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Potentiality of intercropping in managing Diamondback moth (*Plutella xylostella*)

KULDEEP SHARMA[1]*, M K MAHLA[1], S RAMESH BABU[1], K C AHIR[1], A KUMAR[1], BEERENDRA SINGH[1] and RUPINDER SINGH CHEEMA[2]

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, 313 001, India

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ABSTRACT

The present experiment was conducted at horticulture farm of Rajasthan College of Agriculture, Udaipur, Rajasthan, during two winter (*rabi*) seasons 2019–20 and 2020–21. The treatments include, cabbage + marigold, cabbage + onion, cabbage + garlic, cabbage + marigold + insecticides spray, cabbage + onion + insecticides spray, cabbage + garlic + insecticides spray, cabbage + insecticides spray and cabbage sole without insecticide spray as untreated control. The insecticidal treatments scheduled with two sprays, viz. first spray of chlorfenapyr 10% SC @200 g a.i./ha and spinosad 45% SC @45 g a.i./ha. During both years, cabbage intercropped with marigold + insecticides spray proved to be the best treatment with the lowest mean DBM larval population (0.73 and 0.47 larvae/plant) and highest benefit-cost ratio (6.69 and 6.88). Additionally, the intercrops treatments, viz. cabbage + marigold, cabbage + onion and cabbage + garlic also significantly reduced the number of DBM larvae per plant as compared to the untreated sole cabbage. The different intercrops combinations evaluated had a positive effect on the cabbage crop in reducing the pest and can be taken to manage DBM in a sustainable way.

Keywords: Cabbage, Diamondback moth, Insecticides, Intercrops, Management

Cabbage (*Brassica oleracea* var. *capitata* L.) is a leafy vegetable grown for its edible enlarged terminal bud. Many limiting factors have been attributed to low production; among them, the chief constraint is damage caused by the insect pest complex soon after germination till the harvesting. Amongst, diamondback moth (*Plutella xylostella* L.) (Lepidoptera: Plutellidae), is recognised as the most devastating insect pest of cruciferous crops worldwide. Diamondback moth (DBM) manifests a marked preference for cabbage and cauliflower as these crops equip olfactory and gustatory stimuli for successful selection and colonization with fleshy and succulent leaves (Dubey and Chand 1977). It destructs the crop by feeding on the foliage and infests by multitudes of larvae which hinders the growth of the plant leading to a notable reduction in yield. Commercial consideration of cabbage crop has compelled the growers to go for frequent and injudicious use of insecticides for better marketable yield. As a result, DBM has developed resistance to most commonly used insecticides (Atumurirava *et al.* 2011, Zhou *et al.* 2011). To reduce yield losses caused by DBM, farmers routinely follow chemical control, due to the lack of reliable alternatives and the availability of relatively cheaper insecticides. DBM damages had created a situation where the area, production and productivity of cabbage declined rapidly and numerous farmers abandoned the cultivation of cabbage due to the insect pest problem (Anonymous 2018). Therefore, it is essential to find eco-friendly pest management to manage DBM more effectively. Hence, considering these issues, the present experiment was undertaken to evaluate the potentiality of intercropping compounded with insecticides in reducing the infestation and damage caused by diamondback moth (DBM) in cabbage.

[1]Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan; [2]Punjab Agricultural University, Ludhiana, Punjab. *Corresponding author email: kuldeepagri09@gmail.com

MATERIALS AND METHODS

The experiment was conducted at the horticulture farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. The experiment was designed on the prepared field with uniform sized plots of 4.5 m × 4.5 m laid out in randomized block design with eight treatments and three replications. The treatments include, T_1, cabbage + marigold; T_2, cabbage + onion; T_3, cabbage + garlic; T_4, cabbage + marigold + insecticides spray; T_5, cabbage + onion + insecticides spray; T_6, cabbage + garlic + insecticides spray; T_7, cabbage + insecticides spray and T_8, cabbage sole without insecticide spray as untreated control. The golden acre variety of cabbage was transplanted in the last week of October and the first week of November with a spacing of 45 cm × 30 cm (row to row and plant to plant) during winter (*rabi*) season, 2019–20 and 2020–21 respectively. Seedlings of marigold (var. Pusa Narangi with plant to plant spacing-60 cm), onion (var. Nasik red-53 with plant to plant spacing-8 cm) and garlic (var. G-282-TL with plant to plant spacing-8 cm) were planted on main field 15 days prior to cabbage transplanting as intercrops. The main crop and intercrop (2:1) ratio were maintained respectively. The insecticidal treatments scheduled with two sprays, viz. first spray of chlorfenapyr 10% SC @200 g a.i./ha was done when pest reached at the economic threshold level and 2nd spray of spinosad 45% SC @ 45 g a.i./ha was done after 15 days of first spray.

The pre-treatment population before 24 h of the scheduled spray and the post-treatment population on 3, 7 and 10 days after each spray was recorded. Observation, on mean larvae per plant was recorded on 10 randomly selected plants in each replication for evaluating the efficacy. The number of DBM larvae recorded on 10 randomly selected tagged plants in each treatment were transformed into square root values (x + 0.5) and subjected to analysis of variance. The yield of the cabbage and intercrop was recorded for each treatment and computed on a hectare basis. The economics of different treatments were worked out by taking the cost of cultivation of each treatment followed by obtaining prevailing market prices of yields from the local wholesale vegetable market of Udaipur. The benefit-cost (B:C) ratio of each treatment was worked out by using the net returns, obtained by deducting the costs of cultivation from the gross returns of each treatment.

Gross returns = Yield (in kg/ha) × market price (in ₹/kg)

Net profit = Gross return – Cost of cultivation

$$\text{Benefit-cost ratio} = \frac{\text{Net profit of treatment}}{\text{Cost of cultivation}}$$

RESULTS AND DISCUSSION

The effect of different treatments on diamondback moth (DBM) populations was examined in intercropped and sole cabbage during winter (*rabi*) seasons, 2019–20 and 2020–21 (Table 1). During *rabi* 2019–20, pre-treatment populations from all the treatments differed not-significantly. The larval populations were ranged from 5.03–7.20 larvae per plant. However, the least number of larvae per plant (3.73) was noticed after 3 DAS from the treatment cabbage + marigold + insecticide spray followed by the cabbage + onion + insecticide spray (3.83) and cabbage + garlic + insecticide spray (4.17). The highest larval population per plant was depicted from the sole cabbage (6.47). Similarly, trends were observed on 7 DAS and 10 DAS after application. Similar, trends were observed in the second spray. It is evident that during *rabi,* 2020–21, the pre-treatment populations from all treatments not-significantly differed and the number of larval populations ranged from 5.90–7.17 larvae per plant. After 3 DAS first spray, the least number of larvae per plant was documented from the treatment cabbage + marigold + insecticide spray (3.00) followed by the cabbage + onion + insecticide spray (3.23) and cabbage + garlic + insecticide spray (3.37) while the highest larval population per plant was depicted from the untreated sole untreated cabbage (6.80). Likewise, trends were shown at 7 DAS and 10 DAS subsequently, in the second spray.

During *rabi,* 2019–20 the maximum cost-benefit ratio (6.69) was obtained in the treatment of cabbage + marigold + insecticide spray followed by cabbage + onion + insecticide spray (5.66) and cabbage + garlic + insecticide spray (5.55). However, the maximum yield of cabbage was obtained from the treatment cabbage + insecticide spray (Table 2). Similarly, during *rabi,* 2020–21 the maximum cost-benefit ratio (6.88) was documented from the treatment of cabbage + marigold + insecticide spray followed by cabbage + garlic + insecticide spray (6.51) and cabbage + onion + insecticide spray (5.94). However, the maximum yield of cabbage was obtained from the treatment of cabbage + insecticide spray (Table 2).

Insects anticipate visual, olfactory and tactile cues to detect the main host plants on which they feed. The presence of non-host plants may intermeddle with insects to locate the host plants by physically masking the presence of the host plant or by producing volatiles. Diverse habitats can reduce the appearance of host plants to pests (Hooks and Johnson 2003). Therefore, non-host intercrops which are suitable as a companion to the main crop can be used to abate the pest's activity. Diamondback moth has a narrow host range and this pest mainly damages cruciferous crops, hence this may be more readily reduced in number when host crops are intercropped with non-host crops. The crop combinations effect to reduce the pest population has been demonstrated earlier by many of the authors. Non-host plants like garlic, tomato, lucerne, marigold and onion have caused considerable depletion on DBM population when farm scaped with cabbage (Meena and Lal 2002, Singh *et al*. 2006). Similarly, Shankar *et al.* (2007) noticed the least incidence of DBM when marigold was intercropped with cauliflower. Asman *et al.* (2001), found that onion creates confusion by producing olfactory and visual cues to diamondback moth from the non-host plants which lead to disruption in mating and decline in larval numbers. Similarly, Said and Itulya (2003) indicated that the odour from onion repels *P. xylostella* from resting on cabbage when intercropped with onion or garlic. Garlic and onion produce a pungent alliaceous compound, allyl-epropyl-disulphide, which is responsible for its pest repellent attribute. Likewise, taking intercrops with cabbage in combination with insecticides, Asare-Bediako *et al*. (2010) conducted a field trial against *P. xylostella*. They observed that cabbage plants intercropped or sprayed with chlorpyrifos against the *P. xylostella* accounted for significantly higher growth, yield and less damage by pest as compared to the cabbage crops in control.

Scrutiny of the data, from both the seasons divulged that the yield, net returns and cost-benefit ratio among all the treatment schedules were relatively high as compared to the sole untreated cabbage. Similarly, Sharma *et al.* (2018)

Table 1 Bio-efficacy of insecticides against diamondback moth in sole and intercropped cabbage

Treatment	*Rabi,* 2019–20 (mean larvae/plant)							*Rabi,* 2020–21 (mean larvae/plant)						
	First spray				Second spray			First spray				Second spray		
	PTP	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	PTP	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
T_1	5.03* (2.35)	5.37 (2.42)	5.03 (2.35)	3.77 (2.05)	4.33 (2.19)	3.53 (2.00)	3.10 (1.89)	6.03* (2.55)	5.93 (2.53)	4.87 (2.30)	4.10 (2.13)	5.10 (2.36)	4.13 (2.14)	3.57 (2.00)
T_2	5.50 (2.44)	5.40 (2.42)	5.13 (2.37)	4.07 (2.13)	4.87 (2.31)	3.77 (2.06)	3.43 (1.97)	6.00 (2.55)	6.10 (2.57)	5.17 (2.37)	4.37 (2.20)	5.60 (2.46)	4.70 (2.27)	4.13 (2.15)
T_3	5.33 (2.41)	6.00 (2.55)	5.77 (2.50)	4.20 (2.16)	5.00 (2.34)	3.93 (2.10)	3.60 (2.01)	5.90 (2.53)	6.03 (2.56)	5.37 (2.41)	4.50 (2.23)	5.93 (2.53)	5.27 (2.39)	4.50 (2.23)
T_4	5.20 (2.38)	3.73 (2.06)	2.70 (1.78)	1.30 (1.33)	2.87 (1.83)	1.87 (1.53)	0.73 (1.11)	6.37 (2.62)	3.00 (1.87)	2.03 (1.59)	1.77 (1.49)	2.27 (1.66)	1.57 (1.43)	0.47 (0.98)
T_5	5.40 (2.42)	3.83 (2.08)	3.03 (1.88)	1.60 (1.44)	3.10 (1.89)	2.27 (1.66)	1.00 (1.22)	6.60 (2.66)	3.23 (1.93)	2.30 (1.67)	2.03 (1.59)	2.53 (1.73)	1.80 (1.51)	0.90 (1.18)
T_6	5.47 (2.44)	4.17 (2.16)	3.13 (1.90)	1.73 (1.49)	3.33 (1.96)	2.43 (1.71)	1.13 (1.28)	6.47 (2.64)	3.37 (1.96)	2.50 (1.73)	2.30 (1.67)	2.90 (1.84)	1.97 (1.57)	1.10 (1.26)
T_7	6.90 (2.72)	5.00 (2.34)	3.70 (2.05)	2.07 (1.60)	3.93 (2.10)	2.90 (1.84)	1.80 (1.50)	7.17 (2.77)	3.90 (2.09)	3.13 (1.90)	2.83 (1.82)	3.43 (1.98)	2.27 (1.66)	1.90 (1.55)
T_8	7.20 (2.77)	6.47 (2.64)	7.33 (2.80)	7.97 (2.91)	7.47 (2.82)	8.07 (2.93)	8.30 (2.97)	6.40 (2.62)	6.80 (2.70)	7.70 (2.86)	7.87 (2.89)	7.83 (2.88)	7.93 (2.90)	8.87 (3.06)
SEm±	0.110	0.079	0.074	0.091	0.091	0.094	0.119	0.083	0.079	0.103	0.113	0.099	0.129	0.093
CD (P= 0.05)	0.33	0.24	0.22	0.28	0.28	0.28	0.36	0.25	0.24	0.31	0.34	0.30	0.39	0.28

PTP, Pre-treatment population; DAS, Days after spray; * Figures in parentheses are square root (x + 0.5) transformed value.
Treatment details given under Materials and Methods.

Table 2 Economics of the bio-efficacy treatments against diamondback moth during winter (*rabi*) season, 2019–20 and 2020–21

Treatment	Average yield of cabbage (kg/ha) (2019–20)	Average yield of cabbage (kg/ha) (2020–21)	Average yield of intercrops (kg/ha) (2019–20)	Average yield of intercrops (kg/ha) (2020–21)	Gross return from main crop + intercrops (₹/ha) (2019–20)	Gross return from main crop + intercrops (₹/ha) (2020–21)	Value increase over control (₹/ha) (2019–20)	Value increase over control (₹/ha) (2020–21)	Cost of cultivation (₹/ha) (2019–20)	Cost of cultivation (₹/ha) (2020–21)	Net profit (₹/ha) (2019–20)	Net profit (₹/ha) (2020–21)	B:C Ratio (₹/ha) (2019–20)	B:C ratio (₹/ha) (2020–21)
T_1	6468.49	7044.56	2880.37	3012.04	244584.59	260401.94	75201.88	59957.50	43933.0	44940.0	200651.59	215461.94	4.57	4.79
T_2	6369.73	6633.08	3505.82	3579.89	232569.33	246164.68	63186.62	45720.24	45700.0	46400.0	186869.33	199764.68	4.09	4.31
T_3	6303.90	6501.41	2946.21	2979.13	243926.22	277091.63	74543.51	76647.19	48765.0	48980.0	195161.22	228111.63	4.00	4.66
T_4	10533.93	10961.87	5102.37	5308.11	414773.33	426944.96	245390.62	226500.51	53919.0	54200.0	360854.33	372744.96	6.69	6.88
T_5	10402.25	10698.52	5431.56	5563.23	370991.70	391137.84	201608.99	190693.39	55680.0	56380.0	315311.70	334757.84	5.66	5.94
T_6	10336.41	10517.47	4444.00	4633.28	384488.30	439881.93	215105.58	239437.49	58745.0	58580.0	325743.30	381301.93	5.55	6.51
T_7	16197.53	16246.91	0.00	0.00	323950.62	357432.10	154567.90	156987.65	52380.0	52680.0	271570.62	304752.10	5.18	5.78
T_8	8469.14	9111.11	0.00	0.00	169382.72	200444.44	-	-	40750.0	42525.0	128632.72	157919.44	3.16	3.71

BC: Benefit-cost; Chlorfenapyr 200 SC @ ₹5500 (2000 ml/ha); Spinosad 45 SC @ ₹3440 (150 ml/ha); Labour charge @ ₹270/labour; Two labour/spray charge; Market price (*rabi*, 2019–20): Cabbage @20 ₹/kg; Marigold @40 ₹/kg; Onion @30 ₹/kg; Garlic @40 ₹/kg; Market price (*rabi*, 2020–21): Cabbage @22 ₹/kg; Marigold @35 ₹/kg; Onion @28 ₹/kg; Garlic @45 ₹/kg. Treatment details given under Materials and Methods.

examined the effect of different intercrops and border crops against major insect pests of cabbage. They found that the maximum yields were attained in the intercropped treatments when compared to the sole cabbage. Chavan *et al.* (2010) also validated that intercropping bestowed higher returns than sole cropping of cabbage. Choudhari and Jana (2012) revealed that cabbage with intercropping had influenced the yields. Analysis of economics (B:C ratio) had shown that the highest returns were obtained with cabbage in combination with intercrops Mawnai *et al.* (2021). Moreover, it was also noticed that the weight of the cabbage head was significantly influenced by intercropping (Ananda *et al.* 2018).

The different intercrop combinations evaluated had a positive effect on the cabbage crop in reducing the pest load compared to sole cabbage. During both the years, cabbage intercropped with marigold + insecticides spray proved the best treatment and recorded the lowest mean larval population. Cabbage intercropped with onion and garlic + insecticides sprays proved the next best crop combinations in lowering the incidence of DBM, respectively. On the other hand, cabbage intercropped with marigold, onion and garlic were observed the lowest seasonal mean larval population compared to cabbage grown as a sole crop. Additionally, the intercrop treatments, viz. cabbage + marigold, cabbage + onion and cabbage + garlic also significantly reduced the number of larvae per plant compared to the sole untreated cabbage. Thus, the intercropping combinations can be taken to manage DBM in a sustainable way.

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