Journal Crop and Weed, 11(2):172-180(2015)

Positioning IPM compatible pre-mix formulation of cartap hydrochloride 50SP + buprofezin 10EC (KCB-2010) to combat chewing and sucking pests of okra

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Received : 28.04.2015, Revised : 26.11.2015, Accepted : 28.11.2015

ABSTRACT

Field bio-effectiveness of pre-mix formulation of cartap hydrochloride 50% SP + buprofezin 10% EC (KCB-2010) were evaluated against jassid (Amrasca biguttula biguttula), whitefly (Bemisia tabaci) and fruit borer (Earias vittella) during 2011 and 2012 in spring-summer crop. KCB-2010 @ 600 and 750 ml ha^{-1} reduced okra fruit borer population to the tune of 73.07 % and 75.51 % in two seasons respectively. The treatments also provided significant reduction of jassid (59.33% and 60.87 %) and whitefly (69.46 % and 70.91%) population vis-à-vis highest yield (16.62 and 17.27 t ha^{-1}) in comparison to 6.66 t ha^{-1} in untreated plots. Tested dosages were soft against natural enemies like, coccinellides, syrphids, spiders and staphylinids, with population reduction of 8.35 and 9.50%, 10.00 and 9.85%, 7.00 and 8.10% and 1.78 and 3.50%, respectively; hence can be considered as a suitable IPM compatible tool with favorable toxicological profile.

Keywords: *Amrasca biguttula biguttula,* buprofezin, cartap hydrochloride, *Earias vittella*, *Bemisia tabici*

Okra or Lady's finger, *Abelmoschus esculentus* (L.) Moench (Malvaceae), is an important vegetable crop which supplies higher nutrition (carbohydrates, fats, protein, minerals and vitamins) in our diet (Mal *et al*., 2013). It is native to Africa, South East Asia and North Australia to the Pacific (Boswell and Reed, 1962). This annual crop occupies an area of 4.09 lakh ha with production of 41.92 lakh tonnes and productivity of 10.3t ha^{-1} in India (Anon., 2008). One of the important limiting factors in the cultivation of okra is insect pests. Many of the pests occurring on cotton are found to ravage okra crop. It is reported to be attacked by about 72 insect pests (Ghoshal *et al*., 2013); of which the shoot and fruit borer, *Earias vittella* (F.) is a serious pest, causing 17.46% reduction in the yield (Sarkar *et al*., 1996). This insect causes damage to shoots in early vegetative stage and fruits in the reproductive stage. Shoot and fruit borer is also known as tissue borer, as they infest the crop in its early stage of growth. Larvae bore into the young growing shoots and as a result shoots droop down and wither away. Later on, they bore the developing fruit which become unfit for human consumption. The cotton jassid (*Amrasca biguttula biguttula* Ishida) and whitefly (*Bemisia tabaci* Genn.) are of moderate occurrence yet important (Reghupathi *et al.,* 2003). The yield loss due to jassid desapping in okra amounts to 54 – 66% (Satpathy *et al*., 2004). To tackle this sucking pest menace, a number of chemical insecticides are indiscriminately imposed on this vegetable crop, which led to several problems like residues of toxicants, elimination of the natural enemies, environmental disharmony and resistance development. Due to the presence of pesticide residues at harvest, there exist risks of rejection of whole consignments during export. To combat these problems, identification of bio-rational molecules with better insecticidal properties, low mammalian toxicity with softness to natural enemies, is the need of the hour. Farmers rely on conventional insecticides such as organophosphate, carbamate and synthetic pyrethroid to manage these pests (Patel *et al*., 1997). The repeated and indiscriminate use of these conventional insecticides has resulted in problems such as insecticide resistance, disturbance to the agro-ecosystem, affecting the non-targets (Dittrich *et al*., 1990). Very recently, the concepts of using insecticide mixtures, with independent mode of action, are being recommended. A pesticide mixture is, when two or more pesticides are combined into a single spray solution (Cloyd, 2001a) entails exposing individuals in an arthropod pest population to each pesticide simultaneously (Tabashnik, 1989; Hoy, 1998). Pesticide mixtures may be more effective against various life stages of arthropod pests *viz*. eggs, larvae, nymphs and adults than individual applications although the efficacy may vary depending on the rates and formulations of the pesticides mixed together (Blumel and Gross, 2001). Pest population is suppressed by using pesticide mixtures due to either synergistic interaction or potentiation between or among pesticides that are

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mixed together (Warnock and Cloyd, 2005; Cloyd *et al.*, 2007).

The idea of controlling pests by using various agro-techniques in combination with selective use of insecticides making compatible with other components of the management of okra pests are gaining importance as the most effective measure (Konar *et al*., 2013).

Buprofezin, a chitin synthesis inhibitor against larvae of Lepidoptera because it interferes with chitin formation by blocking the polymerizations process of N- acetyl glucose amine units (Ishaaya and Horowitz, 1998). It has both contact and vapor phase activity. It acts on the nymphal stages of leafhoppers, planthoppers, scales, and whiteflies (De Cock and Degheele, 1998). Cartap, a nereistoxin analog, of thiocarbamate group, commonly used as a hydrochloride ($C_7H_{15}N_3O_2S_3HCl$) acts as a synaptic blocking agent and is easily absorbed into the plant tissue and is highly effective in preventing and eliminating lepidopteran pests (Huang *et al*., 2011).

General predators like coccinellids, syrphids, spiders, staphylinids are predominant in the okra agro-ecosystem under inceptisol of India required to be conserved as they are highly prone to indiscriminate selection of insecticides applied with improper dosages.

Hence, the present study was attempted to evaluate the efficacy of an insecticide pre-mix, with independent mode of action, to find out a viable option for sustainable management of the key insect pests of okra.

MATERIALS AND METHODS

A field experiment was laid out in a Completely Randomized Block Design with 7 (seven) treatments and 4 replications with okra *cv* "*Arka Anamika*" in the experimental fields of District Seed Farm (AB Block), BCKV, Kalyani, Nadia, West Bengal, situated at 9.75 above msl during January to April of 2011 and 2012. The spring summer crop (pre-*kharif*) was sown in 3×2 m plots with inter and intra row spacing of 45cm × 60 cm. Standard agronomic practices were followed (80 kg N ha^{-1} along with 3t of FYM as well as 40 kg: 250 kg (P: K) ha^{-1}) and tricyclazole 1 ml^{-L} at the early stage of crop growth for disease control.

The treatments considered were (i) cartap hydrochloride 50% SP + buprofezin 10% EC *i.e.* KCB-2010 @ 375 ml ha^{-1} (187.5 + 37.5g a.i ha^{-1}); (ii) @ 500 ml ha^{-1} (250 + 50g a.i ha^{-1}); (iii) @ 600 ml ha^{-1} (375 + 75g a.i ha^{-1}); (iv) @ 750 ml ha^{-1} (375 + 75g a.i ha^{-1}); (v) chlorantraniliprole 18.5% SC 50 ml ha^{-1} (9.25g a.i. ha^{-1}); (vi) acephate 75 SP 300 g ha^{-1} (118.05g a.i. ha^{-1}); (vii) untreated control.

First spraying was imposed 35 days after sowing followed by two sprays at 15 days interval with a high volume knap-sack sprayer using hollow cone nozzle @ 500 L water ha^{-1}. Five plants were randomly selected and tagged in each plot to record the insect population. Such count was recorded from three different tires (leaves one from top, middle and bottom of each plant). Observations on fruit borers, jassids and whiteflies were recorded a day before and 1, 3, 7 and 10 days after spray (DAS). Picking of fruits were done at 1 day interval and number and weight of healthy and damaged fruits were recorded. During each picking, mean percent of fruit damage (number and weight basis) were worked out. Healthy and damaged fruits due to fruit borer were recorded and weighed separately during each picking. Economics of different treatments evaluated was calculated based on the yield data, cost of treatments and prevailing market price of insecticides. In total 18 rounds of picking were done. The prevalence of insect predators, spiders in okra eco-system after application of different treatments were recorded per 5 plants in each treatment and converted in terms of percent reduction. The predatory population consisted with *Coccinella transversalis*, Syrphids, Staphylinids along with *Lynx* (*Oxyopes* sp.) and *Wolf* (*Hogna* sp.) spiders. The distribution of population varied between 1.60-2.65 (*Coccinella*), 1.60-2.35 (Syrphids), 1.10-1.95 (Staphylinids), 2.60-3.15 (spiders) prior imposition of treatments. Afterwards the treatment means were compared by ANOVA after making necessary transformation wherever necessary. Yield was recorded in t ha^{-1} and assessed with suitable statistical interpretation.

RESULTS AND DISCUSSION

Okra tissue or fruit borer

Table 1 represents the pooled data on the efficacy of different treatment schedules of cartap hydrochloride 50% SP + buprofezin 10% EC (KCB-2010) against the larval population of fruit borer of okra during January – April, 2011 and 2012, (Season I and II) respectively. From table 1, it can be seen that, all the treated plots showed significant reduction of the larval population than untreated control. But, cartap hydrochloride 50% SP + buprofezin 10% EC @ 600 and 750 ml ha^{-1} provided the optimum reduction, with an overall mean population of 2.65 and 2.41 respectively (73.07 and 75.51 % reduction over untreated control) and no significant differences were recorded amongst them. The same trend was observed in January- April 2012 also. During this year the pest load was to some extent lower. Maximum and minimum population was 1.50 - 7.81 larvae per five plants respectively in different treatments. But, the efficacy of cartap hydrochloride 50% SP + buprofezin 10% EC @ 600 and 750 ml ha^{-1} were the best, registering 32.54 and 30.63% mean fruit damage per five plants, which are 57.98 and 60.45% reduction of damage over untreated control. The standard check chlorantraniliprole @ 50 ml ha^{-1} and acephate 75 SP @ 300 g ha^{-1} were also effective in suppressing overall fruit borer damage per five plants to the tune of 25.63 and 35.66% respectively. Now, out of the seven treatments consider, the minimum damage fruit were recorded in chlorantraniliprole @ 50 ml ha^{-1} (25.63% mean fruit damage) followed by cartap hydrochloride 50% SP + buprofezin 10% EC @ 750 ml ha^{-1} (30.63% mean fruit damage). Maximum damage was recorded in untreated control plots (77.43% mean fruit damage).

Perusal of available literature revealed that, no such work has been done yet in this direction with the pre-mix combination insecticides in question. However, some citations are available on individual effect of test insecticides. Such as, Upendra Kumar *et al*. (2013) studied the effectiveness (10-14% fruit damage only) of cartap hydrochloride against *Earias vittella* in okra and it was superior to profenofos, endosulfan *etc.* Cartap hydrochloride is also very effective against other Lepidopteran borers as well. The findings of Singh *et al.* (2010) revealed that, application of cartap hydrochloride @ 25kg ha^{-1}, 45 days after planting, reduces the incidence of shoot borer and top borer of sugarcane. Jhusi and Rao (1995) also found cartap hydrochloride as very effective insecticide against shoot borer. These findings are in conformity of the finding of the present authors.

Whitefly

Table2 represents the efficacy of different treatment schedules of cartap hydrochloride 50% SP + buprofezin 10% EC against whitefly of okra during January-April, 2011 and 2012, respectively. From this table, it can be seen that, in season I, the pre-mix formulation has excellent efficacy (4.44 and 4.68 number of whitefly per leaf) @ 600 and 750 ml ha^{-1}. In season II, *i.e.* 2012, the above mentioned treatments were found again excellent in suppressing whitefly population to the tune of 10.25 and 9.31 per leaf in comparison to 23.88 per leaf in untreated control plots. Considering the percent reduction of whitefly in different treatments in comparison to untreated control revealed that, highest reduction was registered in 750 ml ha^{-1} (70.91% reduction) followed by 600 ml ha^{-1} (69.48% reduction). Minimum reduction was recorded in chlorantraniliprole 18.5% SC treated plots (37.83% reduction).

Das and Islam (2014) reported the excellent efficacy of buprofezin against jassids and whiteflies. This lends support to the finding of the present authors. Sontakke *et al*. (2013) also reported the effectiveness of buprofezin against aphid and other sucking pests *viz*. *Bemisia tabaci*, *Amrasca biguttula biguttula* and *Scirtothrips dorsalis.* Buprofezin was proved to be effective against nymphs of whitefly (Ali *et al*., 2005). Buprofezin affects young instars than the older ones in case of whitefly (Ishaaya *et al*., 1988) as the thicker wax cover of the mature insters and their larger body mass may cause this phenomenon (Gerling and Sinai, 1994). Again, these findings are in parity vis-à-vis support to the findings of the present authors.

Jassid

Table2 (season I) represents the efficacy of cartap hydrochloride 50% SP + buprofezin 10% EC @ 600 and 750 ml ha^{-1} was excellent in providing significant reduction of jassid number than untreated control (15.45 per leaf). Highest reduction was recorded in 750 ml ha^{-1} (5.31 per leaf) followed by 600 ml ha^{-1} (5.56 per leaf). In season II also, the aforesaid treatments were very much effective. The highest reduction was recorded (9.38 per leaf) in case of 750 ml ha^{-1} followed by 600 ml ha^{-1} (9.69 per leaf). In case of overall mean population reduction of jassid it can be seen that cartap hydrochloride 50% SP + buprofezin 10% EC @ 750 ml ha^{-1} reduced highest (7.34 per leaf) which is 60.87% reduction over untreated control.

The above results are in agreement with the findings of Anand *et al*., (2013) where the lowest mean leafhopper population on okra (variety *Arka Anamika*) was recorded from buprofezin which was superior to acetamiprid, pymetrozine, spiromesifen and thiamethoxam. Patel *et al*. (2012) also reported the higher dose of buprofezin recorded significantly lower jassid population in okra than imidacloprid and acephate with significantly higher okra fruit yield. Cartap was found most effective against jassids with 17.00% degradation after 1st day, 88.02% after 7th day and 92.80% after 30th day of its application (Eijaza *et*

Table 1: Effect of cartap hydrochloride 50SP + buprofezin 10EC (KCB-2010) against tissue and fruit borer of okra during 2011-12

Treatment	Dose (ml g^{-1} ha^{-1})	PTC of fruit borer larvae	Mean larval population5^{-1} plants		Overall meanpopulation of fruit borer	% reduction of larval population over control	PT % of fruit damage	Mean % fruit damage 5^{-1} plants		Overall % fruit damage 5^{-1} plants	% reduction of fruit damage over
			2011	2012	(2011-12)			2011	2012	(2011-12)	control
Cartap hydrochloride 50 SP+ Buprofezin 10EC	375	6.25	5.93 (2.43)*	4.13 (2.03)	5.04	48.78	67.38	52.09 (46.19)**	41.44 (6.44)	46.76	39.60
Cartap hydrochloride 50 SP+ Buprofezin 10EC	500	6.75	4.68 (2.16)	2.06 (1.43)	3.37	65.75	65.25	57.69 (49.43)	35.81 (36.76)	46.75	39.62
Cartap hydrochloride 50SP+ Buprofezin 10EC	600	6.63	3.68 (1.91)	1.62 (1.27)	2.65	73.07	68.13	34.81 (36.16)	30.25 (33.37)	32.54	57.98
Cartap hydrochloride 50SP+ Buprofezin 10EC	750	6.38	3.31 (1.81)	1.50 (1.23)	2.41	75.51	67.13	31.38 (34.07)	29.88 (33.14)	30.63	60.45
Chlorantranilipole 18.5SC	50	6.89	3.50 (1.87)	2.50 (1.59)	3.00	69.51	66.00	25.89 (30.58)	25.38 (30.26)	25.63	66.89
Acephate 75SP	300	7.75	4.75 (2.18)	2.68 (1.64)	3.72	62.20	65.75	33.69 (35.49)	37.63 (37.84)	35.66	53.94
Control (Without spray)	-	6.75	11.87 (3.45)	7.81 (2.79)	9.84	-	67.00	81.10 (64.24)	73.75 (59.17)	77.43	-
LSD (0.05)	**NS**	**0.26**	**0.12**	**5.89**	—	**NS**	**5.35**	**5.64**	—	—	

*Note:*Figures in parentheses are square root transformed values ** Figures in parentheses are arc sin transformed values*

Table 2: Effect of cartap hydrochloride 50SP + buprofezin 10EC (KCB-2010) against whitefly and jassid of okra during 2011-12

Treatment	Dose (ml g^{-1} ha^{-1})	PTC of jassid leaf^{-1}	Number of jassid leaf^{-1}		Overall meanpopulation of jassid leaf^{-1} (2011-12)	% reduction of jassid over untreated control	PTC of whitefly leaf^{-1}	Number of whitefly leaf^{-1}		Overall meanpopulation of whitefly leaf^{-1}(2011-12)	% reduction of whitefly over control
			2011	2012				2011	2012		
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	375	14.82	7.75 (2.78)	14.49 (3.80)	11.12	40.73	17.00	6.87 (2.62)	14.13 (3.75)	10.50	56.30
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	500	12.50	7.12 (2.66)	10.93 (3.30)	9.03	51.87	15.50	5.00 (2.23)	10.50 (3.24)	7.75	67.75
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	600	15.34	5.56 (2.35)	9.69 (3.11)	7.63	59.33	16.34	4.44 (2.10)	10.25 (3.20)	7.34	69.46
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	750	13.75	5.31 (2.30)	9.38 (3.06)	7.34	60.87	18.13	4.68 (2.16)	9.31 (3.05)	6.99	70.91
Chlorantranilipole 18.5% SC	50	16.00	6.37 (2.52)	10.63 (3.26)	8.50	54.69	17.00	13.63 (3.69)	16.25 (4.03)	14.94	37.83
Acephate 75% SP	300	14.00	6.00 (2.45)	11.75 (3.42)	8.88	52.67	18.00	13.19 (3.63)	15.06 (3.88)	14.13	41.20
Control (Without spray)	-	13.34	15.45 (3.93)	22.06 (4.69)	18.76	-	16.00	24.19 (4.91)	23.88 (4.88)	24.03	-
LSD (0.05)	**NS**	**0.14**	**0.21**	**6.23**	**-**	**NS**	**0.11**	**1.01**	**5.15**	**-**	

Table 3: Effect of cartap hydrochloride 50SP + buprofezin 10EC (KCB-2010) on natural enemies associated with okra crop during 2011-12

Treatment	Dose (ml g^{-1} ha^{-1})	Pre-application count of motile stage (No.) of predators 20^{-1} plants				% reduction or increase (+) on 15th day after application				Mean percent reduction of predators
		1	2	3	4	1	2	3	4	
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	375	1.95	2.15	3.15	1.45	6.75 (15.05)*	6.25 (14.47)	2.01 (8.15)	1.75 (7.60)	4.19 (11.81)
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	500	2.15	2.35	3.10	1.10	7.25 (15.62)	8.00 (16.42)	5.15 (13.12)	2.19 (8.51)	5.64 (13.73)
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	600	2.65	2.10	2.60	1.95	8.35 (16.79)	10.00 (18.43)	7.00 (15.34)	1.78 (7.67)	6.78 (15.09)
Cartap hydrochloride 50% SP+ Buprofezin 10% EC	750	1.60	1.60	3.10	1.80	9.50 (17.95)	9.85 (18.29)	8.10 (16.53)	3.50 (10.78)	7.73 (16.14)
Chlorantranilipole 18.5% SC	50	2.15	2.15	2.60	1.10	11.15 (19.50)	11.00 (19.36)	9.25 (26.02)	7.25 (15.62)	9.66 (18.10)
Acephate 75% SP	300	2.00	1.60	3.00	1.80	32.00 (34.45)	30.75 (33.67)	34.25 (35.81)	27.50 (31.62)	31.12 (33.90)
Control (Without spray)	-	1.60	2.35	3.10	1.10	+42.65 (0.00)	+45.00 (0.00)	+39.15 (0.00)	+40.50 (0.00)	0.00
LSD (0.05)	**-**	**NS**	**NS**	**NS**	**NS**	**1.29**	**2.34**	**1.98**	**2.01**	**-**

*Note: 1. Coccinella transversalis, 2. Syrphids, 3. spiders (Lynx and Wolf spiders), 4. Staphylinids, *Figures in parentheses are angular transformed values*

Table 4: Yield of okra and economics of different treatment schedules of KCB-2010 during 2011 and 2012

Treatments	Dose (ml g^{-1} ha^{-1})	Yield (t ha^{-1}) (2011)	% yield increase over control (2011)	Yield (t ha^{-1}) (2012)	% yield increase over control (2012)	Mean yield (t ha^{-1})	Overall increase in yield over control	Cost of treatment including labour charges (Rs ha^{-1})	Gross realization (Rs ha^{-1})	Net realization (Rs ha^{-1})	Net profit (Rs ha^{-1})	ICBR
Cartap hydrochloride 50SP+ Buprofezin 10 EC	375	9.90	39.40	10.24	28.52	10.07	33.86	5232.50	120840.00	115608.50	110376.50	1:21.10
Cartap hydrochloride 50SP+ Buprofezin 10EC	500	12.20	50.82	15.50	52.77	13.85	51.91	5380.50	166200.00	160820.50	155440.00	1:28.89
Cartap hydrochloride 50SP+ Buprofezin 10 EC	600	14.41	58.36	18.83	61.13	16.62	59.93	5528.50	199440.00	193912.50	188384.50	1:34.08
Cartap hydrochloride 50SP+ Buprofezin 10EC	750	15.25	60.66	19.28	62.03	17.27	61.44	5776.50	207240.00	201464.50	195688.00	1:33.87
Chlorantranilipole 18.5SC	50	10.32	41.86	14.50	49.52	12.41	46.33	4982.50	148920.00	143930.50	138956.00	1:27.89
Acephate 75SP	300	9.85	39.09	12.95	43.48	11.40	41.58	4766.50	136800.00	132034.50	127268.00	1:26.70
Control (Without spray)	—	6.00	--	7.32	--	6.66	--	—	79920.00	—	—	—

Note:Market price of okra fruit: Rs.12,000 t^{-1}, Labour charge(skilled):Rs.193.00 day^{-1}

al., 2015). This leads further support to the finding of present authors.

Effect of treatments on predatory fauna

It appears from table3, that, the percent reduction of population of *Coccinellids* varied significantly in different treatments. Highest reduction to the tune of 32.00% was recorded in standard check acephate 75 SP @ 300 g ha^{-1}; whereas lowest reduction was recorded in KCB 2010 @ 375 ml ha^{-1} (6.75%). With gradual increase in dose from 500 to 750 ml ha^{-1} revealed the increase in percent reduction in *Coccinellids* population. But, they were below 12.00% and interestingly KCB 2010 at 600 and 750 ml ha^{-1} registered 8.35 and 9.50% mortality respectively, which were statistically *on par.* Likewise, in case of other predators at both the stated doses mentioned herein before recorded reduction in mortality to the tune of 3.50-10.00% in different cases that is syrphids, staphylinids and spiders. It can further be depicted from the table that the mean percent reduction of predators in case of 600 and 750 ml ha^{-1} treatments, 6.78 and 7.73% reduction respectively which were also computed *at par.* Chlorantraniliprole at 50 ml ha^{-1} was also found safe (9.66% reduction) for the prevailing insect predators and spiders in okra eco system.

Jafar *et al*. (2013) found cartap hydrochloride 50 SP at 500g a.i. ha^{-1} safe for natural enemies. These findings are in conformity of the findings of the present investigation.

Yield

The yields obtained during the period of investigation have been depicted in table4. The table reveals that, KCB-2010 @ 600 and 750 ml ha^{-1}, provided highest yield to the tune of 14.41 and 15.25 t ha^{-1} respectively in comparison to 6.00 t ha^{-1} in untreated check plots which were 58.36 and 60.66% increment in yield over untreated control during first season (2011). Again, in 2012, KCB-2010 @ 600 and 750 ml ha^{-1} recorded yield to the tune of 18.83 and 19.28t ha^{-1}, which were 61.13 and 62.03% increase in yield over untreated control (7.32 t ha^{-1}).

So, from the findings presented above, it can be said that among all the treatments, the KCB-2010 @ 600 ml ha^{-1} is most desirable with a promising cost: benefit ratio of 1: 34.08 and showed optimum efficacy against fruit borer, jassids and whitefly in okra and it had no adverse effect on the population of natural enemies. No phytotoxic symptoms were observed in any of the treated plots with cartap hydrochloride 50% SP + buprofezin 10% EC during both the seasons.

The perusal of available literatures shows that there are several eco-friendly ways available to reduce the pesticide usage in vegetable cultivation and produce optimization. There is a need to realize the potential of indigenous bio-control agents and attention should be given to conserve them.

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