THE ASIAN JOURNAL OF HORTICULTURE
Volume **8** | Issue 2 | December, 2013 | 659-666

Research Paper

Article history **:**
Received : 16.08.2013
Revised : 01.10.2013
Accepted : 15.10.2013

Compatibility of insecticides and fungicides mixtures against cabbage leaf spot, *Alternaria brassicae* (Sacc.) Berk.

■ **K.N. SREEDHAR[1], C.T. ASHOK KUMAR[1], K. PADMANABHA** AND **S. SUDHIRKUMAR[1]**

Members of the Research Forum

Associated Authors:
[1]Department of Agricultral Entomoklogy, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARNATAKA) INDIA

Author for correspondence :
K. PADMANABHA
Department of Horticulture, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARNATAKA) INDIA
Email : padduhort@gmail.com

ABSTRACT : Among the insecticides studied, profenophos showed cent per cent mycelial inhibition at all four concentrations (0.0025, 0.005, 0.01 and 0.02) followed by fipronil at 0.01 and 0.02 per cent. Similarly spinosad (36.61- 85.00%), novaluron (25.00-64.68%), endosulfan (35.91-55.00), indoxacarb (35.22-55.00%) and thiodicarb (10.66-52.66%) were proved to be moderately toxic. The combining effect of clorothalonil with insecticides indicated that clorothalonil is compatible with fipronil, profenophos, endosulfan, indoxacarb, spinosad and thiodicarb as its bio-efficacy was increased by 24.39, 24.39, 22.88, 20.16, 19.54, and 2.54 per cent, respectively. However, incompatibility was noticed in combination with novaluron where efficacy was decreased by 3.72 per cent. The bio-efficacy of mancozeb with insecticides indicated that it is compatible with all the insecticides tested where its bio-efficacy was increased substantially with endosulfan (40.08%), profenophos (38.45%), novaluron (29.20%), thiodicarb (27.79%), spinosad (23.33), fipronil (21.21%) and indoxacarb (17.72%). Regarding compatibility of quintal with insecticides its bio-efficacy was enhanced with profenophos (26.09) followed by novaluron (25.53%), fipronil (24.33), endosulfan (22.89), indoxacarb (18.71) and thiodicarb (18.08) indicating that they are compatible. However, incompatibility was noticed between quintal + spinosad combination where efficacy of lowered by 12.95 per cent.

KEY WORDS : *Alternaria brassicae*, Compatibilty, Fungicides, Insecticides

HOW TO CITE THIS ARTICLE : Sreedhar, K.N., Ashok Kumar, C.T., Padmanabha, K. and Sudhirkumar, S. (2013). Compatibility of insecticides and fungicides mixtures against cabbage leaf spot, *Alternaria brassicae* (Sack-Berk). *Asian J. Hort.*, **8**(2) : 659-666.

Cole crops are an important group of vegetables consumed all over the world. Cole crops like cabbage, cauliflower, turnip, kale. broccoli, brussel sprouts, etc., are grown in hills and plains of India. Among them, cabbage and cauliflower are economically important vegetables in India. In recent years, the production of crucifers has been seriously affected by steady increase in insect pest infestation, especially the diamondback moth (DBM), *Plutetla xylostelta* (L.) (Srinivasan and Krishnamoorthy, 1992) and the leaf spot disease caused by the fungus, *Alternaria brassicae*. The Alternaria leaf spot caused by the fungus, *Alternaria brassicae* (Sackberk) affects almost all crucifers and has created serious problems on cabbage and cauliflower in India. Losses occur mostly in the form of reduced quality of heads, although in some cases the pathogen is destructive for seed growers, where the pathogen can shrivel seeds within the pods or kill pod stalks before seed formation. In addition to destruction of seed crops, the pathogen can live within the seed, spread the disease to other fields and cause loss of seedlings (Rangel, 1945).

Pesticides have a great impact on human health, production and preservation of food, fibre and other cash crops. Though, different control methods are available for suppression of pests on crops their efficacy, speed and cost of operations with chemical control measures. However, the over-dependence on chemicals and their indiscriminate use in cabbage ecosystem has led to some serious problems such as, increased cost of plant protection, insecticide resistance in some pests and pathogens, resurgence of certain pest species, apart from the environmental hazards associated with

their use. The problem is also compounded by the occurrence of pests and diseases simultaneously in the field, and it is more common in commercial crops. Any delay in the application of pesticides results in heavy crop losses. To save time and to get quick curative action, the farmers often, mix different pesticides without considering their compatibility.

The number of chemicals involved in plant protection are too many and the information on compatibility of individual chemical is scattered in the literature. Common growers find difficulty in ascertaining their compatibility. Hence, based on experience, Gray (1914) prepared a chart showing compatibility of some of the insecticides and fungicides, then in use. Later several such charts were developed or up-dated by Frear (1948) for the chemicals in use with additional information regarding incompatibility under certain situations and crops. Such information led an understanding that the compatibility might vary with crops, season, aging of mixtures and many other factors. Later Baicu (1980) suggested studying compatibility in different stages including determination of chemical and physical properties, biological activity of compounds, field tests of effectiveness, phytotoxicity and yield after treatment. However, very few studies, which have gone in to the problem of compatibility to such an extent.

Secondly, the chemicals have been developed primarily to control target pest, may be an insect or pathogenic organism, but their toxic effects on unrelated organisms are not well known. There are few reports of fungicides possessing insecticidal properties on insects and insecticides having fungicidal properties on pathogens. But such information on majority of chemicals is desired. A chemical possessing both insecticidal and fungicidal properties, if identified would help in reducing pesticidal load on the environment.

Detailed study to understand the desirable and undesirable effects of mixing two chemicals assume practical significance as several combinations may result in loss of effect of either or both the chemicals or it may results in synergism between the chemical combinations. It may also lead to variation in the relative toxicity of mixtures when compared to individual chemicals, induce toxicity to plants, or interfere with growth and metabolism resulting in decreased crop yields. Keeping these things in view, the present study was undertaken to assess the compatibility of insecticides and fungicides under cabbage ecosystem.

RESEARCH METHODS

The materials used and the methods employed to carry out the investigation of influence of insecticides on the bio-efficacy of fungicides against Alternaria leaf spot *(A. brassicae) in vitro* when applied as mixture was carried out at the Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bangalore during 2004-2005.

General laboratory procedures:

Glassware cleaning:

For all laboratory experimental studies, lorning and borosil glassware's were used. The glassware's were boiled for half an hour and then washed with detergent powder followed by cleaning in tap water and then rinsed into distilled water.

Sterilization:

All glassware used in the studies were sterilized in autoclave at 1.1 kg/cm^2 pressure for 21 minutes and then dried in hot air oven at 55^0 C. Potato dextrose agar media used in the experiments was sterilized at 1.1 kg/cm^2 pressure for 15minutes.

Isolation and maintenance of culture of A. brassicae:

Cabbage leaf showing the typical symptoms of Alternaria leaf spot was collected from a cabbage fields near Bangalore, and the fungus was isolated by the standard tissue isolation technique (Twit, 1969). Infected leaves were washed well in running tap water and infected parts of the leaf were cut into small bits of 2-5 mm size. These bits were surface sterilized with 0.1 per cent mercuric chloride solution for one minute and then washed thoroughly in sterile distilled water separately for three times. Such bits were transferred to sterilized petridishes containing potato dextrose agar (PDA) medium under aseptic conditions. These Petridishes were incubated at room temperature (28±1^0 C) and observed periodically for the growth of the fungus. Pure colonies which were developed from bits were transferred on to the PDA slants and incubated at 28±1^0 C.

ldentification of the fungus:

The fungus was identified based on the morphological and cultural characteristics. The characters were compared with those described by Rangel (1945).

Proving pathogenicity:

Pathogenicity test was carried out by growing 'Maharani' variety of cabbage on earthen pots under green house conditions. One month old cabbage plants were sprayed with spore suspension and mycelial bits of seven days old test culture prepared in sterilized distilled water. Plants were covered with polythene paper bags after inoculation for two days to maintain high relative humidity and later, they were removed. Plants sprayed with distilled water served as control. Observations were recorded on the type of symptoms found on the leaves and then re-isolation was done from infested leaf bits by following usual procedure as mentioned earlier. The culture obtained was compared with the original one to confirm the identity of the pathogen.

Maintenance of culture:

Pure culture of the fungus was obtained by culturing the single sclerotial body on PDA medium. The fungus was grown for seven days at room temperature on PDA slants. Pure cultures so obtained were preserved in refrigerator at 5^0 C for further use. Sub culture was prepared whenever required.

Composition of potato dextrose agar

Potato	–	200 g
Dextrose	–	20 g
Agar	–	20 g
Distilled water	–	1000 ml

Two hundred grams of peeled sliced potatoes were boiled in 500 ml distilled water for 20 minutes. The extract was collected by filtering through the muslin cloths and dextrose was dissolved in it. Agar was melted separately and mixed with the extract and volume was made up to 1000 ml. Known quantity of such medium was dispensed into number of conical flasks, plugged with non-absorbent cotton and then sterilized by autoclave.

Fungicidal property of selected insecticides and fungicides against *A. brassicae* in *vitro*:

Fungicidal action of selected insecticides and fungicides was studied *in-vitro* by poison food technique (Nene and Thapliyal, 1979). The test fungus was allowed to grow on poisoned potato dextrose agar medium and the colony diameter was recorded on per cent inhibition basis over control. Each chemical was tested at four concentrations.

Requisite quantities of each insecticide and fungicide were accurately added in to 100 ml conical flask containing molten agar separately. Care was taken to make up the volume of medium with chemicals to 50 ml. To each flask two mg of streptomycin powder was added to prevent bacterial growth. The contents were well stirred and mixed thoroughly and poured on to three Petridishes (90 mm diameter) equally at 15 ml/Petridish. Seven day old culture grown on agar media was used as inoculum and transferred aseptically in to the centre of each Petridish containing poisoned nutrient medium. The Petridishes were kept in the incubator along with checks were kept on PDA without toxicant. Each treatment was replicated thrice.

The diameter of the radial growth of colonies in each of the treatments was measured in four directions lengthwise and breadthwise and mean was calculated. The observations were made from 2^{nd} to 14^{th} day after inoculation regularly at two days intervals and were compared with the check and per cent inhibition of mycelial growth was determined using the formula suggested by Vincent (1927).

$$\text{Per cent inhibition} = \frac{C - T}{C} \times 100$$

where, C = Colony diameter (mm) in control

T = Colony diameter (mm) in treatment.

Bio-efficacy of fungicides when mixed with insecticides against *A. brassicae*:

Effect of insecticides and fungicides mixtures on test fungus was studied by poison food technique. Each concentration of fungicide was mixed with each insecticide at uniform concentration (100 ppm each) and per cent inhibition in colony growth was calculated. Later, ANOVA was performed to compare the treatment means.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Bio-efficacy of fungicides when mixed with insecticides against *A. brassicae* under laboratory conditions:

Initially the fungicides and insecticides were individually evaluated for their fungicidal properties. Later all the fungicides at four concentrations were evaluated in combination with seven insecticides *in vitro* against *A. brassicae* by using poisoned food technique. All the insecticides were used at 0.01 per cent concentration.

The data pertaining to the efficacy of fungicides against *A. brassicae* are presented in Table 1. The results revealed that highly significant inhibition of mycelial growth was observed with fungicides compared to control. It was also observed that mycelial inhibition increased with corresponding increase in concentration of the chemical. Among the fungicides tested, chlorothalonil was found more effective against *A. brassicae* showing significantiy higher mycelial inhibition of 75.61 followed by quintal with 73.91 per cent inhibition. However mancozeb showed least fungicidal property with 59.92 per cent mycelial inhibition.

The data pertaining to the fungicidal action of insecticides is presented in Table 2. *In vitro* evaluation of insecticides revealed that all the insecticides possessed good fungicidal properties and the effectiveness was increased with corresponding increase in concentration. Among the insecticides, cent per cent mycelial growth was inhibited by profenophos at all the four concentrations tested followed by fipronil at 0.01 and 0.02 per cent concentration. It was interesting to note that these insecticides were better than the other fungicides used in the study. Similarly spinosad (31.61 to 85.00% inhibition), novaluron (25 to 64.68% inhibition) endosulfan (35.91 to 55.00%) and indoxacarb (35.22 to 55.00% inhibition) were proved to be moderately toxic to test fungus. While thiodicarb showed least fungicidal property with 10.66 to 52.66 per cent mycelial inhibition.

Three fungicides were tested at four concentrations in combination with seven insecticides *in vitro* trials against *A. brassicae* by using poisoned food technique. All the insecticides were used at 0.01 per cent concentration. The

results are presented hereunder.

The data pertaining to bio efficacy of chlorothalonil when mixed with different insecticides on the mycelial growth of *A. brassicae* are presented in Table 3. The results revealed that highly significant inhibition of mycelial growth was observed when fungicides were mixed with insecticides compared to control. It was also observed that mycelial inhibition increased with corresponding increase in concentration of chemicals in most of the pesticidal combinations.

Cent per cent inhibition was shown by chlorothalonil + fipronil and chlorothaloplil + profenophos combinations at all four concentrations followed by chlorothaloplil + endosulfan at 0.02 per cent concentration. It was found that as the concentration increased, the per cent inhibition of mycelial growth also increased in chlorothalonil + endosulfan (97.16 to 100.0% mycelial inhibition), chlorothalonil + indoxacarb (93.20 to 98.31% mycelial inhibition), chlorothalonil + novaluron (57.44 to 84.20% mycelial inhibition), chlorothalonil + spinosad (86.53 to 98.42% mycelial inhibition), chloroihalonil + thiodicarb (68.32 to 81.83% mycelial inhibition) combinations. But the increase in concentration has no effect in arresting the mycelial growth in case of chlorothalonil + novaluron combination.

The highest level of increase in toxicity was observed in case of chlorothalonil + fipronil and chlorothalonil + profenophos combinations where mycelial inhibition was increased by 24.39 per cent over fungicide alone in both the combinations. The toxicity of chlorothalonil was also enhanced by endosulfan (22.88%), indoxacarb (20.16%) and spinosad (19.54%). While, thiodicarb slightly enhanced the toxicity of chlorothalonil (2.54%). But novaluron exhibited antagonistic action over chlorothalonil where, mycelial inhibition was decreased by 3.72 per cent over fungicide alone.

The values pertaining to the bio-efficacy of mancozeb when mixed with various insecticides on the mycelial growth of *Alternaria brassicae* are presented in Table 4. The results indicated that cent per cent inhibition was shown by mancozeb + endosulfan at all concentrations followed by mancozeb + novaluron and mancozeb + profenophos at 0.01 and 0.02 per cent concentration. Where as mancozeb + thiodicarb and mancozeb + fipronil at 0.02 per cent also exhibited cent per cent mycelial inhibition. The least mycelial inhibition was observed in case of mancozeb + indoxacarb (77.64 % inhibition) combination. It was also found that except in the

Table 1 : Per cent inhibition of mycelial growth of *A. brassicae* by selected fungicides

Fungicides	Per cent mycelial inhibition over control				Mean
	Concentration of fungicides (%)				
	0.0025	0.005	0.01	0.02	
Chlorothalonil	75.52 (59.03)	75.61 (60.41)	75.78 (60.52)	77.53 (61.70)*	75.61
Mancozeb	50.78 (45.44)	58.25 (49.75)	63.31 (52.72)	67.36 (55.16)	59.92
Quintal	55.54 (67.65)	64.45 (53.40)	65.65 (64.12)	80.02 (63.45)	73.91
	Fungicide	Concentration			
	(F)	(C)	F x C		
S. E.±	0.09	0.07	0.15		
C.D. (P=0.05)	0.26	0.22	0.45		

*Figures in parenthesis are arc sine transformed values

Table 2 : Per cent inhibition of my celial growth of *A . brassicae* by selected insecticides

Insecticides	Per cent mycehail inhibition over control				Mean
	Concentration of insecticides				
	0.0025	0.005	0.01	0.02	
1.Endosulfan	35.91 (36.81)	49.38 (44.64)	50.00 (45.00)	55.00 (47.86)*	47.57
2.Fipronil	98.27 (82.60)	98.34 (82.46)	100.00 (90.00)	100.00 (90.00)	99.15
3.Indoxacarb	35.22 (36.40)	41.88 (40.33)	41.11 (39.87)	55.00 (47.86)	43.30
4. Novaluron	25.00 (30.00)	30.13 (33.29)	55.00 (47.86)	64.68 (53.54)	43.70
5. Profenophos	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00
6. Spinosad	31.61 (34.20)	46.92 (43.23)	62.33 (52.14)	85.00 (67.21)	56.46
7. Thiodicarb	10.66 (19.06)	16.75 (24.16)	20.26 (26.75)	52.66 (46.52)	25.08
	Insecticide	Concentration			
	(I)	(C)	I x C		
S.EM ±	0.03	0.04	0.09		
C.D. (P=0.01)	0.10	0.13	0.26		

*Figures in parenthesis are arc sine transformed values

mixtures of mancozeb + profenophos and mancozeb + novaluron in all other combinations increase in the concentration of chemicals correspondingly increased the mycelial inhibition.

Mancozeb in combination with all the seven insecticides showed increase in the toxicity over fungicide alone. The highest level of potentiation of toxicity was observed in case of mancozeb + endosulfan combination where the mycelia inhibition over fungicide alone was increased by 40.08 per cent. The toxicitv of mancozeb also enhanced by profenophos (38.45%), novaluron (29.2%), thiodicarb (27.79%), spinosad (23.33%), fipronil (21.21%) and indoxacarb (17.72%).

The data pertaining to the effect of insecticides on the bio-efficacy of quintal over mycelial growth of *A. brassicae* are presented in Table 5. The results revealed that complete mycelial inhibition was observed in case of quintal + profenophos combination at all concentrations, followed by quintal + novaluron comibination at 0.005, 0.01 and 0.02 per cent concentration. While quintal + endosulfan and quintal + fipronil combinations also exhibited cent per cent inhibition at 0.02 per cent concentration. But quintal in combination with spinosad produced least mycelial inhibition (60.96%).

The toxicity of quintal increased maximum when it was mixed with profenophos, where, per cent mycelial inhibition

Table 3 : Per cent inhibition of mycelia growth of *A. brassicae* by chlorothalonil in combination with insecticides.

Fungicide + insecticide mixture	Per cent mycelial inhibition over control				Mean	% increase in mycelial inhibition over fungicide alone
	Concentration of chlorothalonil (%)					
	0.0025	0.005	0.01	0.02		
1.Chlorothalonil + Endosulfan (100 ppm)	97.16 (80.35)	97.41 (80.77)	99.41 (85.65)	100.00 (90.00)*	98.49	22.88
2.Chlorothalonil + Fipronil (100 ppm)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00	24.39
3. Chlorothalonil + Indoxacarb(100 ppm)	93.20 (74.89)	93.97 (75.79)	97.62 (81.13)	98.31 (82.54)	95.77	20.16
4. Chlorothalonil +Novaluron (100 ppm)	57.44 (49.27)	70.51 (57.11)	75.40 (60.26)	84.20 (66.58)	71.89	-3.72
5. Chlorothalonil +Profenophos (100 ppm)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00	24.39
6. Chlorothalonil +Spinosad (100 ppm)	86.53 (68.71)	97.31 (80.56)	98.34 (82.61)	98.42 (82.82)	95.15	19.54
7.Chlorothalonil +Thiodicarb (100 ppm)	68.32 (55.70)	76.16 (60.77)	86.28 (70.58)	81.83 (64.77)	75.15	2.54
8.Chlorothalonil (alone)	75.52 (59.03)	75.61 (60.41)	75.78 (60.52)	77.53 (61.70)	75.61	
	Fungicide + Insecticide (FI)	Concentration (C)	FI x C			
S.E.±	0.56	0.74	1.49			
C.D. (P=0.01)	1.59	2.11	4.22			

*Figures in parenthesis are arc sine transformed values

Table 4 : Per cent inhibition of mycelia growth of *A. brassicae* by mancozeb in combination with insecticides

Fungicide + insecticide mixture	Per cent mycelial inhibition over control				Mean	% increase in mycelia inhibition over fungicide alone
	Concentration of mancozeb (%)					
	0.0025	0.005	0.01	0.02		
1.Mancozeb + Endosulfan (100 ppm)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)*	100.00	40.08
2. Mancozeb + Fipronil (100 ppm)	65.17 (53.83)	69.40 (56.41)	89.97 (71.54)	100.00 (90.00)	81.13	21.21
3. Mancozeb +Indoxacarb (100 ppm)	68.95 (56.13)	75.41 (60.27)	76.25 (60.83)	89.96 (71.53)	77.64	17.72
4. Mancozeb +Novaluron (100 ppm)	76.51 (61.01)	80.00 (63.43)	100.00 (90.00)	100.00 (90.00)	89.12	29.20
5. Mancozeb +Profenophos (100 ppm)	97.59 (81.07)	95.91 (79.83)	100.00 (90.00)	100.00 (90.00)	98.37	38.45
6. Mancozeb +Spinosad (100 ppm)	64.64 (53.51)	87.77 (69.53)	89.77 (71.34)	90.81 (72.35)	83.25	23.33
7. Mancozeb +Thiodicarb (100 ppm)	73.17 (58.80)	85.68 (67.76)	92.00 (73.57)	100.00 (90.00)	87.71	27.79
8. Mancozeb (alone)	50.78 (45.44)	58.25 (49.75)	63.31 (52.72)	67.36 (55.16)	59.92	
	Fungicide + Insecticide (FI)	Concentration (C)	FI x C			
S.E.±	0.30	0.40	0.80			
C.D. (P=0.05)	0.85	1.13	2.27			

*Figures in parenthesis are arc sine transformed values

increased by 26.09 per cent. The toxicity of quintal also increased by novaluron (25.53%), fiprontl (24.33%), endosulfan (22.89%), indoxacarb (18.71%) and thiodicarb (18.08%). While spinosad acted antagonistically over quintal and decreased the mycelial inhibition by 12.95 per cent over quintal alone.

Certain chemicals developed as insecticides are known to exhibit fungistatic or fungitoxic properties. Therefore *in vitro* evaluation of insecticides regarding their fungicidal properties was made, against *A. brassicae*. In the present study seven insecticides were tested at four concentrations. *In vitro* evaluation of insecticides revealed that cent per cent mycelial growth was inhibited by profenophos at all four concentrations, followed by fipronil at 0.01 and 0.02 per cent. It was interesting to note that these insecticides were better than other fungicides included in the study in inhibiting the fungal growth. Although no specific studies are available involving above chemical combinations against *A. brassicae*, for comparison, similar trends were observed by some workers. At field concentration endosulfan inhibits growth and sporulation of *Beauveria bassiana*, *Metarhizium anisopliae* and *Entomophthora* sp. *in vitro* (Cadatal and Gabriel, 1970), likewise Murthy *et al*. (1987) observed 35.17, 61.33, 35.00 and 48.32 per cent conidial germination of *A. macrospora*, *Helicoverpa gossypii*, *Cercospora gossypina* and *Phakospora gossypii*, respectively with 100 ppm endosulfan as against 100 per cent in control and further increase in concentration accelerated reduction in germination and mycelial growth also. Similarly, fungicidal properties of other chemicals of selected groups also have been documented. An organophosphate compound monocrotophos at 100 ppm *a.i.* completely inhibited the growth of *Xanthomonas malvacearum* on agar streak (Verma *et al*.,1976). Likewise Habibullakhan (1983) recorded 20.80 to 25.10 per cent inhibition in mycelial growth of *Drecsclera oryzae* with 0.05 per cent monocrotophos. Similarly a carbamate compound carbaryl @ 0.75 per cent concentration reduced *Alternaria tenis* on cotton, 0.25 per cent concentration against *Rhizoctonia solani* and *Stemphylium* sp. (Aboeldahab, 1965), aldicarb aginst Verticilium wilt of potato (Hoyman and Dingman, 1967), *Sclerotium rolfisii* on sugarcane (Champawak and Pathak, 1988), carbofuron against *Sclerotium rolfisii* (Mukhopadhyay and Thakur, 1977) and *Fusarium oxysporium* (Champawak and Pathak, l988).

Regarding the combining effect, all the three fungicides at four concentrations were tested in combination with seven insecticides. As evident from the mycelial inhibition, clorothalonil showed greater efficacy with five out of seven insecticides tested. Though no studies involving above chemical combinations are available for comparison, it is evident from the present findings that all the insecticides were compatible with clorothalonil except Novaluron + clorotharonil combination. As noticed from the earlier laboratory trials, inherent fungicidal property possessed by all the seven insecticides contributed to the mycelial inhibition. Thus, additive effect of combination of these insecticides with clorothalonil accounted for increased mycelial inhibition over fungicide alone.

Regarding the bio-efficacy of mancozeb in combination with insecticides, as evident from the mycelial inhibition the efficacy of mancozeb increased with all the seven insecticides tested. Although, no specific literature is available in respect of bio-efficacy of the above chemical combinations against *A. brassicae* for comparison, it is evident from the available literature on related insecticides of selected groups that mancozeb is biologically and

Table 5 : Per cent inhibition of mycelial growth of *A. brassicae* by quintal in combination with insecticides

Fungicide + insecticide mixture	Per cent mycelial inhibition over control Concentration of quintal (%)				Mean	% increase in mycelial inhibition over fungicide alone
	0.0025	0.005	0.01	0.02		
1. Quintal + Endosulfan (100 ppm)	92.53 (74.22)	96.20 (78.76)	98.47 (82.97)	100.00 (90.00)*	96.80	22.89
2. Quintal + Fipronil (100 ppm)	97.10 (80.20)	97.68 (81.25)	98.20 (82.31)	100.00 (90.00)	98.24	24.33
3. Quintal + Indoxacarb (100 ppm)	82.00 (64.89)	93.00 (74.65)	97.14 (80.27)	98.34 (82.60)	92.62	18.71
4. Quintal +Novaluron (100 ppm)	97.82 (81.52)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	99.44	25.53
5. Quintal +Profenophos (100 ppm)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00	26.09
6. Quintal +Spinosad (100 ppm)	40.01 (39.23)	61.05 (51.38)	67.79 (55.42)	75.00 (59.89)	60.96	12.95
7. Quintal +Thiodicarb (100 ppm)	85.27 (67.43)	87.68 (69.45)	96.72 (79.57)	98.31 (82.53)	91.99	18.08
8. Quintal (alone)	64.45 (53.40)	65.65 (64.12)	80.02 (63.45)	55.54 (67.65)	73.91	
	Fungicide + Insecticide (FI)	Concentration (C)	FI x C			
S.E.±	0.11	0.14	0.29			
C.D. (P=0.01)	0.32	0.42	0.84			

*Figures in parenthesis are arc sine transformed values

chemically compatible *in vitro* and *in vivo* in fresh or stored mixtures with insecticide. BHC carbaryl, acephate, endosulfan, malathion, phosphomidon, monocrotophos,, quinolphos, and cloropyriphos. Mixing copperoxycloride with insecticides resulted in slight reduction in fungicidal toxicity to *Myrothecium roridum*. In contrast, the presence of the insecticides enhanced the fungicidal toxicity of thirum, zirum and mancozeb (Peshney, 1990). Similarly Lakshminarayana and Subbaratnam (2000) in their laboratory experiment on compatibility of certain organophosphate insecticides with monocrotophos revealed that mancozeb 61.73 ppm (LC_{50}) in combination with all the six concentration of monocrotophos resulted in more than 50 per cent non germination of spores. Moreover, with increase in concentration of insecticide there was progressive increase in non germination of spores indicating synergism. However, antagonistic action of monocrotophos and sulphur over mancozeb in controlling powdery mildew of bhendi has been documented (Padmanabhan, 1980). Hence, from the present findings it is clear that mancozeb is compatible with all the insecticides included in the study.

In respect to the bio-efficacy of quintal with the selected insecticides, all the insecticides enhanced the efficacy of quintal substantially except with spinosad where efficacy was decreased over quintal alone. Though exact literature on the above combinations is not traceable, studies on carbendazim, one of the component of quintal clearly showed that it was compatible with the insecticides diclorovos, oxydemetonmethyl, phosphomidon on groundnut. However, antagonistic effect of carbendazim was also noticed when insecticides *viz*., monocrotophos, quinolphos and HCH used at higher doses against *Rhizoctonia solani* as test organism. But at lower concentration there was enhancement of fungicidal effect (Krishnaih and Reddy, 1992). Hence, except with spinosad and quintal is compatible with all other insecticides.

Conclusion:

From the above experiment it may be concluded that profenophos showed cent per cent mycelial inhibition at all four concentrations (0.0025, 0.005, 0.01 and 0.02). The combining effect of clorothalonil with insecticides indicated that clorothalonil is compatible with fipronil, profenophos, endosulfan, indoxacarb, spinosad and thiodicarb except Novaluron. Mancozeb with insecticides indicated that it is compatible with all the insecticides endosulfan, profenophos, novaluron, thiodicarb, spinosad, fipronil and indoxacarb. Regarding compatibility of quintal with insecticides it indicated that it was compatible with all insecticides profenophos, novaluron, fipronil, endosulfan, indoxacarb, thiodicarb except Spinosad.

REFERENCES

Abo-El-Dahab, N.K. (1965). Fungitoxic effect of seven insecticides on certain phytopathogenic fungi. *Phytopath. Mediterranae*, **4**: 138-144.

Baicu, T. (1980). Study and classification of the compatibility of pesticides. *Probl. Prot. Plant.*, **6** : 271-279.

Cadatal, T.D. and Gabriel, B.P. (1970). Effect of chemical pesticides on the development of fungi pathogenic to some rice insects. *Phillipp. Entomol*., **1** (5) : 379-395.

Champawak, R.S. and Pathak, V.N. (1988). Soil application of different insecticides and nematicides for the control of wilt *Fusarium oxysporium* sp.*cumini* of cumin. *Indian J. Plant Prot.*,**16** (2) : 195-196.

Frear, D.E.H. (1948). Compatibility of common spray materials. *Agric. Chemicals*, **4** : 25-28.

Gray. P. (1914). The compatibility of insecticides and fungicides. *Monthly Bull. Calif*., July 1914.

Habibullah Khan, C.B. (1983). Studies on insecticidal action of fungicides, fungicidal action of insecticides and their interaction. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bangalore, 142 pp.

Hoyman, W.G. and Dingman, E. (1967). Temic, a systemic insecticide effective in delaying Verticillium wilt of potato. *Am. Potato. J*., **44** : 3-8.

Krishnaiah, N.V. and Reddy, C.S. (1992). Compatibility and co-toxicity of selected insecticides and fungicides against brown plant hopper and sheath blight in rice. *Indian J. Plant Prot.,* **20** (1) : 99-101

Lakshminarayana, M. and Subbaratnam, G.V. (2000). Laboratory studies on compatibility of certain organophosphorus insecticides with mancozeb. *J. Res. ANGRAU*, **28** (1/2) : 78-81.

Mukhopadhyay, A.N. and Thakur, R.P. (1977). Effect of some soil insecticides on Sclerotium root rot of sugar beet. *Indian J. Agric. Sci.,* **47**: 533-536

Murthy, B.R., Rao, P.S.S. and Mallaiah, K, V. (1987). Effect of insecticides on four foliar pathogens of cotton. *Pesticides*, **21** (7) :12-14.

Nene, Y.L. and Thapliyal, P.N. (1979). *Fungicides in plant disease control*, Oxford and IBH Publishing House, New Delhi, 163 pp.

Padmanabhan, V. (1980). Studies on compatibility of insecticides, fungicides and urea. M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, T.N. (INDIA).

Peshney, N.L. (1990). Compatibility of fungicides with some insecticides with reference to fungitoxicity and phytotoxicity. *PKV-Res. J.*, **14** (1): 35-37

Rangel, J. F. (1945). Two Alternaria diseases of cruciferous plants. *Phytopathol.*, **35**: 1002-1007.

Srinivasan, K. and Krishnamoorthy, P.N. (1992). Development and adoption of integrated management for major pests of cabbage using Indian mustard as a trap crop. In: Talekar, N.S. (ed.), Diamondback Moth and other crucifer pests. Proc. II Internationl. Workshop, Tainan, Taiwan, pp. 511-522.

Twit, T. (1969). *Plant pathological methods, fungi and bacteria*. Burgrees Publishing Co, Minn USA, 239 pp.

Verma, J.P., Singh, R.P. and Nayak, M.L. (1976). Laboratory evaluation of chemicals against *Xanthomonas malvacearum*, the incitant of bacterial blight of cotton. *Indian Phytopathol*., **28** (2) : 171-174

Vincent, J.M. (1927). Distoration of fungal hyphae in the presence of certain inhibitors. *Nature*, **159** (4051) : 850.