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INTEGRATED CONTROL OF CABAGGE PESTS *Plutella xylostella* (L) AND *Crocidolomia binotalis* (Z) BY RELEASE OF IRRADIATED MOTHS AND THE PARASITOID *Diadegma semiclausums*(H) UNDER FIELD CAGE AND A SMALL AREA CONDITIONS

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ABSTRACT

INTEGRATED CONTROL OF CABAGGE PESTS *Plutella xylostella* (L) AND *Crocidolomia binotalis* (Z) BY RELEASE OF IRRADIATED MOTHS AND THE PARASITOID *Diadegma semiclausums*(H) UNDER FIELD CAGE AND A SMALL AREA CONDITIONS. The impact of the release of irradiated Diamondback moth (DBM) *Plutella xylostella* (L) with a dose of 200 Gy was studied in field cage experiments by releasing of irradiated and untreated DBM at a 9:1 ratio . Releasing male and female (F-1) of irradiated DBM caused a considerable level of sterility in the subsequent generations. The sterility level in those respective generations were 73.03% and 73.30%,while the release of the F-1 male only induced a level of sterility of about 55.40% and 56.44%.Inundative releases of irradiated males caused the level of sterility to reach about 44.78% and 68.01% in F-1 and F-2 respectively. The effect of the release of irradiated male Cabbage webworm (CWW) moths *Crocidolomia binotalis* (Z), and the release of both sexes on the population were studied under laboratory cage conditions. There was a significant difference between the**)** effects of releasing irradiated male only and both sexes at a level of $F \leq 0.001$,where the percentage of egg hatch were 22.78% and 24.75% respectively in the F-1 and F-2 generations. The effects of combining two tactics, inherited sterility and the release of parasitoid *Diadegma semiclausums* (H) for controling DBMs *were* studied.The pupal viability in the F-1 generation was 32.5% as compared to the untreated DBMs. The impacts of respective single tactic the release of F-1 males and parasitoid *D. semiclausums* on the pupal viability were 57.5% and 81%. The effects of the release of substerile insects in a small area of about 1000 m^2 located at an isolated area in the forest in Malang, East Jawa was found that average number of moths caught per week from first to the fifth month at the release area was about 89.42% as compared to those at the control area. The highest level of parasitation of *D. semiclausums* was found in the second instar larvae of DBMs.Population growth of parasitoid *D. semiclausums* from the first generation to the eleventh generation increased till to the fifth generation larvae, than declined to the eleventh generation.

ABSTRAK

PENGENDALIAN TERPADU HAMA KUBIS *Plutella xylostella*(L)DAN *Crocidolomia binotalis* (Z)DENGAN PENGLEPASAN SERANGGA RADIASI DAN DAN PARASIT *Diadegma semiclausums*(H) PADA KONDISI KURUNGAN LAPANGAN DAN LAPANGAN TERBATAS. Pengaruh penglepasan ngengat *Plutella xylostella* (L) yang diradiasi dosis 200 Gy dipelajari didalam percobaan kurungan lapangan dengan penglepasan ngengat *P. xylostella* radiasi dan ngengat tidak diradiasi dengan perbandingan 9:1. Penglepasan serangga jantan dan betina (F-1)keturunan serangga radiasi menyebabkan kemandulan pada generasi-generasi berikutnya. Kemandulan pada serangga yang diradiasi dan keturunan pertamanya adalah 73,03 dan 73,30 % , sedang dengan penglepasan serangga jantan radiasi (F-1) menyebabkan kemandulan 55,40 % dan 56,44 %. Pengaruh penglepasan ngengat jantan *Crocidolomia binotalis* (Z) radiasi dan pengaruh penglepasan ngengat jantan dan betina radiasi dipelajari didalam kondisi laboratorium.Ada perbedaan yang sangat nyata antara pengaruh penglepasan ngengat jantan radiasi saja dan kedua jenis kelamin pada taraf $F < 0,001$, dan persentase telur yang menetas adalah 22,78 % dan 24,75 % berturut-turut pada generasi F-1 dan

F-2. Telah dipelajari pula pengaruh kombinasi dua macam teknik pengendalian yaitu kemandulan yang diwariskan dan penglepasan parasit *Diadegma semiclausums*(H) untuk pengendalian *P. xylostella.* Viabilitas pupa pada generasi F-1 adalah 32,5 % dibandingkan dengan control.Dampak pengendalian dengan kemandulan yang diwariskan dan penglepasan parasit *D.semiclausums* pada persentase viabilitas pupa masing-masing 57,5 % dan 81 %. Pengaruh penglepasan serangga substeril pada lahan terbatas kurang lebih 1000 m^2 yang terletak di daerah terisolasi di hutan di Malang , Jawa Timur ditemukan bahwa rata-rata jumlah ngengat yang tertangkap per minggu dari bulan pertama ke bulan ke lima adalah 89,42 % dari lahan control . Persentase parasitasi tertinggi *D.semiclausums* adalah pada larva *P. xylostella* instar ke dua .Pertumbuhan populasi parasit *D.semiclausums* dari generasi pertama ke generasi ke sebelas makin besar sampai generasi ke lima kemudian menurun sampai dengan generasi ke sebelas.

INTRODUCTION

The Diamondback moth *P. xylostella* (DBM)and cabbage webworm (CWW) *C. binotalis* are the most important pests in cabbage or other cruciferous plants in Indonesia (1). DBM larvae attack the young cabbage plants, while cabbage webworm larvae attack plant all development stages. The use of insecticides to control these insects is inadequate. It was reported that a strain of DBM in West Jawa was resistant to a pyrethroid insecticide (2). The use of the parasitoid *Diadegma semiclausums*(H) to control DBMs has been introduced in Indonesia as an alternative control tecnique. This control technique is intended to be one of the components in integrated pest management of cabbage in Indonesia. The level of parasitization at several cabbage production areas in West Jawa (Lembang and Pangalengan) ranged from 6% to 76% (3).

The new approach to control DBMs and CWWs by using the Sterile Insect Technique (SIT) is being explored in several countries in the Asia Pasific Region because these insect pests are very important and present control measures are inadequate (4,5). The use of insects to control populations of their own kind through the transfer of damaged genetic material at mating represents an approach that could prove to be usefull for the control of a number of major insect pests throughout the world (6).In DBMs a dose of 300 Gy could induce 90 % sterility , while sub sterilizing dose 200 Gy could induce about 73.2 % sterility in the irradiated DBMs and 56.81 % sterility in the F-1 moths(7). The strategy of Integrated Pest Management (IPM) of cabbage in Indonesia is not eradication of the target species, but maintaining the pest population below the economic threshold. The Indonesian Department of Agriculture has determined the economic injury levels for *P. xylostella* and *C. binotalis* are five larvae per ten cabbage plants and three eggs clusters per ten cabbage plants, respectively (8). If the level of parasitization in DBM is less than 75%,than it is necessary to control with insecticides.In this paper the experiment about the effect of combining SIT and the release of parasitoid *D. semiclausums* on the the population of DBMs under laboratory conditions are reported.The experiment to obtain information of the potential of

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SIT to control *P. xylostella* in field cages and a small isolated area are described. Progress of experiments about the effect of releasing irradiated males, irradiated females or irradiated unsexed CWW *C. binotalis* on the progeny under laboratory conditions are also reported.

MATERIALS AND METHODS

Unsexed, 3 to 4-d-old pupae of *P.xylostella* were irradiated with 200 Gy of gamma rays in ^{60}Co gamma Cell Irradiator.Substerilizing dose of 200 Gy caused 73.2%, and 56.81% sterility in the irradiated DBMs and F-1 male respectively. The experiments on the effect the release of irradiated DBMs and the F-1 were conducted under field cage conditions at a cabbage production area in Cipanas, West Jawa in 1997.The size of each of five field cages used in these experiments was 2.5 m in length, 1.5 m in height and 1 m in width. In each of the respective three cages 50 pairs of untreated moths only, 50 pairs of untreated moths and 450 irradiated male moths (1:9), and 50 pairs of untreated moths and 450 F-1 males came from irradiated males mated with normal females were introduced. The treatment in the fourth cage was similar to the third cage, but the number of F-1 progeny were 450 pairs of moths . The treatment in the fifth cage was similar to that in the first cage, but at the next generation in this cage the same number of irradiated moths were released again (inundative release). The parameters observed in these experiments were percentage of egg hatch, number of pupae, and the number of moths emerged in the first and the second progeny.Egg hatch were assayed by taking sample of 250 eggs and those were removed from the cages. By using paint brush the eggs of DBMs were kept in lines on the surfase of masking tape, after 7 days the eggs were observed for hatching using binocular microscoope.The number of pupae developed were assayed by collecting them after pupation and then these were kept in a small cage, for observing the alive moths. Then the moths were released again in the field cages .

The experiment conducted in *C. binotalis* was under laboratory conditions.Six day old pupae of CWW were irradiated with a dose of 250 Gy(substerile dose). A dose of 250 Gy caused 63.95 % sterility of the irradiated CWW (SUTRISNO *et. al* 1993). The effects of releasing irradiated males and mixed sexes with a dose of 250 Gy were studied in the seven laboratory cages. In the first cage, 60 pairs of irradiated moths and 20 pair of untreated moths (3:1) were introduced. The treatment in the second and third cages was similar to that in the first cage, but the number of irradiated moths were 60 males and 60 females (1:1), respectively. Treatments in cage no. 4 - 7 were used to compare the sterility level between the irradiated moths and untreated moths.

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The experiments under field cage conditions to assess the impact of combining irradiated DBMs and the release of the parasitoid *D. semiclausums* was conducted to explore the possible suppression of DBMs by the release of sterile insects and the parasitoid *D. semiclausums*.The impact of the release of irradiated DBMs on the reduction of population was conducted at a small isolated area (1000 m^2),located in the forest of Cangar, Malang, east Jawa. This study area was about 2 Km away from the cabbage production area with an assumption that there would be no reinfestation from out side of the study area. The distance from the irradiation facility in Jakarta to field experiment in Malang, East Jawa is about 700 km away. About 3,000 irradiated male pupae with a dose of 200 Gy were used in these experiments.

In the development of a rearing technique for parasitoid *D. semiclausums*, the level of parasitism in the larval host(DBMs) was observed by introducing 10 pairs of *D. semiclausums* for 1000 DBM larvae of various instars.The number of alive *D. semiclausums* in the subsequent generations which were developed at the second instar DBM larvae of DBMs was observed by introducing 10 pairs of *D. semiclausums* for 1000 second instar DBM larvae.

RESULTS AND DISCUSSION

The impact of the release of irradiated males DBMs with a dose of 200 Gy on the population of DBMs with ratio (9:1) in the field cage conditions caused 44.95 % and 44.3 % sterility in the respective irradiated DBMs and in the first progeny (Table 1).The release of F-1 male(IR) first progeny of a cross between irradiated male and untreated female) caused the level of sterility of the released moths and the first progeny about 55.4% and56.44%. Inundative release of irradiated male and female DBMs caused sterility about 44.78 % and 68.01 % in the F-1 generation.The release of unsexed F-1(IR) showed the highest level of sterility about 73.03% and 73.3 % in the respective released DBMs and in the F-1 as compared to the inundative release of irradiated males only, the release of irradiated males only, and the release of F-1(IR)males. But the release of F-1(IR) has disadvantage because this method needs addition cost for mass rearing of the F-1 (IR) in the laboratory before releasing them to the field. So inundative release of irradiated males and females should be considered to be the method of release because the level of sterility in the first progeny is high enough (68.01%).

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Table 1. The effect of releasing irradiated dbms and f-1 dbms on the subsequent generation under field cage conditions

Treatment	% Sterility (1)		No.of Pupae (1)		No.of Moths (1)	
	IR	F-1	F-1	F-2	F-1	F-2
50 pairs UT /control	5.2	3.47	829 (100)	1706 (100)	772 (100)	1566 (100)
50 pairs UT + 450 ♂ IR	44.95	44.36	477 (57.5)	963 (56.4)	282 (36.5)	520 (33.2)
50 pairs UT + 450 ♂ F1 (IR)	55.4	56.44	350 (42.2)	697 (40.8)	163 (21.1)	309 (19.7)
50 pairs UT + 450 pairs F1 (IR)	73.03	73.3	128 (15.4)	261 (15.2)	31 (4)	62 (3.9)
50 pairs UT + 450 ♂ IR + 450 ♀ IR	44.78	68.01	471 (56.9)	549 (32.1)	261 (33.8)	181 (11.5)
Leas of Significant Difference (LSD)						
5%	7.49	10.79	66.85	103.82	54.53	78.19
1%	10.73	15.36	95.10	147.67	77.56	111.21
CV	9.22	12.08	8.14	6.83	9.89	8.15

UT = Untrated
IR = Irradiated DBMs 3 to 4 -d-old pupae with a dose of 200 Gy (sub sterile dose)
F1 (IR) = First Progeny originated come from cross between rradiated male and untreated female
(1) = average of 3 replications
( ) = % control

In CWW *C.binotalis* the effect of releasing males only or females only , unsexed (males and females) of irradiated CWW on the eggs hatchability showed in the Table 2. The percentage of fertility or eggs hatchability showed a significant difference at $F < 0.005$ in the release of respective irradiated males (24.75%) or females only(22.17 %),and the release of unsexed irradiated CWW (28.50 %).The eggs hatchability as affected by the release of irradiated males of CWW showed the lowest percentage , this method shoud be considered in the implementation of SIT in the field.

The effect of combining the release of irradiated DBMs and parasitoid *D.semiclausums* for managing DBMs shown in the Table 3.The effect of releasing the respective irradiated DBMs, the release of parasitoid *D. semiclausums* , and the release of combining irradiated DBMs and parasitoids on the DBM pupal viability of the first progeny showed a significant difference at $F < 0,005$, each of them were 57.5%, 81 % and 32.5 % .Combining those two tactics is the most

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effective.The succesful application of these two tactics has also been demonstrated in the control of *Helicoverpa zea* (9).

Table 2. The effect of releasing irradiated males or female and unsexed of cww C. *binotalis* on the egg hatchability under laboratory conditions

Treatment **♂ IR : ♀ IR : ♂ UT : ♀ UT**	**No. of eggs**	**No. of egg hatch**	**Egg hatch (%)**
3 : 3 : 1 : 1	503	124	24.75
3 : 0 : 1 : 1	523	116	22.17
0 : 3 : 1 : 1	507	145	28.5
0 : 0 : 4 : 1	524	501	92.43
0 : 0 : 1 : 4	645	600	93.02
1 : 0 : 0 : 1	476	0	0
0 : 1 : 1 : 0	510	0	0
LSD 5% 1% CV (%)	-	-	0.22 0.32 2.36

UT = Untreated CWW
IR = Irradiated CWW 3 to 4-d-old pupae with a dose of 250 Gy (sub sterile dose)

Table 3. The effect of combining irradiated DBMs and the parasitoid *D. semiclausums* for controling DBMs P. *xylostella* under field cage conditions

No.	Treatments	First generati-on			Second Generation		
		Unhatch Eggs (%Sterility)	Pupal DBM	Mortality (%) Parasitoid	Unhatch Eggs (%Steriliy)	Parasitoid (No)	DBM pupal viability (%)
1.	50 pairs (UT)	5.2	0 (UT)	-	5.47	-	100
2.	50 pairs (UT) + 450 pairs (IR)	44.9	0 (UT) 14.6 (IR)	-	54.3	-	57.5
3.	50 pairs (UT) + 25 pairs (P)	4.9	0 (UT)	0	4.47	19	81
4.	50 pairs (UT) + 450 pairs (IR) + 25 pairs (P)	43.7	0 (UT) 14.6 (IR)	0	52.9	35	32.5

UT = Untreated DBM
IR = Irradiated DBM pupae 3 to 4- d -old with a dose of 200 Gy (sub sterile dose)
P = Parasitoid

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The result of the preliminary experiment on the release of irradiated DBMs at the study area is shown in the Table 4. The average number of DBM moths caught per month from the first month fifth month ranged from 74.2 to 149.6 or about 89.42 % of the untreated area.The average pecentage of fertility of those treated area and untreated area ranged between 75.6% to 79.3 % .

Table 4. The effect of the release of irradiated male DBMs on the reduction of the population at a small isolated area , in cangar (1)

Time after release	Average no. of moths caught per week (2)		The average level of fertility (%)	
	at control area	at release area	at control area	at release area
First month	85.7	74.2	95.4	79.1
Second month	107.4	96.3	94.7	75.6
Third month	117.7	103.2	95.7	77.9
Forth month	124	114.5	95.1	79.3
Fifth month	164.2	149.6	93.4	75.7

(1) 3 to 4-d-old of 3000 male DBM pupae were irradiated with a dose of 200 Gy (sub sterile dose)
(2) Average of 10 pheromone traps

Table 5. The level of parasitism of *D. semiclausums* (H) in the larval host of DBMs

Instar larvae of DBMs (1)	Average of parasitism (2)	
	Number of *D. semiclausums*	Percentage of *D. semiclausums*
First instar larvae	0	0
Second instar larvae	634	63.4
Third instar larvae	307	30.7
Fourth instar larvae	0	0

(1) Introducing 10 pairs of *D.semiclausums* on the larva of DBMs for 12 hours
(2) The average of four replications (10 pairs of *D. semiclausums* and 1000 larvae of DBMs)

As shown in Table 5 the level of parasitation of *D.semiclausums* much higher compared to the third instar larvae (63.4 % and 30.7 %), while parasitoid *D.semiclausums* could not develope in the first and the fourth instar larvae. The population growth of parasitoid *D. semiclausums* from the first generation to the eleventh generation as showed that the number of parasitoid was increasing up to the fifth generation from 163 larvae to 891 larvae and after that

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declined to the number of 89 in the eleventh generation (Table 6). It might be caused by the quality of DBM larvae which was decreasing.

Table 6. Population growth of parasitoid *D. semiclausums* in the second instar larvae of DBMs

Generation	No. of alive *D. semiclausums(1)*		
	♂	♀	Total
1	107	56	163
2	78	115	193
3	327	304	631
4	364	276	640
5	474	367	841
6	269	322	591
7	232	152	384
8	183	196	379
9	104	121	225
10	110	70	180
11	43	46	89

(1) The average of three replications of each subsequent generation from the rearing cage containing 10 pairs of *D. semiclausums* and 1000 DBM larvae

CONCLUSION

Inundative release of irradiated males and females in DBMs should be considered to be the method of release because the level of sterility in the first progeny is high enough and more efficient than the release of F-1 sterility or irradiated males only. The effect of combining the release of irradiated DBMs and parasitoid *D. semiclausums* showed promising result . The release of irradiated males of CWW with a dose of 250 Gy showed the the lowerst percentage in the progeny , this method should be implemented in the future control of CWW.

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