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Research Article

Compatibility of selected insecticides with plant growth regulator Energy® against diamondback moth, *Plutella xylostella* (Plutellidae; Lepidoptera)

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Abstract
Compatibility of seven insecticides (chlorantraniliprole, flubendiamide, Hamla®, Proton®, indoxacarb, novaluron and profenophos) and plant growth regulator, Energy®, was assessed against third instar larvae of diamondback moth (DBM) using a "leaf-dip" bioassay technique All seven insecticides in combination with PGR (Energy®) showed synergistic effect against *P. xylostella* larvae. The combination of flubendiamide and Energy® was comparatively more toxic than other combinations.

Keywords: Insecticide, Plant growth regulator, energy, compatibility and toxicity.

1. INTRODUCTION

Among various insect pests, diamondback moth is the most serious in causing economic loss on cole crops. Though, the moth originated in the Mediterranean area, it has surpassed all the natural barriers and is believed to have become a cosmopolitan pest (Meyriche, 1928).Diamondback moth, *P. xylostella* is one of the most destructive pests of cruciferous vegetables in the world and has been reported from at least 128 countries. In recent years, DBM acquired serious dimension and has become major limiting factor for successful cultivation of cabbage in India (Sexena *et al*., 1989; Srinivasan and Krishnamoorthy, 1991). Diamondback moth is known to cause yield loss in cabbage from 31 per cent (Abraham and Padmanabhan, 1968) to 100 per cent (Cardleron and Hare, 1986) and the annual cost for managing this pest is estimated to be US $1 billion (Talekar, 1992).

The number of chemicals involved in plant protection is too many and the information on compatibility of individual chemical is scattered in the literature. Common growers find difficulty in ascertaining the compatibility of agro-chemicals. Hence, based on experience Gray (1914) prepared a chart showing compatibility of some insecticides and fungicides. Later several charts were developed or updated by Frear (1979), Gruzdyed *et al*.,(1983) for the chemicals in use with additional information regarding incompatibility under certain crops, season, aging of mixtures and many other factors. Later Baicu (1980) suggested studying compatibility in different stages including determination of chemicals and physical properties, biological activity of compounds, field tests of effectiveness, phytotoxcity and yield after treatment.Several insecticide molecules are available in market, but many of them are not tested for the compatibility or recommended by reputed research institutes. Hence, it is necessary to investigate the compatibility of the most common agro-chemicals with respect to insect pest management in cabbage ecosystem.Therefore, the present research is planned with the following objectives

i. Insecticidal property of plant growth regulator
ii. Influence of plant growth regulator on the bio-efficacy of insecticides

2. MATERIAL AND METHODS

2.1 Seven insecticides and one plant growth regulator were selected for the experiments and these are presented in table 1.

2.2 Insecticidal action of PGR Energy® against *P. xylostella*

A study was carried out to know the insecticidal property of selected agro-chemicals(fungicide and plant growth regulator). The *P. xylostella* larvae collected from cabbage field around Chikmagalur, Karnataka were reared to first generation on mustard seedlings. The third instar larvae were exposed to different concentrations of plant growth regulator Energy®

2.3 Bioassay

For every insecticide and plant growth regulator mixture and individual insecticide, keeping the company's recommendation or farmer's practice as the base, five concentrations in geometric progression were used for each bioassay experiment. For every concentration, three replications of 30 third instar larvae were maintained and the leaves treated with water served as control. Fresh and uniform sized cabbage leaves were dipped in insecticide dilutions for thirty seconds and dried under room temperature. The cut ends of petioles of treated leaves were provided with wet cotton wads to retain the vigour. The treated cabbage leaves were placed in petridishes. Thirty early third instar larvae of *P. xylostella* were released on treated leaves in each petridish. The treated larvae were maintained in room temperature and the mortality was recorded at 6, 12, 18, 24, 30, 36, 42 and 48 hours after the treatment.

Observed mortality data were converted to percentages and corrected for control mortality according to Abbott(1925). Observed mortality data were converted to percentage and were subjected to probit analysis (Finney, 1971) for obtaining regression equations for dosage mortality response and to determine the LC_{50} and LT_{50} values.

3. Results and discussion

3.1 Insecticidal properties of Plant growth regulator Energy.

Certain compounds are marketed as plant growth regulators to be used exclusively for regulating plant growth. However, many workers have reported such compounds when mixed with insecticides enhance the insecticidal activity. In this line a study was undertaken to evaluate the insecticidal properties of selected plant growth regulator against third instar larvae of *P. xylostella* in the laboratory at five concentrations. The results revealed that plant growth regulators possess insecticidal properties and the mortality was significantly more at higher concentrations. The plant growth regulator Energy® possesses slight toxicity causing 8.89 per cent mortality at 385 ppm concentration (table 2). However, Energy® was almost nontoxic at lower dosages; no similar studies have been reported in the literature.

3.2 Influence of plant growth regulator on the bio-efficacy of insecticides

Compatibility of pesticides is the behavior of combination with reference to active component that is, whether it has maintained, reduced or potentiated its insecticidal activity. The changes in chemical contentsof individual components, their respective characters, formulation, qualities *etc.*, occurring in the mixtures have not been studied deeply for majority of chemicals. If a new chemical discovered then studying its behaviour in the presence of other chemicals is equally important to exploit utilization of more than one chemical at a time in combination. However, only few attempts have been made to study the compatibility problem in the light of increase in number of chemicals. Hence, attempts were made to study the compatibility of insecticides in combination with plant growth regulators under laboratory conditions by using third instar larvae of *P. xylostella*as test insect. The toxicity of insecticides with plant growth regulator and individual insecticides to test insect was quantified by adopting leaf dip bioassay method and the compatibility was assessed based on the median lethal concentrations(LC_{50}) and median lethal time(LT_{50}) cumulative per cent larval mortality and relative toxicity values.

In combination with Energy® the LC_{50} values of seven insecticides *viz.*, chlorantraniliprole, flubendiamide, novaluron, indoxacarb, Proton®, Hamla® and profenophos were 209.24, 207.93, 294.11, 289.21, 575.81, 580.90 and 1068.88 ppm, respectively. In combination with Energy® the LT_{50} values of seven insecticideswere chlorantraniliprole (26.90, 37.32 and 46.74 h), flubendiamide (27.16, 38.53 and 47.48 h), Novaluron (36.60, 43.71 and 54.74), indoxacarb (30.05, 37.11 and 48.97 h), Proton®(31.36, 39.48 and 49.57 h), Hamla®(27.28, 34.33 and 48.01 h) and profenophos (34.47, 40.15 and 47.03 h). These seven insecticides when combined with Energy® the LT_{50} values were decreased which shows synergistic nature. In combination with Energy® the per cent cumulative mortality of Seven insecticides after 48 hours of treatment impose were chlorantraniliprole (100.00, 93.33, 83.33, 50.00 and 33.33 per cent), flubendiamide (100.00, 93.33, 83.33, 53.33 and 40.00 per cent), novaluron (100.00, 86.67, 73.33, 40.00 and 23.33 per cent), indoxacarb (100.00, 93.33, 83.33, 53.33 and 36.67 per cent), Proton® (100.00, 93.33, 83.33, 53.33 and 36.67 per cent), Hamla®(100.00, 93.33, 83.33, 47.78 and 30.00 per cent) and profenophos (100.00, 93.33, 83.33, 60.00 and 36.67 per cent) (table 3, 4 and 5). These seven insecticides when combined with Energy®, the mortality were increased as compared, when insecticides used alone. The studies on this aspect are lacking in literature for comparison of potentiation of toxicity of insecticides by Energy® and few works are furnished. De Nardo (2003) reported that three plant growth regulators, ancymidol, paclobutrazol and uniconazole-P are compatibility with *Steinernemafeltiae* and insecticides (spinosad,*Bacillus thuringiensis*, diflubenzuron, acephate and fenoxycarb). Alexander (1951) suggested that Arsenical insecticides are compatible with Zinc Sulfite. Elmer and Haller (1945) also reported that insecticide DDT is compatible with Iron when applied in mixtures. Khan *et al.* (2012)reported that seven plant growth regulators tested showed good spore germination (above91.7%) and were compatible with *Beauveria bassiana and Metrhazium anisopliae.* The entire seven plant growth regulators tested were compatible and percentage reduction in vegetative growth was below 14.2%. The vegetative growth of *B. bassiana* and *M. anisopliae* was also enhanced by BA (benzyl adenine) (250 ppm), Ethrel (250 ppm), IAA (30 ppm) and NAA (Naphthalene acetic acid) (30 ppm). Brujlo *et al.* (2005) suggested that for obtaining high productivity in apple orchards to use manganese, zinc and boron with insecticides.

Table 1. Details of agrochemicals selected for the bioassay

Sl. No	Common name	Chemical name	Trade name and formulation	Manufacturing company
Insecticides				
1.	Chlorantraniliprole	3-bromo-*N*-[4-chloro-2-methyl-6-[(methylamino)carbonyl] phenyl]-1-(3-chloro-2-pyridinyl)-1H-pyrazole-5-carboxamide	Coragen®18.5 SC	E.I. Dupont India Pvt. Ltd., Gurgaon, Haryana
2.	Flubendiamide	3-iodo-*N*'-(2-mesyl-1,1-dimethylethyl)-*N*-{4-[1,2,2,2-tetrafluoro-1-(trifluoromethyl)ethyl]-*o*-tolyl}phthalamide	Fame®480 SC	Bayer Crop Science India Ltd., Mumbai
3.	Chlorpyriphos + Cypermethrin	*O,O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate +	Hamla®505 EC	Gharda Chemicals Ltd., Mumbai
4.	Proton	Cocktail of botanicals *viz.*, Langdu root extract (*Stellerachamaejasme*L.)- 2.9 %, CGL extract- 1.50 %, *Brassica campestris*L.- 0.5 %, Eugenol- 9.0 %, Siberian cocklour fruit extract-10 %, Trace elements- 10 % (Venkateshalu*et al.*,2009)	Proton®	United Crop Care, Mumbai
5.	Indoxacarb	Methyl(S)-N-[7-choloro-2,3,4a,5-tetrahydro-4a-Hethoxycarbomyl) indeno [1,2-e]-[1,3,4] oxadiazin-2-ylcarbonyl]-4-(trifluromethoxy)carinilat	Avaunt® 14.5 EC	E.I. Dupont India Pvt. Ltd., Gurgaon, Haryana
6.	Novaluron	1-∂3-Chloro-4-(1, 1,2-trifluro-2-trifluoromethoxyethoxy) Phenyl	Rimon® 10 EC	Indofil Chemical Company, Mumbai
7.	Profenophos	O-(4-Bromo-2-chlorophenyl)-O-ethyl-S-propyl phosphorothioate	Curacron® 50 EC	Syngenta India Ltd., Mumbai
Plant growth regulator				
1.	Energy®	Zn-3%, Mn-1%, Fe-2%, B-5%	Energy®	Kaveri Seed Company Ltd., Secunderbad

Table 2. Per cent mortality of *P. xylostella* larvae against Saaf® and Energy® formulations

Chemicals	Concentration (ppm)	Per cent larval mortality at different hours after treatment	
		24 (h)	48 (h)
Saaf® (Carbendazim + Mancozeb)	1875	18.89 (25.72)	28.89 (32.49)
	1500	13.33 (21.39)	22.22 (28.09)
	1125	6.67 (14.89)	14.44 (22.27)
	750	3.33 (10.47)	10.00 (18.44)
	375	3.33 (10.47)	5.56 (13.42)
Energy®	385	6.67 (14.89)	8.89 (17.26)
	330	3.33 (10.47)	6.67 (14.89)
	275	0.00 (0.00)	3.33 (10.47)
	220	0.00 (0.00)	0.00 (0.00)
	165	0.00 (0.00)	0.00 (0.00)
Control	0.00	0.00 (0.00)	0.00 (0.00)
S Em ±		0.25	0.70
C D 1%		1.01	2.81

Figures in parenthesis are arc sine transformed value

Table 3.Cumulative per cent larval mortality of *P. xylostella* against selected insecticides in combination with Energy®

Treatments (ppm)	Cumulative per cent larval mortality at different hours after treatment							
	6 h	12 h	18 h	24 h	30 h	36 h	42 h	48 h
Chlorantraniliprole + Energy® @ 408.12	3.33 (10.47)	16.67 (24.04)	33.33 (35.24)	60.00 (50.77)	86.67 (68.53)	96.67 (79.37)	100.00 (90.00)	100.00 (90.00)
Chlorantraniliprole + Energy® @ 348.5	1.11 (3.49)	3.33 (10.47)	13.33 (21.39)	40.00 (39.23)	70.00 (56.79)	86.67 (68.53)	90.00 (71.56)	93.33 (75.00)
Chlorantraniliprole+ Energy® @ 288.87	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	33.33 (35.24)	60.00 (50.77)	76.67 (61.07)	83.33 (65.88)
Chlorantraniliprole+ Energy® @ 229.25	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	8.89 (17.26)	20.00 (26.56)	36.67 (37.23)	43.33 (41.15)	50.00 (45.00)
Chlorantraniliprole+ Energy® @ 169.65	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	22.22 (28.09)	28.89 (32.49)	33.33 (35.24)
Flubendiamide+ Energy® @ 434.18	3.33 (10.47)	18.89 (25.72)	40.00 (39.23)	63.33 (52.71)	83.33 (65.88)	96.67 (79.37)	100.00 (90.00)	100.00 (90.00)
Flubendiamide+ Energy® @ 369.35	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	36.67 (37.23)	63.33 (52.71)	80.00 (63.44)	90.00 (71.56)	93.33 (75.00)
Flubendiamide+ Energy® @ 304.51	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	33.33 (35.24)	60.00 (50.77)	73.33 (58.89)	83.33 (65.88)
Flubendiamide+ Energy® @ 239.67	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	14.44 (22.27)	31.11 (33.89)	43.33 (41.15)	53.33 (46.89)
Flubendiamide+ Energy® @ 174.83	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	14.44 (22.27)	27.78 (31.77)	40.00 (39.23)
Novaluron+ Energy®@ 485	0.00 (0.00)	6.67 (14.89)	13.33 (21.39)	26.67 (31.05)	46.67 (43.05)	73.33 (58.89)	96.67 (79.37)	100.00 (90.00)
Novaluron+ Energy®@ 420	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	36.67 (37.23)	63.33 (52.71)	80.00 (63.44)	86.67 (68.53)
Novaluron+ Energy®@355	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	6.67 (14.89)	17.78 (24.88)	34.44 (35.90)	57.78 (49.45)	73.33 (58.89)

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Treatments (ppm)	Cumulative per cent larval mortality at different hours after treatment							
	6 h	**12 h**	**18 h**	**24 h**	**30 h**	**36 h**	**42 h**	**48 h**
Novaluron+ Energy®@ 290	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	8.89 (17.26)	25.56 (30.32)	40.00 (39.23)
Novaluron+ Energy®@ 225	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	6.67 (14.89)	13.33 (21.39)	23.33 (28.86)
Indoxacarb+ Energy®@602.5	0.00 (0.00)	6.67 (14.89)	21.11 (27.33)	44.44 (41.78)	70.00 (56.79)	90.00 (71.56)	100.00 (90.00)	100.00 (90.00)
Indoxacarb+ Energy®@511.5	0.00 (0.00)	3.33 (10.47)	16.67 (24.04)	40.00 (39.23)	66.67 (54.70)	86.67 (68.53)	90.00 (71.56)	93.33 (75.00)
Indoxacarb+ Energy®@420	0.00 (0.00)	0.00 (0.00)	10.00 (18.44)	30.00 (33.21)	53.33 (46.89)	76.67 (61.07)	80.00 (63.44)	83.33 (65.88)
Indoxacarb+ Energy®@ 328.75	0.00 (0.00)	0.00 (0.00)	6.67 (14.89)	18.89 (25.72)	32.22 (34.56)	40.00 (39.23)	50.00 (45.00)	53.33 (46.89)
Indoxacarb+ Energy®@237.5	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	10.00 (18.44)	20.00 (26.56)	26.67 (31.05)	33.33 (35.24)	36.67 (37.23)
Proton®+ Energy®@ 1277.5	0.00 (0.00)	6.67 (14.89)	20.00 (26.56)	40.00 (39.23)	66.67 (54.70)	86.67 (68.53)	100.00 (90.00)	100.00 (90.00)
Proton®+ Energy® @1073.75	0.00 (0.00)	0.00 (0.00)	13.33 (21.39)	33.33 (35.24)	56.67 (48.79)	76.67 (61.07)	86.67 (68.53)	93.33 (75.00)
Proton®+ Energy® @870	0.00 (0.00)	0.00 (0.00)	6.67 (14.89)	23.33 (28.86)	46.67 (43.05)	66.67 (54.70)	76.67 (61.07)	83.33 (65.88)
Proton®+ Energy® @666.25	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	8.89 (17.26)	23.33 (28.86)	40.00 (39.23)	46.67 (43.05)	53.33 (46.89)
Proton®+ Energy® @462.5	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	10.00 (18.44)	18.89 (25.72)	30.00 (33.21)	36.67 (37.23)
Hamla®+ Energy® @1210	3.33 (10.47)	13.33 (21.39)	33.33 (35.24)	60.00 (50.77)	83.33 (65.88)	96.67 (79.37)	100.00 (90.00)	100.00 (90.00)
Hamla®+ Energy®@ 1017.5	0.00 (0.00)	6.67 (14.89)	26.67 (31.05)	56.67 (48.79)	82.22 (65.07)	88.89 (70.55)	92.22 (73.85)	93.33 (75.00)
Hamla®+ Energy®@825	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	33.33 (35.24)	53.33 (46.89)	73.33 (58.89)	83.33 (65.88)
Hamla®+ Energy®@632.5	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	8.89 (17.26)	15.56 (23.16)	27.78 (31.77)	36.67 (37.23)	47.78 (43.70)
Hamla®+ Energy® @440	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	6.67 (14.89)	13.33 (21.39)	20.00 (26.56)	26.67 (31.05)	30.00 (33.21)
Profenophos+ Energy®@2135	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	32.22 (34.56)	57.78 (49.45)	80.00 (63.44)	93.33 (75.00)	100.00 (90.00)
Profenophos+ Energy®@1830	0.00 (0.00)	3.33 (10.47)	10.00 (18.44)	23.33 (28.86)	46.67 (43.05)	73.33 (58.89)	90.00 (71.56)	93.33 (75.00)
Profenophos+ Energy® @1525	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	13.33 (21.39)	33.33 (35.24)	56.67 (48.79)	76.67 (61.07)	83.33 (65.88)
Profenophos+ Energy®@ 1220	0.00 (0.00)	3.33 (10.47)	10.00 (18.44)	20.00 (26.56)	33.33 (35.24)	46.67 (43.05)	53.33 (46.89)	60.00 (50.77)
Profenophos+ Energy® @ 915	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.33 (10.47)	10.00 (18.44)	20.00 (26.56)	30.00 (33.21)	36.67 (37.23)
Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
S Em ±	0.59	0.14	0.13	0.41	0.33	0.41	0.31	0.11
C D 1%	2.21	0.53	0.49	1.52	1.24	1.54	1.15	0.41
Cv 1%	-	4.44	1.52	2.75	1.50	1.45	0.92	0.31

Figures in parenthesis are arc sine transformed values

Table 4. The dosage-mortality response of *P. xylostella* larvae to selected insecticides in combination with Energy®

Treatments	χ^2	Regression equation Y= a ± bx	LC_{50} (ppm)	Fiducial limits at 95% (ppm)	LC_{99} (ppm)
Chlorantraniliprole	5.09	2.98±3.47x	7.21	5.71-8.55	33.69
Chlorantraniliprole + Energy®	2.83	15.82±6.82x	209.24	186.16-228.17	458.94
Flubendiamide	5.36	3.59±3.14x	13.99	4.18-20.69	77.06
Flubendiamide + Energy®	3.20	13.85±5.97x	207.93	179.39-229.94	509.62
Novaluron	1.33	22.13±11.83x	74.25	70.51-77.29	89.55
Novaluron + Energy®	2.95	19.73±7.99x	294.11	270.35-315.27	574.72
Indoxacarb	3.44	10.54±5.32x	95.47	82.13-106.66	261.00
Indoxacarb + Energy®	2.69	14.97±6.08x	289.21	251.64-319.04	697.50
Proton®	3.45	13.82±5.33x	391.74	337.02-437.63	1070.27
Proton® + Energy®	2.90	15.26±5.52x	575.81	493.90-641.54	1517.29
Hamla®	2.82	17.12±6.52x	420.72	378.84-460.18	956.20
Hamla® + Energy®	3.51	16.98±6.13x	580.90	513.08-639.17	1390.16
Profenophos	1.65	19.17±6.48x	907.68	798.81-993.35	2074.43
Profenophos + Energy®	1.30	20.18±6.66x	1068.88	935.20-1171.33	2388.40

Addition of boron, manganese, and 2,4-DB to fenpropathrin, lambda-cyhalothrin, and prohexadione calcium combinations changed solution pH dramatically. Prohexadione calcium had the least effect on pH of thecarrier.Changes in solution pH and formation of precipitates varied by combination (Chahal*et al*., 2012). Eric *et al.* (2003) studied on Soybean (*Glycine max*) response to glyphosate, diflubenzuron, and boron Combinations. Both glyphosate and boron caused significant foliar injury and diflubenzuron in combination did not cause significant damage.Hence, from the above studies it is clear that all the insecticides are compatible with Energy®.

Table 5. The time-mortality response of *P. xylostella* larvae to selected insecticides in combination with Energy® at different concentrations

Treatments (ppm)	χ^2	Regression equation Y= a ± bx	LT_{50} (h)	Fiducial limits at 95% (ppm)	LT_{99} (h)
Chlorantraniliprole + Energy® @ 408.12	7.58	4.61±3.22x	26.90	23.65-32.17	141.34
Chlorantraniliprole + Energy® @ 348.5	12.08	3.52±3.35x	37.32	28.98-70.76	184.49
Chlorantraniliprole+ Energy® @ 288.87	7.56	7.10±4.20x	46.74	41.54-56.13	164.66
Flubendiamide+ Energy® @ 434.18	4.18	4.20±2.95x	27.16	23.57-33.20	166.29
Flubendiamide+ Energy® @ 369.35	5.89	5.55±3.50x	38.53	33.85-46.68	177.76
Flubendiamide+ Energy® @ 304.51	6.08	7.01±4.18x	47.48	42.08-57.29	170.84
Novaluron+ Energy®@ 485	12.22	6.53±4.17x	36.60	29.45-63.26	132.011
Novaluron+ Energy®@ 420	7.02	7.51±4.57x	43.71	39.40-51.08	140.87
Novaluron+ Energy®@355	3.45	7.66±4.40x	54.74	48.12-67.65	184.50
Indoxacarb+ Energy®@602.5	5.70	6.37±4.31x	30.05	27.30-34.24	104.17
Indoxacarb+ Energy®@511.5	12.30	5.39±3.43x	37.11	29.92-58.89	176.27
Indoxacarb+ Energy®@420	12.50	5.09±3.01x	48.97	34.28-287.70	289.03
Proton®+ Energy®@ 1277.5	8.46	6.31±4.22x	31.36	26.77-41.37	111.57
Proton®+ Energy® @1073.75	5.86	5.96±3.74x	39.48	34.98-47.20	165.15
Proton®+ Energy® @870	9.77	5.64±3.32x	49.57	39.46-82.71	247.85
Hamla®+ Energy® @1210	5.90	4.75±3.31x	27.28	24.06-32.45	137.51
Hamla®+ Energy®@ 1017.5	12.33	4.54±2.96x	34.43	25.24-91.14	210.40
Hamla®+ Energy® @	2.78	7.07±4.21x	48.01	42.58-57.90	171.40
Profenophos+ Energy®@2135	3.19	6.81±4.43x	34.47	31.36-39.26	115.49
Profenophos+ Energy®@1830	7.28	6.37±3.97x	40.15	35.83-47.32	154.47
Profenophos+ Energy® @1525	6.14	7.13±4.26x	47.03	41.80-56.48	165.24

Table 6.Compatibility chart for agro-chemicals tested against *P. xylostella*larvae

Agro-chemicals	Energy®
Chlorantraniliprole	+
Flubendiamide	+
Novaluron	+
Indoxacarb	+
Proton®	+
Hamla®	+
Profenophos	+

+ = Compatible
- = Incompitable

4. COMPATIBILITY CONCLUSION

From the results of *in vitro* experiments on the interaction of agro-chemicals, a compatibility chart has been prepared and presented in the Table. In combination with Energy® all insecticides namely Chlorantraniliprole, flubendiamide, novaluron, indoxacarb, Proton®, Hamla® and profenophos were clearly compatible against test insect (table 6).

Interestingly, some of the combinations which behaved differently against test insect are to be viewed differently on the basis of desirable action exhibited by the chemicals in the mixture. A mixture of insecticide in combination with plant growth regulator may cause desirable effect on insect or vice- versa. If a mixture intended to suppress insect, failed to accomplish and causes adverse effects, such a combination may be rejected. The literature review also highlighted such variations in compatibility of pesticides this may be due to variability in test organism or crop. In most of the studies, where compatibility among agro-chemicals tried were too low to exert desirable effects. Hence further combination is needed regarding compatibility and bio-efficacy and compatibility of various pesticidal mixtures and plant growth regulators at their recommended doses in the laboratory and under field conditions. These combinations can be evaluated for phytotoxicity in field conditions. Baseline studies can be undertaken for individual insecticides, so that the folds of resistance can be worked out.

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