GARLIC BASED BIOPESTICIDES: A NOVEL TOOL FOR INTEGRATED PEST MANAGEMENT

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ABSTRACT

GB Ag was applied to test the efficacy on selected insect pests and diseases of gherkins. It was found that GB Ag treated gherkin plants had less incidence of pests, *viz.,* thrips (*Thrips tabaci* Lindeman) and fruit fly (*Bractrocera cucurbitae* Coquillett) and diseases, *viz*., leaf spot and downy mildew. GB Ag treated plants had better cost benefit ratio (1:1.72) than gherkin plants receiving synthetic chemicals (1:1.80). GB Ag was tested against coconut blackheaded caterpillar (BHC), *Opisina arenosella* Walker during 2008- 09 at Gubbi, Tumkur. The leaflets treated with GB + (10 ml) showed increasing larval mortality of *O. arenosella* from 29.77 % to 69.67%. In Monocrotophos (10 ml) and 5% Azadirachtin (10 ml) the corresponding figures were 26.17 to 52.22 % and 25.67 to 100 %, respectively. However, the GB+ treated leaflets supported natural enemies of BHC and other major pests on coconut. In contrast Monocrotophos treated leaflets caused mortality of natural enimies, has also high mammalian toxicity especially to eggs of birds. The use of Humi Bloom or bloomfert and GB-Ag also helped in increasing yields and in repelling sucking pests. These advantages cumulatively proved economical. GB Ag was evaluated against Tea mosquito bug (TMB), *Helopeltis antonii* Signoret infestation in 2007-08 in cashew plantation. The per cent reduction in TMB in GB Ag treated trees was 5.97 compared to 4.20 in Imidacloprid and 5.60 in Indoxacarb. However, other than these two insecticides, other insecticides were also found to lower the TMB infestation more than GB Ag. But when the cost effectiveness was considered, long term effects and safety, GB Ag is desired.

Key words: Garlic, biopesticides, insect pests, IPM tools, tea mosquito bug (TMB), coconut blackheaded caterpillar (BHC), *Opisina arenosella.*

Amonkar and Banerji (1971) identified Diallyl di-sulphide, Diallyl tri-sulphide and Diallyl sulfide as major components having antagonistic properties against pests of economic importance such as potato tuber moth, red cotton bug, red palm weevil, house flies and mosquitoes. Methanol or ethanol extracts applied directly in the solvent to the insect or the plants are very potent insecticides. Garlic extract is very broad spectrum and is less hazardous to beneficials like lady beetles (Stein and Klingauf, 1990; Nasseh and Furassy, 1992). Garlic clove contains 0.2-0.3% of allicin or alliin. A potent insecticide is larvicidal principle of garlic identified as Diallyl disulphide and Diallyl trysulphide. Allin is a sulfoxide that is a natural constitute of fresh garlic. It is a derivative of the amino acid cysteine. When fresh garlic is chopped or crushed the enzyme alliinase converts into allicin. Steam distilled (garlic oil) is more potent insecticide.

Extracts of garlic have proved effective against *Alternaria* spp, powdery mildew, black spot, *Phytopthera, Fusarium* spp. and bacterial pathogens like *Pseudomonas*. The National Research Center for Onion and Garlic, Pune, Maharastra is conducting research on this pesticide. Mode of action as well as the fungicidal and insecticidal properties of garlic, might be partly due to enzyme inhibition. Bio-efficacy tests were conducted against major pests of vegetables like gherkins and potatoes and plantation crops like cashew (*Anacardium occidentale*) and coconut (*Cocos nucifera* L.) In South Karnataka (2005-2009) possibilities of using garlic based biopesticide as an IPM tool explored.

MATERIAL AND METHODS

Gherkin

The field trials were carried out at Kunigal, Thurivekere and Tiptur taluks of Tumkur district (13^{o} 20$^{'}$ 77^{o} 18.8''N; 77^{o}6' 4.3''E) in August to December, 2006-07. The gherkin growers were given all the inputs by the companies, who also supervised the cultivation practices and picked up the harvested fruits. A portion of such fields were allocated for application of GB Ag, so that its bioefficacy could be compared by the respective company. GB Ag was mixed with water @ 5 ml/liter of water. The degree of infestation by the pests was scored before and after application of insecticides in both the plots. For observations, 15 creepers of were selected at random. For assessing the fruit damage due to fruit borer, *Diaphania indica*, (Saunders) and fruit fly, *Bactrocera cucurbitae* (Coquillett) the number of damage to healthy fruits in each creeper were recorded and expressed in percentage.

In non GB Ag plots, Dimethoate 30EC @ 2ml/liter; Neemazal 1EC@ 2ml/l; Manget 75WP @1g/l; Accephate 75 @ 2g/l; Ridomil @ 1.5g/l; Copper oxy chloride @ 0.3g/l and Bavistin @ 3g/l. were applied for suppression of pests and diseases. Applications of above chemicals were repeated as and when required. In GB plots 4 applications of GB Ag were made at weekly intervals. GB Ag was mixed with fungicides whenever outbreak of downy mildew or leaf spot occurred in the gherkin plots. The field tests were conducted in replicated RCBD trials.

Potato

Bioefficacy of GB Ag was determined with six insecticides against the defoliator, *Spodoptera litura* Fab. and the sucking insect pests- aphids, *Myzus persicae* (Sulzer) and thrips, *Thrips tabaci* Lindeman on Kufri Jyothi was recorded at Madenur, Hassan. The mean number of insect pests found before and after application of insecticides was determined and four observations were recorded at weekly intervals.

In one acre, tubers are planted with Kisan Mitra (U) Humi-Bloom. In ½ acre, Humi-Bloom was not used. In Kisan Mitra plot about 3 bags of 10:26:26 (3 bags; 1 bag =50kg) + 10 Kg Kisan Mitra 10:26:26 is from SPIC. In non-Kisan Mitra plot, applied 3 bags of 10:26:26 or manure only. In another pepsi-1335 was sown on 27 May 2008. The farmer applied 70% of 250 Kg of 20:20:20 + 20 Kg (10+10 at top dressing) of Kisan Mitra. In Chikmagalur, plots of 6 farmers applied 75% of recommended fertilizers + 20Kg of Kisan Mitra (10+10Kg along with FYM). At Anekatte, Chikaballapura potato was cultivated in an acre during rabi 2008- 09.He incorporated organic manure, Kisan Mitra @10 kg\ac as basal dose. While his neighbor cultivated potato (Papsi-1335) with inorganic fertilizers alone in two acres. Basal dose of fertilizers @ 10:26:26, 140Kg/ac + DAP = 22 Kg/ac were applied. Top-dressing dose was applied 35 days after sowing @ urea 92 Kg + Potash 60 Kg/ac. The organic materials were applied @ 10 Kg/ac. during sowing and as top dressing. For phytotoxicity and longevity tests, portions of potato plots were chosen and treatments were imposed and observations recorded during June to August, 2008-09.

Cashew

In the 2007-08, Vengurla -4 variety at Brahmavara and Anakayam-1 of cashew was used for recording observations on TMB in Chintamani. Both were 10 years old. Each tree represented a replicate and there were five replications treatment. For testing bioefficacy of chemicals, 52 panicles (13 from each of the four directions) were randomly chosen and per cent panicle affected by tea mosquito bug (TMB) was recorded before and after applications, each month. The panicles were sprayed with the test chemicals at the determined dosages. Each panicle was enclosed in a perforated polybag and newly emerged five pairs of TMB adults were enclosed. Observations on the percent mortality of the TMB were recorded at 24 hr intervals for 5 days. The tests were repeated twice and mean per cent mortality calculated. The data sets were subjected to Analysis of variance test (ANOVA).

Coconut

A coconut farm of Tiptur-Tall variety, 20 years old at Kangovi farm, Kukunahalli village, Dasanapura hobli, Golahalli post, Bangalore Rural was selected for the study. The whole farm of 4 acres was affected by black headed caterpillar (BHC) severely (>60% frond affected). Green leaflets with few brown spots had 2^{nd} or 3^{rd} instar larvae generally and leaflets were selected for observations. Simultaneously observations were also recorded in Nittoor and Bellahally.

The observations on number of BHC infested fronds per palm, number of larvae and natural enemies per leaflet at 10 days intervals were recorded during August to December, 2008-09. The number of surviving black headed caterpillar larvae and pupae were counted before and after each treatment and at 10 days intervals from two randomly selected fronds. All leaflets in the fronds were examined for the surviving larvae and pupae. The data were subjected to ANOVA.

RESULTS AND DISSCUSSION:

Gherkin

On gherkins, fruit fly, *B. cucurbitae* Coquillett is one of the major pests in South Karnataka. On GB Ag applied plants the number of bent fruits at harvest varied from 0 to 1 and the corresponding figures in non GB Ag plants varied from 2 to 3. The bent fruits were attributed due to fruit fly damage, *B. cucurbitae*. The downy mildew incidence on GB Ag applied plants was considerably less (16.50 to 23.50%) compared to on Non GB Ag plants (66.56 to 70.43%). Therefore, gherkins receiving GB Ag applications had better plant growth and productivity parameters and less pest and disease incidence (Table 1). The antifeedant properties of garlic juice is ascribed to the sulphur containing secondary metabolites. Garlic extracts must be used before the pest can damage the crop. Garlic juice is an effective deterrent for insects specially with sucking mouthparts (Cavallito and Bailey, 1944; Arun *et al.,* 1996).

The cost benefit ratio (Table 2) in GB Ag applied plots worked out to be 1:1.72 compared to 1:1.50 in non- GB plot. Since, GB Ag is a botanical formulation there is no need to worry about waiting period. The pollinators and natural enemies of pests like coccinellids, wasps and other hymenopterans were noticed in plots applied with GB Ag but their numbers and frequency of occurrence (activity) was much lower on plots sprayed with chemical insecticides. The GBAg not impact any odour to he products.

A summery of the comparative performance of GB Ag with recommended insecticides on pests of four crops is presented in Fig 1. Although greater effective suppression of the pest was realised on all the four crops by chemical insecticides, GB Ag proved better. This is because it is an eco friendly material, cheap, safe to the natural enemies and other beneficials and its application on crops results in economical and sustainable yields and is compatible in organic farming systems.

Potato

Of the pest insects attacking the potato crop, sucking insects, *viz* Aphids, *Aphis gossypii* Glav, Whitefly, *Bemisia tabaci* Gennadius and jassids, *Amrasca bigutulla bigutulla* Ishida were major sucking pests. Eight treatments replicated four times were evaluated for bioefficacy (Table 3). All insecticides except Carbofuran *viz* Imidacloprid, Monocrotophos and Dimethoate suppressed the sucking insects significantly when applied twice. It is interesting to note that even two botanicals tried, *viz.* Neem oil and GB Ag too suppressed the sucking pests on par with the three insecticides tested. Neem oil and GB Ag acted as repellents to the sucking pests. These treatments were statistically significant compared to water, control and Carbofuran 3G. Carbofuran 3G, being a granular formulation, was not very effective in suppressing the sucking insects when applied to soil @ 20 Kg/ha. Two applications of Neem oil and GB Ag were as effective as two applications of Dimethoate, Imidachloprid and Monocrotophos. But the botanicals take time to be effective compared to chemical insecticides. So, prophylactic and frequent applications of botanicals are desirable. The insecticides were applied on 6^{th} and 20^{th} July 2007 coinciding with the peak numbers of aphids and thrips. In severe infestation conditions, a prophylactic application by June-end is desirable. GB Ag is much cheaper (Rs.600/liter) than insecticides, *viz* Imidachloprid (Rs. 2220/liter). GB Ag proved non phytotoxic and can be stored upto one year.

Cashew

Tea mosquito bug (TMB) is a major pest on cashew. Despite insecticidal applications, the pest is causing 30-40% yield losses (Devasahayam and Nair, 1986). Evaluation of insecticides under confined conditions at Chintamani during November 07 to January 2008 revealed consistent results with respect to the efficacy of GB Ag -1 and GB Ag-2 that recorded on an average 6.0 and 5.2 per cent infestation. The mean number of adults surviving on treated plants 7 days after treatment and the per cent damage rate 48 hr after caging under laboratory conditions is presented in Table 4. The results showed that the performance of GB Ag-1 and GB Ag -2 is on par with Carbaryl and Endosulfan and better than Imidacloprid and Fipronil. GB Ag is cost effective and safer to human beings, environment and beneficials. Therefore it helps in sustaining the yields for a long period.

The per cent infestation of panicles by TMB at 3 monthly intervals at Brahmavara is presented in Table 5. The per cent reduction in TMB infestation on GB Ag treated trees was 5.97 compared to 4.20 in Imidacloprid and 5.60 in Indoxacarb. When compared to Monocrotophos and Carbaryl the per cent infestation is lower from the GB Ag treated trees. However, other than these two insecticides, other insecticides were also found to lower the TMB infestation more than GB Ag but based on cost effectiveness, long term effects and safety, GB Ag proved better.

Coconut

Formulations developed from garlic were evaluated against the blackheaded caterpillar, *O. arenosella.* Chemicals were also treated through root feeding to coconut palms (Table 6). Pre-treatment larval counts were on par (3.59 to 7.84 larvae /infested frond) with each other. Ten days after imposing treatment, Monocrotophos and Azadirachtin were on par and recorded the least larval count of 1.76 and 3.24 per infested frond compared to 6.41 larvae per infested frond in control. The larval counts made on the 20 DAT revealed that Monocrotophos and Azadirachtin continued to be effective in reducing larval counts (0.46 and 1.54 larvae/infested frond).

Neem based formulations were found to be effective on the blackheaded caterpillars. Srinivasa Murthy *et al.* (1994) were the first to evaluate neem based commercial insecticides against *O. arenosella*. The above authors conducted bio-assay for different neem formulations and showed that Neemox at 10 and 20 ml per palm was as effective at 20 days after treatment. Soluneem, in aqueous solution, showed significant reduction in the populations of *O.arenosella.*

The effective concentration of 5% Azadirachtin, GB+, Monocrotophos and control in coconut palms were estimated in the laboratory using bioassays with fourth and fifth *O. arenosella* instars larvae. Uniform sized larvae of BHC were selected for the bioassay. The larvae were starved for 6 hr before implanting on the treated leaflets. The effect of these treatments was studied at 0, 5, 10, 20 days after treatment (Table 7).

On the day of treatment or 0^{th} day of chemical administration to the palms there were no significant differences between treatments with respect to mortality of 5^{th} instar larvae as on 0 DAEP (Days After Exposure Period=5 days of feeding on treated leaflets),when fed on leaflets collected from the field. The per cent larval mortality among treatments were statistically on par with each other. The leaf lets which were treated with GB + (10 ml) showed increasing mortality of larvae from 29.77 % to 69.67%. In Monocrotophos (10 ml) and 5% Azadirachtin (10 ml) the corresponding figures were 26.17 to 52.22 % and 25.67 to 100 %, respectively. However, the GB+ treated leaflets would support natural enemies of BHC and other major pests on coconut. In contrast Monocrotophos treated leaflets cause mortality of natural enemies of BHC and other pests. Monocrotophos has high mammalian toxicity and is lethal to eggs of birds especially. So Monocrotophos has been banned in developed countries. When compared to Azadirachtin, GB+ was superior in causing mortality of larvae and is cheaper than Azadirachtin. So, GB+ is recommended for the suppression of BHC on coconut through root feeding @10 ml+10ml water/palm. GB+ is Rs.1500 / litre compared to Azadirachtin which is Rs.2000/liter.

CONCLUSIONS

Garlic biopesticides have the unique property of repelling and preventing the insects from feeding especially the sucking pests. The biopesticide is compatible with chemical insecticides and fertilizers. The garlic biopesticide not harmful to natural enemies, pollinators and other beneficials, are cheaper and compatible with other organics and chemicals. They can form an important IPM tool in sustainable and organic cultivated farming systems.

ACKNOWLEDGEMENT

The authors are thankful to The Director of Research, UAS, GKVK, Bangalore: to Mr.Tarunn Hindocha, Veeraxim Private Limited, Jayamahal, Bangalore, who supplied the GB Ag and organic mannures and sponsored the trials: growers of Tumkur, Kolar, Bramhavara, Hassan, Chikmagalur and Deevanahalli and Mr. Shivakumar M.S. and Naga Chaitanya for encouragement and help at various stages of this investigation.

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Table 1 Gherkin fruit fly and fruit borer damage in GB and Non GB plots

Parameters*	GB Ag					NON GB Ag				
	Plot.1	Plot.2	Plot.3	Plot.4	Mean	Plot.1	Plot.2	Plot.3	Plot.4	Mean
Number of bent fruits at harvest	0	1.54	0	1.21	0.69	2.12	3.21	3.43	2.76	2.88
% leaf showing downy mildew disease	18.00	16.50	22.11	23.50	20.03	62.54	70.43	55.65	68.43	64.26
Immature fruit drop/plant	2.45	2.45	3.13	3.0	2.76	5.11	7.12	6.98	5.43	6.16
Number of flowers/plant	14.67	20.50	16.55	11.23	15.74	14.50	16.90	13.31	11.34	14.01

* Mean of 15 gherkin plants

Table 2 Cost economics of Gherkins applied with GB Ag in Tumkur

Treatments	Yield* (t/Ac)	Gross returns (Rs.)	Cost involved (Rs.)		Total Cost (Rs.)	Net profit (Rs.)	C:B ratio
			Pest management	Other expenditure			
GB Ag	5.58	38, 152	3150	10870	14020	24,132	1:1.72
Controlled plot (chemicals)	5.38	37,450	3475	11,560	15,035	22,420	1:1.50

* For calculations, converted to average of four grades (grade I = Rs. 11.50/kg: II = Rs. 7.50/kg; III = Rs. 4.50/kg; IV = Rs. 2.50/kg); Cost Rs. 7.00/kg; GB Ag 1.68lt @ Rs. 750=00/lt;

Table 3 Suppression of sucking insect pests on potato, Kharif, 2007, Madenur, Hassan.

Chemical/Insecticide	Avg. No. of sucking pests/plant* - DAS			
	15	30	45	60
Imidacloprid 200 SL 0.5ml/lit	3.50 (2.00)	0.00 (0.70)	0.00 (0.70)	0.80 (1.14)
GB Ag @ 5ml/lit	3.55 (2.01)	0.50 (1.00)	0.00 (0.70)	1.80 (1.51)
Monocrotophos 36 SL 1.5ml/lit	3.40 (1.97)	0.00 (0.70)	0.00 (0.70)	1.20 (1.30)
Neem oil 2%	3.59 (2.02)	0.60 (1.04)	1.50 (1.41)	2.40 (1.70)
Dimethoate 30 EC 1.5ml/lit	3.22 (1.92)	0.00 (0.70)	0.600 (1.04)	1.80 (1.51)
Carbofuran 3G @20Kg/ha	3.81 (2.07)	4.92 (2.32)	7.65 (2.85)	10.30 (3.28)
Water	4.65 (2.26)	8.30 (2.96)	14.20 (3.83)	19.60 (4.48)
Control (no application	9.33 (3.13)	13.20 (3.70)	15.80 (4.03)	23.20 (4.86)
CD at 5%)				4.26 (2.18)
SEM±	0.42	0.29	0.47	0.52
CD @ p= 0.05	1.22	0.98	1.18	1.48

*sucking pests included nymphs+adults of aphids+thrips, average of one bottom, middle and top compound leaf/plant x 10 plants. The chemical applied on 14th and 29th days after sowing. Crop sown on 22/6/07. Data subjected to $\sqrt{x+0.5}$ transformation before analysis by ANOVA.

Table 4 Efficacy of selected insecticides against TMB at Chintamani (Nov- 07 to Jan- 08) under confined conditions

Treatments	No. adults surviving on the treated plants				Percent damage grade 48 hr after caging			
	0DAT	3DAT	7DAT	Mean	0DAT	3DAT	7DAT	Mean
Carbaryl 50 WP 0.1 (2 g/lit)	10	1.10	0.0	0.51	0.0	4.15	5.20	4.60
Endosulfan 35 EC 0.05 (2 m/lit)	10	1.60	0.80	1.20	0.0	5.0	6.5	5.75
Fipronil 5SC 0.05 (1ml/lit))	10	4.15	1.70	2.92	0.0	8.15	11.20	9.67
Imidacloprid 17.8 EC 0.05 (0.25 ml/lit))	10	2.70	1.00	1.85	0.0	7.10	13.3	10.20
GB AG-1 (5 ml/lit)	10	3.10	1.10	2.10	0.0	5.0	7.40	6.0
GB AG-2 (5ml/lit)	10	2.80	0.80	1.80	0.0	4.80	5.60	5.20
L.cyhalothrin 5EC 0.05 (1ml/lit)	10	1.20	0.0	0.60	0.0	2.60	3.80	3.20
Control	9.0	5.60	7.30	0.0	13.20	16.70	14.95	14.85
	NS	*	*	--	*	*	*	---

* Significant at p=0.05 (ANOVA); NS: Non Significant

Table 5 Field efficacy of selected insecticides against TMB on Cashew at Brahamavara (2007-08)

Treatments	TMB infestation on panicles (%)											
	DBT	November			December			January			% Reduction	C:B
		10	15	20	10	15	20	10	15	20		
Carbaryl 50 WP 0.1 (2 g/lit)	10.5	1.60	3.40	3.6	2.10	4.20	3.66	1.80	3.60	3.40	7.10	1:12.15
Fipronil 5SC 0.05 (1ml/lit))	12.0	2.70	4.10	4.7	3.10	5.70	6.06	2.60	5.80	5.16	6.84	1:3.08
Imidacloprid 17.8 EC 0.05 (0.25 ml/lit))	8.70	2.10	3.50	4.0	2.70	4.10	4.36	2.10	4.80	4.50	4.20	1:6.30
Monocrotophos 36 EC 0.01 (1.5ml/lit)	11.20	1.80	3.70	3.93	1.70	3.80	3.83	1.50	2.80	2.66	8.54	1:11.20
Acephate 75SP 0.1 (2ml/lit)	12.40	3.60	5.70	5.13	4.10	6.30	6.86	3.80	5.60	6.03	6.37	1:5.20
Indoxacarb 14.5 SC 0.05 (1ml)	9.60	2.70	4.60	4.36	3.20	5.40	4.9	2.7	4.10	4.0	5.60	1:3.20
L.cyhalothrin 5EC 0.05 (1ml/lit)	10.40	1.20	2.10	2.90	1.80	2.70	2.80	1.50	2.70	2.50	7.90	1:13.15
Endosulfan (Thiodan) 35 EC 0.05 (2 m/lit)	9.80	2.20	2.70	3.70	1.80	2.70	4.20	1.80	4.60	3.83	5.97	1:12.80
GB Ag (5ml/lit)	11.50	2.80	4.60	4.23	3.60	4.80	5.40	2.60	4.30	4.36	7.14	1:8.60
Control	10.20	5.40	7.80	8.56	14.10	16.30	15.86	21.30	23.60	23.0	---	--
C:D	NS	*	*	*	*	*	*	*	*	*	--	--

* Significant at p=0.05 (ANOVA); NS: Non Significant; DBT- Days before treatment

Table 6 Effect of different chemicals treated through root feeding on larval numbers of Black headed caterpillar

Treatment	Dosage	Number of larvae/infested leaflet		
		Pre-treatment	Post treatment	
			10 DAT	20 DAT
5% Azadirachtin	7.5 ml+7.5 ml water	5.81 (2.60)	3.45 (1.83)[ab]	1.04 (1.25)[ab]
5% Azadirachtin	10.0 ml+ 10.0 ml water	3.79 (2.40)	4.00 (2.06)[bc]	2.10 (1.79)[bc]
GB+	7.5 ml+7.5 ml water	4.44 (2.38)	4.16 (2.11)[bc]	2.52 (1.93)[c]
GB+	10.0 ml+ 10.0 ml water	4.20 (2.27)	3.92 (2.49)[c]	2.07 (1.83)[bc]
Monocrotopos (36 EC)	7.5 ml+7.5 ml water	4.08 (2.30)	5.00 (2.40)[bc]	2.50 (1.98)[c]
Monocrotopos (36 EC)	10.0 ml+ 10.0 ml water	4.88 (2.01)	1.36 (1.39)[a]	0.66 (0.97)[a]
Control	-	5.40 (2.27)	6.14 (2.54)[c]	5.55 (2.39)[c]
F-test		NS	*	*

Means followed by the same letters in column are not statistically significant NS: Non Significant;* Significant (p=0.05); DAT: Days after treatment, 1DAT= no mortality of larvae

Table 7 Efficacy of different chemicals in laboratory against fourth and fifth instar larvae of Black headed caterpillar when fed on leaves 10-20 days after treatment to the palms in field

Treatment	Dosage	Larval mortality (%)			
		0 DAT	5 DAT	10 DAT	20 DAT
5% Ozoneem	7.5 ml+7.5 ml water	28.78 (30.99)	63.33 $(62.14)^{bc}$	57.78 $(62.25)^{bc}$	46.67 $(49.22)^{bcd}$
5% Ozoneem	10.0 ml+ 10.0 ml water	26.17 (30.67)	84.44 $(81.59)^{ab}$	70.00 $(74.81)^{ab}$	52.22 $(23.03)^{e}$
GB+	7.5 ml+7.5 ml water	38.34 (34.93)	86.67 $(68.86)^{bc}$	89.33 $(66.14)^{b}$	60.11 $(57.78)^{b}$
GB+	10.0 ml+ 10.0 ml water	26.77 (23.86)	50.01 $(50.85)^{d}$	63.33 $(46.92)^{d}$	69.67 $(54.78)^{bc}$
Monocrotopos (36 EC)	7.5 ml+7.5 ml water	28.67 (19.93)	70.33 $(59.71)^{cd}$	59.11 $(50.85)^{cd}$	43.33 $(35.22)^{cde}$
Monocrotopos (36 EC)	10.0 ml+ 10.0 ml water	25.67 (30.79)	96.00 $(83.47)^{a}$	93.30 $(80.76)^{a}$	100 $(89.43)^{a}$
Control	-	22.00 (26.57)	26.67 $(30.99)^{e}$	29.23 $(33.00)^{e}$	31.67 $(30.99)^{de}$
F- test		NS	*	*	*
S Em ±		4.06	5.36	6.79	7.78
CD (p=0.05)		12.85	13.37	14.88	19.10

Figures in the parentheses are Arcsine √ Percentage transformed values

Means followed by the same letters in column are not statistically significant
NS: Non significant;*: Significant (p=0.05); DAT; Days after treatment
Coconut palms of 4-6 meter height were used for root feeding

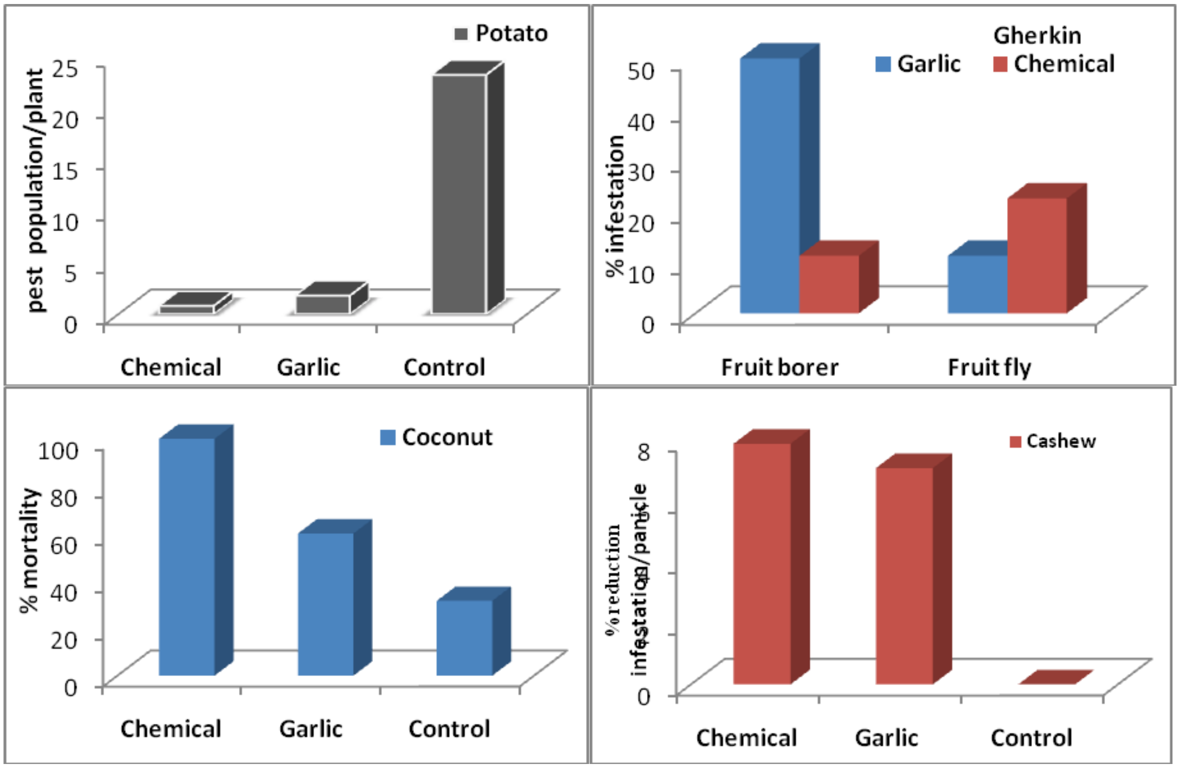

Fig.1 Comparison of bioefficacy of GB Ag with insecticides on four crop pests