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ROLE OF OKRA PLANT EXTRACT TO ENHANCE THE HOST SEARCHING ACTIVITY

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ABSTRACT
Laboratory and field investigations were undertaken during 2013 and 2014 at College of Horticulture, Bidar, Karnataka to assess the competence of extracts obtained from okra plant in enhancing host searching ability of *Trichogramma* species and later the performance of plant extracts as IPM component in okra. Among the different okra genotypes the hexane bud wash obtained from Parabhani Kranti attracted highest number of *Trichogramma chilonis* adults (5.72 out of 10) in eight arm olfactometer and Mahalaxmi Amisha effected lowest attraction (one *T. chilonis* adult). Among the different species *T. chilonis* registered highest parasitisation (29.01%) on leaf. IPM module M-II (with spray of Parabhani Kranti okra leaf extract) recorded highest parasitism on *Helicoverpa armigera* eggs (27.43%) compared to IPM module M-I (without the spray of leaf extract) (21.72 % parasitism). M-II module registered significantly lower fruit damage (11.79%) and higher yield (122.4 q/ha) compared to M-I module (16.19 % fruit damage and 112.7 q/ha yield). RPP recorded highest fruit damage (22.53%) and lowest yield (103.3 q/ha). Parabhani Kranti okra leaf extract as an effective IPM component enhanced the field parasitisation of *H.armigera* eggs by *T. chilonis*.

INTRODUCTION

Horticultural production especially vegetables play a very important role in global food security. Besides being a vegetable, it acts as clarifying agent in jaggery preparation (Chauhan, 1972). Crude fiber derived from the stem of okra plant is used for rope making. India tops the list of okra producing countries in the world with an area of 0.53 Mha, 6.35 Mt production and 12 tonnes/ha productivity (Anonymous, 2013). One of the important limiting factors in cultivation of okra is insect pests (Zala *et al.,* 2015), of which fruit borer, *Helicoverpa armigera* (Hubner) remains the most serious constraints causing 22.1% yield loss (Dandapani *et al.,* 2003).

The chemical means of pest control has lead to the development of resistance, high cost of plant protection, residue problem and several other ecological backlashes. As a compliment to the chemical control the conventional biological control aims to achieve pest management below economic threshold level. However, biological control measures have failed to achieve acceptable containment of the pest. It has been demonstrated that the olfactory cues from the host plant also influence the parasitoid/predator action on the pest (Smiley, 1978; Lewis *et al.* 1972; Barbosa and Latourneau, 1988). This would obviously increase the rate of parasitisation and hence, success in biological control.

The *Trichogramma* has been recorded on various lepidopterous pests on different crops like yellow stem borer in rice (Bhushan *et al.,* 2012), brinjal shoot and fruit borer (Tamoghna *et al.,* 2014) and many others. However, the basic information on plant extracts (containing infochemicals) responsible for attracting the parasitoid has not been exploited extensively in Integrated Pest Management. Hence, the present studies were taken up to assess the role of okra plant extract to enhance the host searching activity and parasitisation by *Trichogramma* species on *Helicoverpa armigra* eggs and later the performance of the plant extract as a component in the IPM programme.

MATERIALS AND METHODS

Evaluation of *T. chilonis* behaviour towards the bud washes of different okra genotypes

An investigation was undertaken during 2013 to assess the influence of synomone of okra genotypes *viz.,* Parabhani Kranti, Ankur (AROH-10), Mahalaxmi Amisha and Shakti-303 on orientation of *T. chilonis*. The hexane bud wash of okra genotypes was prepared by dipping two live buds in 5 ml of hexane for 30 minutes. In an olfactometer, bud wash of different okra genotypes through cotton swab was presented to 10 adults of *T. chilonis* and they were allowed free movement. The olfactometer was rotated intermittently to overcome azimuthal or geographical effect on parasitoids. The number of parasitoids attracted to different bud washes was registered. Experiment was replicated six times. The experiment was conducted by following the standard procedure described by Hanumanthraya *et al.,* 2008.

Evaluation of okra plant parts in causing *H. armigera* egg parasitisation by *Trichogramma* species

Investigations on the influence of synomones of okra genotypes revealed that Parabhani Kranti was most effective in attracting the *Trichogramma* species. Hence, to assess the impact of substrates *viz.,* Parabhani Kranti okra leaf and flower bud on parasitic competence of *Trichogramma* species using *H. armigera* eggs as host, a study was conducted by following the standard method described by Satyanarayana, 2004 . *H. armigera* was reared in laboratory to obtain the stock of eggs needed for the study. Hundred eggs of *H. armigera* were collected and glued on the okra leaf lamina and flower buds and were exposed to five different *Trichogramma* species *viz., Trichogramma japonicum* (Ashmead), *Trichogramma pretiosum* (Riley), *Trichogramma achaea* (Nagaraja and Nagarakatti), *Trichogramma brasiliensis* (Ashmead) and *Trichogramma chilonis* (Ishii) for 24 hrs in 300 ml beaker. Five replications were made for each of the five species. Parasitisation was accomplished in the beakers fastened with muslin cloth on open end. Ten per cent honey was provided as streaks on the inner walls of the beakers to nourish parasitoids. After 24 hrs of exposure to the parasitisation the eggs were withdrawn, the parasitisation was observed on third day after release. The host, *H. armigera* egg hatching from remaining unparasitized eggs was also recorded.

Evaluation of Integrated pest management modules using promising okra genotype and effective *Trichogramma* species

The practice of releasing the *Trichogramma* parasitoids to combat the fruit borers in IPM approach is already in vogue. However, as evidenced in the earlier investigations, the ability of Parabhani Kranti plants volatiles to attract higher number of *T. chilonis* individuals has not been exploited hitherto. A study was conducted to observe the fitness of Parabhani Kranti leaf extract spray in IPM prior to the release of *T. chilonis*. The study was undertaken in 0.2 ha. area each with two different modules (Table 1) and were compared with recommended plant protection schedule (Anonymous, 2013a) during Kharif 2013 season. The Mahalaxmi Amisha okra variety which was observed to attract lowest number of *T. chilonis* was sown on 24th June, 2013 with spacing of 45cms X 30 cms and crop was raised by following package of practices (Anonymous, 2013a) recommended for the region, except plant protection measure which was followed as mentioned in schedule (Table 1). In module II (M-II) release of *T. chilonis* was preceded by spray of 5 % aqueous extract of Parabhani Kranti okra leaf derived from Parabhani Kranti okra plants grown separately. In both modules treatments were imposed only when pest population reached ETL. Suitable replications in each block were made for taking observations and for statistical analysis.

To confirm impact of genotype in attracting *T. chilonis* parasitoid, Parabhani Kranti okra variety was raised in separate piece of land and IPM schedule and RPP was followed for plant protection during *Kharif* 2014.

Three days after the release, the eggs collected from tagged plants were observed for parasitism. Observations made were converted to percentage. The *H. armigera* egg load and fruit damage were noted by selecting 5 plants randomly from each block. Okra yield data recorded from each block were computed to hectare basis.

RESULTS AND DISCUSSION

Evaluation of *T. chilonis* towards the bud washes of different okra genotypes

Highest number of *Trichogramma* adults (5.72) were attracted by the budwash derived from the Parabhani Kranti okra variety (Table 2). The Mahalaxmi Amisha okra varietiy effected the lowest attraction (1.00 adult). Synomones in the different genotypes was directly responsible for the difference in the number of *Trichogramma* adults attracted to the bud washes obtained from the different okra genotypes. Similar attributes were observed by Anon. (1998) and Satyanarayana (2004) while deciphering the reason for difference in number of *Trichogramma* individuals attracted towards cotton genotypes. The findings are in line with reports of Hanumanthraya *et al.* 2008 who described that the difference in the composition of the synomones in the different genotypes of the safflower is the direct cause for the difference in the attraction by the parasitoid

Evaluation of okra plant parts in causing *H. armigera* egg parasitisation by *Trichogramma* species

Highest parasitism (29.01%) was registered by *T. chilonis* on leaf (Table 3). The *Trichogramma pretiosum* and *T. japonicum* recorded lowest parasitisation of 17.02 and 15.82 per cent,

Table 1: Components of plant protection modules used in present study

Sl.No	Components of M-I	Components of M-II	Recommended Package of Practices (RPP)
1	Oxydemeton methyl 25 EC @ 1.3 ml/l at 15 DAS	Oxydemeton methyl 25 EC @ 1.3 ml/l at 15 DAS	Oxydemeton methyl 25 EC @ 1.3 ml/l at 15 DAS
2	NSKE @ 5% at 25 DAS	NSKE @ 5% at 25 DAS	Malathion 50 EC @ 2 ml/l at 35 DAS
3	Release of *T. chilonis* (5 releases at weekly interval) @ 2.5 lakh/ha 35 days onwards	Parabhani Kranti leaf extract spray followedby - Release of *T. chilonis* (5 releases at weekly interval) @ 2.5 lakh/ha 35 days onwards	
4	Malathion 50 EC @ 2 ml/l at 45 DAS	Malathion 50 EC @ 2 ml/l at 45 DAS	
5	NSKE 5% @ at 55 DAS	NSKE 5% @ at 55 DAS	
6	*Bacillus thuringiensis var. kurstaki* @ 1 ml/l	+ HaNPV @ 250 LE/ha at 65 DAS	*Bacillus thuringiensis var. kurstaki* @ 1 ml/l + HaNPV @ 250 LE/ha at 65 DAS
7	NSKE 5% at 75 DAS	NSKE 5% at 75 DAS	

Table 2: Attraction of *T. chilonis* to the Bud washes of different okra genotypes

Sl.No	Verities	Number of *T. chilonis* attracted
1	Parabhani Kranti	5.72[a]
2	Shakti-303	2.02[b]
3	Ankur (AROH-10)	1.24[c]
4	Mahalaxmi Amisha	1.00[c]

Note: In vertical columns means followedby same letters are not different statistically (p = 0.01) by DMRT.

respectively. Cumulative mean parasitisation on leaves (22.41%) was significantly higher compared to flower buds (18.00%). Among the different parasitoids tested *T. chilonis* registered highest cumulative mean parasitisation (26.92 %) and *T. japonicum* the lowest (13.43 %). With the advancement in the age, the plant undergoes selective but destructive changes. Synomone in the later stage of the crop growth especially in reproductive parts might have receded leading to the decline in the ability of the plant parts to attract the *T. chilonis*. Hence, leaf must have supported higher parasitism compared to flower buds, further as observed in course of investigation *T. chilonis* was most responsive, hence, brought about highest parasitisation among the different *Trichogramma* species tested. The present findings corroborate with Romies *et al*. (1997) and Satyanarayana (2004) who reported the repulsion of *Trichogramma* to the volatiles derived from the reproductive stage of pigeonpea and cotton, respectively.

Host *H. armigera* egg hatching

Egg hatching showed reciprocal trend to that of parasitisation. The egg hatching was significantly highest from the eggs recovered from flower buds (56.03%) and leaf (51.21%) after parasitism by *T. japonicum* (Table 4). The *T. chilonis* recorded lowest egg hatching both on flower buds (21.05%) and leaf (17.05%). Among the two substrates cumulative mean egg hatching was significantly higher (37.88%) on flower buds. The rate of parasitisation on leaf surface was significantly higher than on flower bud surface, consequently, the number of unparasitized *H. armigera* eggs recovered from leaf surface, after the culmination of parasitisation by *T. chilonis* was lower compared to the eggs obtained from the flower bud surface. Hence, the decreased rate of host *H. armigera* egg hatching was observed in the eggs obtained from leaf surface compared to the eggs obtained from the flower bud surface.

Evaluation of IPM Modules

H. armigera egg load and parasitism in different modules on Mahalaxmi Amisha okra variety during Kharif, 2013

IPM module M-I recorded significantly highest egg load of 1.83 and differed significantly from module M-II (0.67 eggs) and RPP (0.33 eggs) (Table-5). M-II was significantly superior over other 2 practices by registering highest parasitism of 27.43 per cent.

The RPP showed lowest egg load compared to IPM schedules on both Mahalaxmi Amisha and Parabhani Kranti genotypes (Table-5 and Table-6). This was due to the fact that IPM schedules failed to lower the oviposition by gravid moths, *H. armigera,* thus, registered highest number of eggs per plant. The results obtained are in agreement with findings of Sreenivas (1996). Highest parasitism was observed in M-II compared to M-I and RPP. This was because in M-II, *T. chilonis* release was preceded by spray of okra leaf extract of Parabhani Kranti variety. The ability of Parabhani Kranti to enhance the parasitism was evident by the observations made during *Kharif,* 2014 and bud wash study also. The results obtained in the present investigation corroborate with findings of Sreenivas (1996) who reported the parasitisation of *H. armigera* eggs to the tune of 18.5 percent in IPM module as against no activity of parasitoid, *Trichogramma* spp in RPP module.

H. armigera egg load and parasitism in different modules on Parabhani Kranti okra variety during Kharif, 2014.

The Module M-I recorded significantly highest egg load (1.79) and differed significantly from RPP (0.22 eggs). On the contrary,

Table 3: Influence of substrates for parasitic competence of *Trichogramma* species

Sl.No	Parasitisation	Percent parasitisation at 3 days of release		
		Leaf	Flower buds	Cumulative mean
1	*T. pretiosum*	17.02[c](24.35)	12.01[c](20.27)	14.42[c](22.30)
2	*T. japonicum*	15.82[c](23.42)	11.04[c](19.37)	13.43[d](21.47)
3	*T. brasiliensis*	25.17[b](30.13)	21.11[b](27.35)	23.14[b](28.73)
4	*T. achaea*	25.05[b](30.00)	21.01[b](27.28)	23.03[b](28.66)
5	*T. chilonis*	29.01[a](32.58)	24.83[a](29.87)	26.92[a](31.24)
Cumulative mean	22.41[a](28.25)	18.00[b](25.10)	-	

Note: Figures in parentheses are arc sine transformed values used for statistical analysis; In vertical columns means with the same letters are not different statistically (P = 0.01) by DMRT

Table 4: Host, *H. armigera* egg hatching after the release of parasitoids

Sl.No	Parasitoids	Per cent egg hatching		
		Leaf	Flower buds	Cumulative mean
1	*T. pretiosum*	36.23[b](36.99)	46.01[b](42.71)	41.12[b](39.87)
2	*T. japonicum*	51.21[a](45.69)	56.03[a](48.45)	53.62[a](47.06)
3	*T. brasiliensis*	29.24[c](32.71)	33.04[c](35.06)	31.14[d](33.89)
4	*T. achaea*	29.45[c](32.83)	33.25[c](35.18)	31.35[c](34.08)
5	*T. chilonis*	17.05[d](24.43)	21.05[d](27.35)	19.05[e](25.92)
Cumulative mean	32.64[b](34.82)	37.88[a](38.00)	-	

Figures in parentheses are arc sine transformed values used for statistical analysis; In vertical columns means with the same letters are not different statistically (P = 0.01) by DMRT.

Table 5: *Helicoverpa armigera* egg load and parasitism in different modules in Mahalaxmi Amisha okra variety during *Kharif* 2013

Sl.No	Module	Number of *H. armigera* eggs	Percent parasitisation
1	M-I	1.83[a]	21.72[b]
2	M-II	0.67[b]	27.43[a]
3	RPP	0.33[b]	13.46[c]

In vertical columns means followedby same letters are not different statistically (P = 0.05) by DMRT.

Table 6: *Helicoverpa armigera* egg load and parasitism in different modules in Parabhani Kranti okra variety during *Kharif* 2014

Sl.No	Module	Number of *H. armigera* eggs	Per cent parasitisation
1	M-I	1.79[a]	29.51[a]
2	RPP	0.22[b]	17.42[b]

In vertical columns means followedby same letters are not different statistically (P = 0.05) by DMRT.

Table 7: Fruit damage and yield of okra in different practices in Mahalaxmi Amisha okra variety during *Kharif* 2013

Module	Fruit damage (%)					Yield (q/ha)
	50 DAS	60 DAS	70 DAS	80 DAS	Mean	
M-I	15.63(23.26)[a]	15.21(22.95)[b]	18.70(25.62)[b]	15.23(22.95)[b]	16.19(23.73)[b]	112.7[b]
M-II	15.096(22.87)[a]	8.10(16.54)[a]	14.13(22.06)[a]	9.83(18.24)[a]	11.79(20.09)[a]	122.4[a]
RPP	21.43(27.56)[b]	24.28(29.53)[c]	21.74(247.76)[b]	22.78(28.52)[c]	22.53(28.32)[c]	103.3[c]

Figures in parentheses are arc sine transformed values used for statistical analysis; In the vertical columns means followed by same letters are not different statistically (P = 0.05) by DMRT

Table 8: Fruit damage and yield of okra in different practices in Parabhani Kranti okra variety during *Kharif* 2014

Module	Fruit damage (%)					Yield (q/ha)
	50 DAS	60 DAS	70 DAS	80 DAS	Mean	
M-I	9.58(18.05)[b]	8.09(16.54)[b]	7.46(15.79)[b]	4.65(12.39)[b]	7.44(15.79)[b]	115.3[a]
RPP	11.88(20.18)[a]	14.68(22.46)[a]	20.79(27.06)[a]	9.89(18.34)[a]	14.31(22.22)[a]	102.7[b]

Figures in parentheses are arc sine transformed values used for statistical analysis; In the vertical columns means followed by same letters are not different statistically (p = 0.05) by DMRT

M-I registered significantly highest parasitisation (29.51 %) compared to RPP (17.42%) (Table 6).

Fruit damage and yield of okra in different modules on Mahalaxmi Amisha okra variety, during Kharif, 2013.

Among the three schedules followed M-II registered significantly lowest fruit damage (11.79%) and differed significantly from other 2 schedules M-I (16.19% fruit damage) and RPP (22.53% fruit damage) (Table-7). The IPM module M-II was again significantly superior by registering highest yield (122.4 q/ha) compared to IPM module M-I module (112.7 q/ha yield) and RPP (103.3 q/ha yield). The notable feature of the present study was that, M-II recorded significantly lower fruit damage and higher yield in contrast to M-I and RPP. This was due to the application of leaf extract from Parabhani Kranti okra variety in M-II which caused higher parasitism and hence, lowering the problem of fruit borer, *H. armigera* this was evident by the observations made on Parabhani Kranti okra genotype during *kharif* 2014 (Table 8) The present findings are in agreement with reports of Satyanarayana (2004) on role of cotton leaf extract in attracting the parasitoid.

Fruit damage and yield of okra in different modules on Parabhani Kranti okra variety, during Kharif, 2014.

The module M-I was significantly superior by recording lower fruit damage (7.44%) and higher yield (115.3 q/ha) compared to RPP (14.31% fruit damage and 102.7 q/ha fruit yield (Table-8).

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