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Biological control of cowpea aphid, *Aphis craccivora* and Brinjal mealy bug, *Coccidohystrix insolita* using coccinellid predators

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Abstract
Coccinella septempunctata and *Cryptolaemus montrouzieri* were used @ 10 and 20 1st instar larvae/plant in cowpea and brinjal for control of aphid, *Aphis craccivora and* mealy bug, *Coccidohystrix insolita* during 2013 and 2014. Aphid population was brought down significantly by both predators in both the years, but, it was *C. septempunctata* which was more efficient. On the contrary, mealy bug population was also brought down significantly by both the predators, but, it was *C. montrouzieri* who proved to be more efficient. In both cases, release of 20 first instar larvae/plant was as effective as use of insecticides in controlling both the pests.

Keywords: Biological control, Cowpea, *Aphis craccivora*, Brinjal, *Coccidohystrix insolita*, coccinellid predators

Introduction
Coccinella septempunctata and *Cryptolaemus montrouzieri* are very effective predators of aphids and mealy bugs and have been extensively used for control of these sucking pests [3, 9]. Mastoi *et al.*, (2019) observed that *C. septempunctata* and *C. sexmaculata* can be exploited as bio control agents of mealy bugs [6]. These coccinellids are general predators and can predate upon soft bodied insects like aphids, mealy bugs, scales, whiteflies, eggs and small larvae of other insects [12] *A. craccivora* Koch, causes considerable damage to cowpea crop and is reported as one of the important, major and economic pests [2]. Choudhary *et al*., (2017) reported that the cowpea aphid, *Aphis craccivora* Koch is the most serious pest of this crop, causing 20-40 percent yield loss [1]. Similarly, the mealy bug, *Coccidohystrix insolita* has been described as a major pest of brinjal [8, 0].
Part of the Ph.D. thesis submitted to the Odisha University of Agriculture and Technology
Keeping these in view, field experiments were conducted at Odisha University of Agriculture and Technology, Bhubaneswar, India during 2013 and 2014 to evaluate the two bio control agents against the cowpea aphid, *Aphis craccivora* and the brinjal mealy bug, *Coccihystrix insolita.*

Materials and Methods
Field experiments were conducted during 2013 and 2014 to evaluate the effectiveness of *Coccinella septempunctata*and *Cryptolaemus montrouzieri* against *Aphis craccivora* in cowpea and *Coccidohystryx insolita* in brinjal. There were seven treatments and three replications for each crop. The crops were raised following all standard package of practices. The plot size was 6x5 meters. The desired predatory coccinellids were collected from the stock culture maintained in the laboratory. *Verticillium lecanii*, a fungal biopesticide effective against both aphids and mealy bugs and Thiomethoxam were taken as checks. The experiments were laid out in Randomized Block Design. The treatments were as follows:
T1: Release of 10 1st instar larvae of *C. montrouzieri*/.plant
T2: Release of 20 1st instar larvae of *C. montrouzieri/*plant
T3: Release of 10 1st instar larvae of *C. septempunctata/*plant
T4: Release of 20 1st instar larvae of *C. septempunctata/*plant
T5: Appln of *Verticillium lecanii* 2x 10^7 CFUs g^{-1} @ 2.5kg ha^{-1}
T6: Insecticidal check (Thiomethoxam 25g a.i/ha)
T7: Control

The treatments were applied twice, *i.e*. after 15 days of germination of cowpea and 30 days after transplanting of brinjal respectively, when the pest population had built up in sufficient number. The second treatment was given 15 days later. The coccinellid larvae were released in the evening hours with the help of camel hair brushes and the fungal pesticide and insecticide were sprayed on the crops with a knapsack sprayer. Observations were taken from 10 randomly selected and marked plants at 1DBT (Day before treatment) and 15, 30, 45 and 60 DAT (Days after treatment) for count of aphids and mealy bugs. The mealy bugs were counted from three leaves, top, middle and bottom leaf. The Data obtained were statistically analyzed after suitable transformation.

Results and Discussion

During 2013, the population of *A. craccivora* ranged between 89.6/ 10 cm twig and 98.7/10 cm twig among different treatments one day before application of different control measures (Table 1) After 15 days, the population of aphids was the lowest (4.3/10 cm twig) in T6 (Insecticidal check).The treatments with *C. septempunctata* (T4 and T3) were behind T6 in respect of aphid population reduction with 37.8 and 49.2/10 cm twig. Treatment with *V. lecanii* (T5) had 42.4 aphids/10 cm twig whereas, treatments with *C. montrouzieri* (T2 and T1) recorded 65.7 and 73.4 aphids/10 cm twig. The trend of aphid population remained the same at 30DAT, the lowest population/10 cm twig being in T6 (1.80) followed by T4 and T5 (18.8 and 29.8 aphids/10 cm twig). It was 49.8/10 cm twig in T3 as against 102.4 in untreated control. The same trend continued at 45 DAT and 60 DAT too, aphid population being lowest in T6 (0.9 and 1.0) followed by T4 (10.2 and 2.3), T5(18.4 and 11.5),T3(18.7 and 12.2),T2(31.1 and 22.4)) and T1(38.1 and 29.2) respectively. Aphid population in control plots during the same period was 105.2 and 98.7/10 cm twig. The yield was highest in T6(359.6 q/ha) followed by T4(317.3q/ha), T5(309.9 q/ha), T3(284.9q/ha), T2(263.2q/ha)andT1(243.9q/ha). The aphid population on cowpea during 2014(Table 2) varied between 74.8/10 cm twig in T1 and 90.2 aphids/10 cm twig in control, one day before application of the treatments. Fifteen days after, the aphid population was lowest in T6 (12.6/10 cm twig) followed by T4 (27.2/10 cm twig). The aphid population in T5, T3, T2 and T1 followed in that order with 32.5, 39.8, 64.8 and 69.2 aphids/10 cm twig. In control plots, it was 93.4 aphids/10 cm twig. At 30DAT, the trend of aphid population remained the same, the lowest population (6.9/10 cm twig) in T6. The aphid population in treatments with *C. septempunctata* (T4 and T3) was 17.5 and 22.4/10 cm twig whereas, in *V. lecanii* treatment (T5) it was 20.7/10 cm twig. *C. montrouzieri* treatments (T2 and T1) recorded 42.7 and 56.8 aphids/10 cm twig and the control recorded 89.5 aphids/10 cm twig. At 45 and 60 DAT, the population of aphids were 6.5 and 5.5,12.6 and 11.4,20.2 and 19.5,18.1 and 15.3,29.9 and 30.7 and 46.5 and 31.1aphids/10 cm twig in T6,T4,T5,T3,T2,and T1 respectively. The control treatment had 102.3 and 92.5 aphids/10 cm twig for the same period. Yield was highest (362.1q/ha) in T6 and lowest in control (187.5q/ha). T4, T5, T3, T2 and T1 produced 319.6, 311.9, 292.9, 267.3and 249.8 q/ha in that order. Shera *et al.,* (2010) [11] have demonstrated that *C. septempunctata* prefers aphids over mealy bugs as prey.

Effect of different treatments on the population of the brinjal mealy bug *Coccidohystryx insolita* during the year 2013 and 2014 is depicted in Table 3 and 4. During 2013(Table 3) the population of mealy bug varied from 134.3 to 171.3 per plant in different treatments one day before their application (1DBT). Fifteen days after treatment (DAT), the mealy bug population was reduced and lowest population (22.8/plant) was recorded in T6 (Insecticidal check).Treatments with *Cryptolaemus montrouzieri* (T2 and T1) recorded 67.8 and 69.6 mealy bugs respectively. Treatments with *Coccinella septempunctata* (T4 and T3) recorded 121.9 and 128.4 mealybugs respectively whereas, treatment with *Verticillium lecanii* (T7) had 75.6 mealy bugs after 15 days and control plots had 181.9 mealy bugs. The same trend also continued 30DAT. Minimum population (16.2/plant) was found in T6 followed by T2 (39.2), T1 (43.2), T5 (54.5), T4 (97.2) and T3 (110.2). At 45 DAT, again the insecticidal check recorded least population of the mealy bug (9.4/plant) followed by T2 (14.6), T1 (15.9), T5 (46.1), T4 (59.8) and T3 (69.5).Sixty days after treatment the lowest population of the mealy bug (1.3/plant) was recorded in the insecticidal check (T6).Treatments with *C. montrouzieri* (T2 and T1) recorded 2.1 and 4.7 mealy bugs/plant respectively. *V. lecanii* incorporated treatment (T5) recorded 24.9 mealy bugs/plant. Treatments with *C. septempunctata* (T3 and T4) had 34.2 and 31.8 mealy bugs/plant respectively. In all the days of observations, the control plots recorded more number of mealy bugs/plant than all the treated plots. The yield was highest in T6 (322.9 q/ha) followed by T2 (292.8 q/ha), T1 (278.4 q/ha), T5 (251.7q/ha), T4 (248.9q/ha) and T3 (239.5q/ha).During 2014(Table 4) the population of mealy bugs varied between 134.8/plant and 146.7/plant in different plots one day before treatment.15 days after treatment the lowest population was recorded in T6 (7.8/plant) followed by T5 (59.7), T2 (61.9), T1 (73.2), T4 (101.8) and T3 (127.2). The control plots recorded 142.9 mealy bugs/plant. The trend remained same evens at 30DAT the lowest population being in insecticidal treatment T6 (5.9/plant). Treatments with *C. montrouzieri* (T2 and T1) recorded 28.6 and 42.1mealy bugs/plant whereas, treatments with *C. septempunctata* (T4 and T3) recorded 74.3 and 82.6 mealy bugs/plant. T5, the *V. lecanii* incorporated treatment, recorded 51.4 mealy bugs/plant. At 45 DAT, T6 has the lowest population per plant again (3.1) followed by T2 (16.2), T1 (21.6), T5 (42.8), T4 (59.3) and T3 (61.8) in comparison to 157.3/plant in control. The observation at 60 DAT also produced the same trend, the lowest mealy bug population/plant being in T6 (1.2), followed by T2 (2.1), T1 (3.1), T5 (31.9), T4 (32.5) and T3 (49.20). Control plots have 148.8 mealy bugs/plant. Yield was maximum in T6 (339.5q/ha) followed by T2 (288.4q/ha), T1 (263.9q/ha), T5 (238.3q/ha), T4 (211.9q/ha) and T3 (188.8q/ha) as against 169.9q/ha in control. The population reduction of mealy bugs were at par in T1, T2 and T6, indicating that the Australian lady bird, *C. montrouzieri* was more efficient than the seven spotted lady bird, *C. septempunctata* in controlling mealy bugs. The effectiveness of *C. montrouzieri* for control of mealy bugs has been well demonstrated by Moses *et al.* (2000) [7] and Kaur and Virk (2011) [4]. Maes *et al*. (2014) [5] have observed that the feeding efficiency of *C. montrouzieri* was at par on green peach aphid, *Mizus persicae* and citrus mealy bug, *Planococcus citri.* Our findings were in agreement with the authors. This experiment confirmed that, both *C. septempunctata* and *C. montrouzieri* can effectively manage the aphids and mealy bugs, but the former is more efficient against aphids whereas, the later is more efficient against mealy bugs. Therefore, in crops which are ravaged by both aphids and mealy bugs in the same time, the use of both the predatory beetles will be a boon for integrated pest management.

Table 1: Control of aphid, *Aphis craccivora* in cowpea using coccinellid predators during 2013

Treatments	Number of aphids per 10 cm twig					
	1 DBT	15 DAT	30DAT	45 DAT	60DAT	Yield (Q/Ha)
T_1 – Release of 10 1st instar larvae of *C. montrouzieri*	89.6(9.46)	73.4(8.56)	59.2(7.69)	38.1(6.17)	29.2(5.40)	243.9
T_2 - Release of 20 1st instar larvae of *C. montrouzieri*	93.2(9.65)	65.7(8.10)	49.8(7.05)	31.1(5.57)	22.4(4.73)	263.2
T_3– Release of 10 1st instar larvae of *C. septempunctata*	84.7(9.20)	49.2(7.01)	29.8(5.45)	18.7(4.32)	12.2(2.48)	284.9
T_4-Release of 20 1st instar larvae of *C. septempunctata*	93.9(9.69)	37.8(6.14)	18.8(4.33)	10.2(3.19)	2.3(1.51)	317.3
T_5 - Appln. of *V. lecanii* 2x 10^7 CFUs g^{-1} @ 2.5kg ha^{-1}	89.8(9.47)	42.4(6.51)	21.2(4.60)	18.4(4.28)	11.5(3.39)	309.9
T_6 - Insecticidal check *	98.7(9.93)	4.3(2.07)	1.8(1.34)	0.9(0.94)	1.0(1.00)	359.6
T_7 – Control	94.5(9.72)	102.4(10.11)	108.1(10.39)	105.2(10.25)	98.7(9.93)	201.3
SE(m) ±	(0.53)	(0.60)	(0.65)	(0.79)	(0.70)	4.6
CD(P= 0.05)	(1.60)	(1.81)	(1.97)	(2.39)	(2.12)	13.95

*Thiomethoxam 25g a.i/ha

Table 2: Control of aphid, *Aphis craccivora* in cowpea using coccinellid predators during 2014

Treatments	Number of aphids per10 cm twig					
	1DBT	15DAT	30DAT	45DAT	60DAT	Yield (Q/Ha)
T_1 – Release of 10 1st instar larvae of *C. montrouzieri*	74.8(8.64)	69.2(8.31)	56.8(7.53)	46.5(6.89)	31.1(6.3)	249.8
T_2 - Release of 20 1st instar larvae of *C. montrouzieri*	79.2(8.89)	64.8(8.04)	42.7(6.53)	29.9(5.46)	30.7(5.54)	267.3
T_3– Release of 10 1st instar larvae of *C. septempunctata*	82.4(9.07)	39.8(6.30)	22.4(4.73)	20.2(4.49)	19.5(4.41)	292.9
T_4-Release of 20 1st instar larvae of *C. septempunctata*	87.9(9.37)	27.2(5.21)	17.5(4.18)	12.6(3.54)	11.4(3.37)	319.6
T_5 - Appln. of *V. lecanii* 2x 10^7 CFUs g^{-1} @ 2.5kg ha^{-1}	79.5(8.91)	32.5(5.70)	20.7(4.54)	18.1(4.25)	15.3(3.91)	311.9
T_6 - Insecticidal check *	87.2(9.33)	12.6(3.54)	6.9(2.62)	6.5(2.54)	5.5(2.34)	362.1
T_7 – Control	90.2(9.49)	93.4(9.66)	89.5(9.46)	102.3(10.11)	92.5(9.61)	187.5
SE(m)±	(0.61)	(0.64)	(0.71)	(0.60)	(0.59)	5.46
CD(P=05)	(1.85)	(1.94)	(2.15)	(1.81)	(1.78)	16.54

*Thiomethoxam 25g a.i/ha

Table 3: Control of mealybug, *Coccidohystryx insolita* in brinjal using coccinellid predators during 2013

Treatments	Number of mealy bugs /plant					
	1 DBT	15 DAT	30DAT	45 DAT	60DAT	Yield (Q/Ha)
T_1 – Release of 10 1st instar larvae of *C. montrouzieri*	134.3(11.58)	69.6(8.34)	43.2(6.57)	15.9(3.98)	4.7(2.16)	278.4
T_2 - Release of 20 1st instar larvae of *C. montrouzieri*	140.3(11.84)	67.8(8.23)	39.2(6.26)	14.6(3.82)	2.1(1.44)	292.8
T_3– Release of 10 1st instar larvae of *C. septempunctata*	151.9(12.32)	128.4(11.33)	110.2(10.49)	69.5(8.33)	34.2(5.84)	239.5
T_4-Release of 20 1st instar larvae of *C. septempunctata*	160.4(12.66)	121.9(11.04)	97.2(9.85)	59.8(7.73)	31.8(5.63)	248.9
T_5 - Appln. of *V. lecanii* 2x 10^7 CFUs g^{-1} @ 2.5kg ha^{-1}	165.8(12.87)	75.6(8.69)	54.5(7.38)	46.1(6.78)	24.9(4.98)	251.7
T_6 - Insecticidal check *	162.4(12.74)	22.8(4.77)	16.2(4.04)	9.4(3.06)	1.3(1.14)	322.9
T_7 – Control	171.3(13.08)	181.9(13.48)	143.2(11.96)	202.3(14.22)	212.2(14.56)	149.3
SE(m) ±	(1.43)	(0.69)	(0.67)	(0.69)	(0.68)	4.79
CD(P= 0.05)	(4.33)	(2.09)	(2.03)	(2.09)	(2.05)	14.52

*Thiomethoxam 25g a.i/ha

Table 4: Control of mealybug, *Coccidohystryx insolita* in brinjal using coccinellid predators during 2014

Treatments	Number of mealy bugs /plant					
	1 DBT	15 DAT	30DAT	45 DAT	60DAT	Yield (Q/Ha)
T_1 – Release of 10 1st instar larvae of *C. montrouzieri*	140.3(11.84)	69.6(8.34)	43.2(6.48)	21.6(4.64)	3.1(1.76)	263.3
T_2 - Release of 20 1st instar larvae of *C. montrouzieri*	139.6(11.81)	61.9(7.86)	28.6(5.34)	16.2(4.02)	2.1(1.45)	288.4
T_3– Release of 10 1st instar larvae of *C. septempunctata*	141.4911.89)	127.2(11.27)	82.6(9.08)	61.8(7.86)	49.2(7.01)	188.8
T_4-Release of 20 1st instar larvae of *C. septempunctata*	146.7(12.11)	101.8(10.08)	74.3(8.61)	59.3(7.70)	32.5(5.70)	211.9
T_5 - Appln. of *V. lecanii* 2x 10^7 CFUs g^{-1} @ 2.5kg ha^{-1}	139.3(11.80)	59.7(7.72)	51.4(7.16)	42.8(6.54)	31.9(5.64)	238.3
T_6 - Insecticidal check *	142.3(11.92)	7.8(2.79)	5.9(2.42)	3.1(1.76)	1.2(1.09)	339.5
T_7 – Control	137.8(11.73)	142.9(11.95)	151.8(12.32)	157.3(12.54)	148.8(12.19)	169.9
SE(m) ±	(0.79)	(0.77)	(1.03)	(1.19)	(0.90)	4.6
CD(P= 0.05)	(2.39)	(2.33)	(3.12)	(3.60)	(2.72)	13.95

* Thiomethoxam 25g a.i/ha

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