarkable damage to the crop. Around 10 species belonging to Othoptera, Lepidoptera, Hemiptera, and Thysanoptera showed variable economic significance and five species were observed as high degree of severity and regular in nature as major pests affecting crop production by either defoliators or sucking pests. In southern part of India, the order of magnitude of insect pest and its damage and problem arises to quite high, where it is grown mainly as rainfed crop, resulting in lower seed yield. The pest problem in castor include defoliators namely *A. janata*, tobacco caterpillar, semilooper, *S. litura*, capsule borer, *C. punctiferalis* [Sarma *et al*., 2005]. The sucking pests namely *flavescens* Fab., leafhopper, *E.* , thrips, *Retithrips syniacus* Mayet and white fly, *T. ricini*also cause considerable damage to crop [Lakshminarayana and Raoof, 2005].

Apart from defoliators such as borers sap feeders have great regional importance and quite sporadic in nature, these pests *viz*., castor gallfly,spiny caterpillar, *Ergollis merione* C. *Aspondylia ricini* M., and red spider mite, *Tetranychus telarius* L. In Gujarat, castor inflorescence thrips [*Scirtothrips dorsalis* Hood] also attained a pest status by infesting the crop causing considerable loss to the crop in the flowering stage. Highly resistant and polyphagous pest, *Helicoverpa armigera* Hubner also causes considerable damage to castor crop by feeding foliage at vegetative stage and boring into the castor capsules at later stage [Basappa, 1995].

In the castor ecosystem, insect pests are also having good number of natural enemies and attack at different growth stages, among them; the egg parasitoid, *Trichogramma chilonis* Ishii; larval parasitoid, *Microplitis maculipennis* Szepligate, insect predators, insectivorous birds and some of the microbial agents exert greater biological resistance in the succession of the pest complex of castor [Basappa, 2003].

Due to severe pest outbreak such as leafhoppers, semiloopers, cutworms, whiteflies, hairy/slug caterpillars, capsule borers, etc. remarkable yield losses occur in cultivated castor [Jayaraj and Diraviam, 2004]. Basic inputs like fertilizers and pesticides greatly helps in enhancing the production and productivity of crops. Indiscriminate use of chemical pesticides and fertilizers have drastic impact on environment by affecting soil fertility,development of insect resistance, genetic variation in plants, increasing toxic residue through food chain water hardness, and animal feed thus increasing health problems and many more. This necessitates to introduce measures that can harness challenges arise due to chemical pesticides. Thus, use of bio-pesticides and bio-fertilizers can play a major role in dealing with these challenges in a sustainable way [Gupta, 2010].

In recent years, the application of synthetic insecticides in crop protection program resulted in adverse effect on the environment, pest resurgence and pest resistance in the existing pest population and noticing pesticide residues in the crop produce, etc. This lead to increased importance of naturally occurring plants associated with rich traditional knowledge base available with the highly diverse indigenous communities in India, as it is an environmental friendly agricultural technology for ensuring food safety and food security [Raghavendra *et al*., 2016]. India is in a possession of vast potential use of bio-pesticides. Some bio-pesticides currently developed may be excellent alternative to chemical pesticides. Bio-pesticides being target pest specific presumed to be relatively safe to non-target organism including humans, livestocks and water bodies. However, in India, some of the bio-pesticides like Bt, NPV and and plant based neem, mahua bio-pesticides; *Trichderma*, pongamia etc and have already been registered and are also being practiced. There are many locally available plants like beshram, neem, garlic, *etc.* which can be easiy processed and used for the management of many of the hard-core insect pests of crops [Dutta, 2015]. Keeping the above information and literature pertaining to the current investigation in view, it is evident that, castor is being majorly affected by the lepidopteran defoliators and sucking pests. Hence, management of defoliators as well as sucking pests through integrated/eco-friendly approach is of prime importance to keep the pest population below the level of economic injury. In this context, current investigation has been undertaken by adopting integrated approaches for the management of sucking pest leafhopper *Empoasca flaviscens* on castor.

MATERIALS AND METHODS: The DCH-177 variety of castor seeds were sown at 90 x 60 cm spacing in plots of 5.0 x 5.0 m adopting Randomized Complete Block Design [RCBD] with three replications at Zonal Agricultural Research Station, University of Agricultural Sciences [UAS], Gandhi Krishi

Vigyan Kendra [GKVK], Bengaluru during 2018-19 and 2019-20. Before sowing, the seeds were soaked in cold water to smoothen the seed coat that makes easy for the germination. Two seeds were dibbled at each spot. Sprouting of seeds was observed after one week. The newly germinated seedlings were allowed to grow for few days, later thinning was done. Among the two seedlings in each spot, healthy seedling was allowed to grow and weak and slow growing seedlings were removed. This technique was followed for maintaining optimum population in the field. The crop was raised by following recommended package of practices [except for plant protection measures] developed for rainfed condition with protective irrigation as and when required for better crop stand and to maintain required population in the field [Anonymous, 2016]. Treatments imposed immediately after the leafhopper population reached above the threshold level. Second spray was under taken at 25th days after first spray.

The observations of leafhopper *Empoasca flaviscens* recorded from 6 randomly selected plants from each treatments at one day before imposition of treatment and 3,7,11 and 15 days after imposition of treatments. Simultaneously natural enemies like green lace wings, damselfly and other natural enemies populations were also recorded along with leafhopper population. Data collected from the experimental plot before and after the treatments imposition subjected to statistical analysis.

Table1 : Test pesticides used in the study:

Sl No.	Common name	Trade name	Formulation	Dosage [ml/litre]	Source of supply
1	Fenvalerate	Rocket	20 EC	1.00	TATA (Rallys) Mumbai
2	Profenophos	Prahar	50 EC	0.75	Biostadt (India) Ltd., Mumbai
3	Quinalphos	Ekalux	25 EC	1.50	Bayer (India) Ltd., Mumbai
4	Mahuva oil	-	-	-	M/S Venkateshwara Oil Manufacturers, Hoskote Taluk, Bengaluru Rural District
5	Neem oil	-	-	-	
6	Pongamia oil	-	-	-	

Results and Discussion:

The insecticides were tested under field conditions on the basis of number of leafhopper per plant. It is clear from the result that the leafhopper population did not vary significantly among the treatments before application of insecticides at 3 days after spraying the population of leafhopper/plant goes on decreasing among the chemical and plant based insecticidal treatments up to 15 days after spraying leafhopper/plant maintained under normal limit. Among the eight treatments, the lowest leafhopper/plant recorded by T6 Neem oil 2% with 59.60% reduction over control followed by T5 Mahuv aoil 2% recorded 57.53% reduction over control recorded during 1st spray. The population of leafhopper per plant was highest recorded by T1 treatment it was mainly due to, this treatment did not receive any insecticidal spray either chemical or plant based insecticides throughout the experimental period. Same trend was noticed after 2nd spray also. During 2nd spray highest percent of reduction over control recorded by T4 QUINOLPHOS 25 ec @ 0.05% recorded 89.64% reduction over control followed by T6 Neem oil2% recorded 85.60% reduction over control. In both the spraying population of leafhopper considerably reduced after 3 days after spraying and continued even after 15 days. Lowest population of leafhopper per plant recorded by T4 Quinolphos 25 EC @0.05% and T6 Neem oil2% which were statistically at par with throughout the observation. The T4 quinolphos and T6 Neem oil 2% recorded as best treatments over rest of the treatments. The grain yield in the treatment. Significantly highest grain yield @3730.00 kg and 3627.63 kg recorded by T6 Neem oil 2% and T7 Pongamia oil 2% followed by T5 Mahuva oil recorded yield @ 3283.30kg. However the chemical treatments viz., T3 Profenophos 50 EC @0.03% and T4 quinolphos 25 EC @ 0.05% recorded yield @ 2956.66 and 2936.00 kg/ha both at par with each other. Where as untreated control recorded the lowest yield @2426.03 kg/ha.

Efficacy IPM Modules on natural enemis populations at different days after imposition of treatments:

Green lacewings :

Selective integrated management practices adopted against leafhopper on castor showed non-significant variation with respect to green lacewing population on a day before their imposition. On the other hand, their number varied significantly at 3rd, 7th, 11th and 15th days after the imposition of treatments. Considerable reduction in population of green lacewings was noticed when selective integrated management practices consists of chemical and plant based insecticides used for the management of leafhopper on castor. At 3rd day, T0 [Control] [1.247/plant] and T1 [Cucumber+ *T. chelonis* @ 2 lakh eggs/ha at 30 DAS] [1.143/plant] recorded significantly highest population of green lacewings as these two treatments did not receive insecticidal spray and similar trend was noticed at 7th [1.100 and 1.023/plant], 11th [1.000 and 0.830/plant] and 15th days [1.143 and 0.867/plant] after imposition of treatments, respectively. Among the chemical and plant based treatments, at 3rd day, T3 [Profenophos 50 EC @ 0.03%] recorded highest population of 0.843/plant with a reduction of -35.35% population over control, while at 7^{th} day, T7 [Pongamia oil @2%] recorded a green lacewing population of 1.023/plant with a meager reduction of -7.527% population as compared to control. However, at 11^{th} and 15^{th} days, T3 [Profenophos 50EC @ 0.03%] and T7 [Pongamia oil @2%] registered highest green lacewing population of 0.800 and 0.857/plant with -26.08 and -32.99% decrease in population over control, respectively.

Damselfly

Damselfly population varied on a day before the imposition of selective integrated management practices adopted for the management of leafhopper on castor. Considerable increase in population of damselfly was observed in T1 [Cucumber+ *T. chelonis* @ 2 lakh eggs/ha at 30 DAS] [0.923, 0.990, 0.933 and 0.943/plant] and T0 [Control] [0.900, 0.930, 0.890 and 0.833/plant] at different days [3^{rd}, 7^{th}, 11^{th} and 15^{th}] after imposition of integrated management practices on castor as these two treatments did not receive either chemical or plant based insecticides. Among the chemical and plant based treatments, T6 [Neem oil @ 2%] at 3^{rd} day [0.867/plant] and T7 [Pongamia oil @2%] at 7^{th} [0.800/plant], 11^{th} [0.833/plant] and 15^{th} day [0.780/plant] recorded considerable increase in population but their number decreased by -3.667, -16.95, -5.181 and -7.001 when compared to control, respectively

Other natural enemies

Population of other natural enemies not varied significantly on a day before and 3^{rd} day after imposition of integrated management practices adopted against leafhopper on castor. Notably, at 7^{th} day, significantly highest population of other natural enemies [0.680/plant] were recorded in T7 [Pongamia oil @ 2%] with 12.21% increase over control. At 11^{th} day, T1 [Cucumber+ *T.chelonis* @ 2 lakh eggs/ha at 30 DAS] recorded highest population of other natural enemies [0.633/plant] with 11.64% increase when compared to control. On the other hand, significantly higher population of other natural enemies [0.530/plant] was recorded in T0 [Control] at 15^{th} day after imposition of integrated management practices together with T6 [Neem oil @ 2%] and T7 [Pongamia oil @ 2%] where both of them recorded other natural enemies population of 0.500/plant with a meagre reduction of -7.143% over control

TABLE 2: Effect of chemical and plant based pesticides on leafhopper *Empoasca flaviscens* on castor 2018-19

Sl.no	Integrated management pracrices	Pre	Leafhopper /plant 2018-19		Yield kg/ha

		treatment	3 DAS	7DAS	11 DAS	15 DAS	% ROC	3 DAS	7DAS	11 DAS	15 DAS	% ROC	
			(1st spray)					(2nd spray)					
1	T0 control	30.66 (33.62)	32.20 (35.18)	33.10 (35.12)	34.78 (36.14)	36.21 (36.99)	------	37.46 (37.74)	39.20 (38.76)	42.43 (40.64)	43.03 (40.99)	------	2426.03
	T1 cucumber +release of *T.chelonis* 2 lakhs eggs/ha @30 DAS	31.38 (34.07)	31.94 (34.41)	30.20 (33.33)	29.36 (32.81)	27.43 (31.58)	24.25	30.76 (33.68)	25.43 (30.31)	20.08 (26.62)	18.81 (25.70)	56.29	2730.03
2	T2 release of *T.chelonis* 2 lakhs eggs/ha @30 DAS +Fenvalerate20EC@0.02%	31.22 (33.96)	26.89 (31.23)	23.16 (28.76)	19.00 (25.81)	17.40 (24.65)	51.95	19.70 (26.34)	16.35 (23.84)	14.13 (22.08)	11.93 (20.20)	72.28	2793.36
3	T3 release of *T.chelonis* 2 lakhs eggs/ha @30 DAS + Profenophos 0EC@0.03%	31.05 (33.86)	25.22 (30.17)	21.76 (27.80)	20.16 (26.67)	18.45 (25.43)	49.05	20.50 (26.91)	17.18 (24.48)	12.26 (20.48)	6.71 (15.00)	84.41	2956.66
4	T4 release of *T.chelonis* 2 lakhs eggs/ha @30 DAS + Qinolphos 25EC@0.05%	30.99 (33.83)	23.44 (28.95)	20.30 (26.77)	17.77 (24.93)	15.90 (23.49)	56.09	17.56 (24.77)	15.03 (22.81)	9.45 (17.89)	4.46 (12.13)	89.64	2936.00
5	T5 release of *T.chelonis* 2 lakhs eggs/ha @30 DAS +Mahuva oil 2%	30.83 (33.72)	22.77 (28.49)	21.10 (27.34)	17.96 (25.06)	15.38 (23.08)	57.53	16.25 (23.76)	14.80 (22.62)	13.55 (21.59)	7.13 (15.42)	83.44	3283.30
6	T6 release of *T.chelonis* 2 lakhs eggs/ha @30 DAS + Neem oil 2%	30.79 (33.69)	21.53 (27.64)	20.18 (26.69)	16.95 (24.31)	14.63 (22.48)	59.60	15.62 (23.28)	13.16 (21.27)	9.50 (17.92)	6.20 (14.39)	85.60	3730.00
7	T7 release of *T.chelonis* 2 lakhs eggs/ha @30 DAS + Pongamia oil 2%	31.05 (33.86)	21.03 (27.29)	20.11 (26.64)	17.95 (25.06)	16.10 (23.65)	55.54	17.20 (24.50)	15.50 (23.18)	13.08 (21.18)	7.60 (15.99)	82.34	3627.63
Sem±		0.16	0.58	0.49	0.69	0.40	——	0.37	0.47	0.57	0.59		91.66
CD		NS	1.71	1.49	2.08	1.22		1.11	1.41	1.71	1.79		275.00
CV		-----	3.79	3.59	5.46	3.46		3.89	4.12	5.83	7.72		13.10

Values in parentheses are Arc sign transformed values

Table3 : Efficacy of selective Integrated management practices on natural enemie green lacewing at different days after imposition of treatment on castor 2018-19

Integrated management practice	Day before imposition	Third day	Seventh day	Eleventh day	Fifteenth day
T_0 =Control	1.023 ± 0.053	1.247 ± 0.153	1.100 ± 0.085	1.000 ± 0.017	1.143 ± 0.030
T_1 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS	0.933 ± 0.071 [-8.798]	1.143 ± 0.057 [-8.340]	1.023 ± 0.039 [-7.000]	0.830 ± 0.100 [-22.16]	0.867 ± 0.082 [-24.15]
T_2 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Fenvalerate 20 EC @ 0.02%	1.023 ± 0.079 [0.000]	0.800 ± 0.040 [-39.11]	0.843 ± 0.030 [-25.12]	0.767±0.020 [-23.30]	0.810 ± 0.092 [-38.41]
T_3 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Profenophos 50 EC 0.03%	0.820 ± 0.146 [-21.76]	0.843 ± 0.070 [-35.35]	0.857 ± 0.059 [23.75]	0.800 ± 0.051 [-26.08]	0.770 ± 0.000 [-43.02]
T_4 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Quinalphos 25 EC @ 0.05%	0.957 ± 0.047 [-7.074]	0.643 ± 0.047 [-52.84]	0.697 ± 0.033 [-39.39]	0.623 ± 0.079 [-49.15]	0.757 ± 0.030 [-44.52]
T_5 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Mahua oil @ 2%	1.037 ± 0.033 [1.501]	0.577 ± 0.062 [-58.62]	0.833 ± 0.082 [-26.10]	0.723 ± 0.096 [-36.12]	0.810 ± 0.042 [-38.41]
T_6 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Neem oil @ 2%	0.937 ± 0.033 [-9.218]	0.723 ± 0.062 [-45.84]	1.000 ± 0.058 [-9.775]	0.797 ± 0.033 [-26.47]	0.823 ± 0.101 [-36.91]
T_7 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Pongamia oil @ 2%	1.080 ± 0.010 [6.109]	0.823 ± 0.039 [-37.10]	1.023 ± 0.029 [-7.527]	0.753 ± 0.039 [-32.20]	0.857 ± 0.057 [-32.99]
Mean	0.976 ± 0.026	0.850 ± 0.051	0.922 ± 0.031	0.787 ± 0.028	0.855 ± 0.030
F - value	1.342^{NS}	9.716^{**}	5.762^{**}	2.905^{*}	3.755^{*}

DAS : Days after sowing *: $p \leq 0.05$ **: $p \leq 0.01$ NS: Non-significant [ ] : Per cent change over control

Table4 : Efficacy of selective Integrated management practices on natural enemie damselfly at different days after imposition of treatment on castor 2018-19

Integrated management practice	Day before imposition	Third day	Seventh day	Eleventh day	Fifteenth day
T_0 =Control	0.813 ± 0.030	0.900 ± 0.040	0.930 ± 0.000	0.890 ± 0.010	0.833 ± 0.067
T_1 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS	0.867 ± 0.117 [6.642]	0.923 ± 0.053 [2.653]	0.990 ± 0.061 [7.823]	0.933 ± 0.020 [17.23]	0.943 ± 0.043 [14.53]
T_2 =Sowing of cucumber along with castor + release of *Trichogramma chil onis* @ 2 lakh eggs/ha at 30 DAS + Fenvalerate 20 EC @ 0.02%	0.603 ± 0.033 [-24.22]	0.380 ± 0.049 [-59.98]	0.367 ± 0.038 [-73.40]	0.423 ± 0.039 [-44.22]	0.233 ± 0.049 [-79.26]
T_3 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Profenophos 50 EC 0.03%	0.433 ± 0.020 [-43.83]	0.477 ± 0.091 [-48.79]	0.443 ± 0.127 [-63.49]	0.357 ± 0.013 [-52.17]	0.500 ± 0.101 [-43.99]
T_4 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Quinalphos 25 EC @ 0.05%	0.523 ± 0.039 [-33.45]	0.397 ± 0.033 [-58.02]	0.437 ± .0330 [-64.28]	0.447 ± 0.039 [-41.33]	0.487 ± 0.030 [-45.71]
T_5 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Mahua oil @ 2%	0.777 ± 0.023 [-4.152]	0.737 ± 0.067 [-18.80]	0.653 ± 0.062 [-36.12]	0.787 ± 0.030 [-0.361]	0.657 ± 0.098 [-23.25]
T_6 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Neem oil @ 2%	0.967 ± 0.049 [17.76]	0.867±0.052 [-3.667]	0.767±0.033 [-17.53]	0.830 ± 0.100 [5.063]	0.757 ± 0.072 [-9.124]
T_7 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Pongamia oil @ 2%	0.877 ± 0.029 [7.382]	0.853 ± 0.039 [-5.421]	0.800 ± 0.051 [-16.95]	0.833 ± 0.020 [-5.181]	0.780 ± 0.049 [-7.001]
Mean	0.733 ± 0.040	0.692 ± 0.049	0.673 ± 0.050	0.675 ± 0.046	0.649 ± 0.049
F - value	13.40**	17.68**	14.99**	27.18**	11.42**

DAS : Days after sowing **: $p \leq 0.01$ NS: Non-significant [ ] : Per cent change over control

Table5 : Population of other natural enemies at different days after imposition of selective integrated management practices on castor 2018-19

Integrated management practice	Day before imposition	Third day	Seventh day	Eleventh day	Fifteenth day
T_0 =Control	0.690 ± 0.061	0.553 ± 0.077	0.623 ± 0.079	0.567 ± 0.033	0.530 ± 0.058
T_1 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS	0.603 ± 0.033 [-12.61]	0.490 ± 0.076 [-11.39]	0.467 ± 0.084 [-25.04]	0.633 ± 0.082 [11.64]	0.420 ± 0.067 [-20.76]
T_2 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Fenvalerate 20 EC @ 0.02%	0.500 ± 0.051 [-31.51]	0.547 ± 0.062 [-1.224]	0.320 ± 0.049 [-64.88]	0.357 ± 0.030 [-33.18]	0.210 ± 0.076 [-76.19]
T_3 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Profenophos 50 EC 0.03%	0.557 ± 0.030 [-22.06]	0.543 ± 0.047 [-2.041]	0.400 ± 0.017 [-47.75]	0.477 ± 0.062 [-14.22]	0.220 ± 0.049 [-73.81]
T_4 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Quinalphos 25 EC @ 0.05%	0.543 ± 0.047 [-24.38]	0.433 ± 0.052 [-24.49]	0.433 ± 0.078 [-40.69]	0.323 ± 0.023 [-38.55]	0.367 ± 0.038 [-38.81]
T_5 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Mahua oil @ 2%	0.500 ± 0.051 [-31.51]	0.413 ± 0.030 [-28.57]	0.443 ± 0.047 [-38.54]	0.447 ± 0.077 [-18.96]	0.387 ± 0.043 [-34.05]
T_6 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Neem oil @ 2%	0.567 ± 0.020 [-20.40]	0.513 ± 0.072 [-8.163]	0.490 ± 0.059 [-28.48]	0.453 ± 0.023 [-18.01]	0.500 ± 0.017 [-7.143]
T_7 = Sowing of cucumber along with castor + release of *Trichogramma chilonis* @ 2 lakh eggs/ha at 30 DAS + Pongamia oil @ 2%	0.590 ± 0.010 [-16.584]	0.377 ± 0.053 [-35.92]	0.680 ± 0.095 [12.21]	0.487 ± 0.057 [-12.64]	0.500 ± 0.051 [-7.143]
Mean	0.569 ± 0.017	0.484 ± 0.022	0.482 ± 0.030	0.468 ± 0.025	0.392 ± 0.029
F - value	2.222^{NS}	1.255^{NS}	2.993^{*}	3.585^{*}	5.495^{**}

DAS : Days after sowing *: $p \leq 0.05$ **: $p \leq 0.01$ NS: Non-significant [ ] :Per cent change over control

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