Journal homepage:https://www.environcj.in/

Environment Conservation Journal

ISSN 0972-3099 (Print) 2278-5124 (Online)

Impact of different intercrops on the incidence of insect pests in cabbage

Rajneesh Kumar Verma
Department of Entomology, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Sameer Kumar Singh ✉
Department of Entomology, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Umesh Chandra
Department of Entomology, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Kamal Ravi Sharma
Department of Entomology, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

ARTICLE INFO

Received : 01 November 2023
Revised : 31 December 2023
Accepted : 09 January 2024

Available online: 01 March 2024

Key Words:
Aphid
Cabbage
Coriander
Intercrops
Onion
Plutella xylostella
Radish
Spodoptera litura

ABSTRACT

In India, cabbage is attacked by approximately 35 insect pests; due to the high nutritional value and succulent nature of cabbage, it has attracted the attention of several insect pests. Monocultures are low-diversity agroecosystems that may be more prone to outbursts of pests. The present study aimed to determine the impact of different intercrops on the incidence of insect pests on cabbage. The outcomes revealed that during *Rabi* 2021-22, populations of *Plutella xylostella* and *Spodoptera litura* were recorded for the first time during the 51st standard meteorological week (SMW). The incidence of aphids was first recorded in the 2nd SMW and reached the maximum level in the 8th SMW along with *P. xylostella* and *S. litura*. The lowest incidence of *P. xylostella* and aphids was recorded in the T_6-Cabbage + Coriander treatment (2:2), followed by the T_5-Cabbage + Coriander treatment (2:1); the maximum incidence of *P. xylostella* and aphids was observed in the T_3-Cabbage+ Radish treatment (2:1), and all the intercropping treatments were superior to those used for the sole cabbage crop, with the maximum incidence of *P. xylostella.* The lowest incidence of *S. litura* T_6-Cabbage + Coriander (2:2) was followed by T_5-Cabbage + Coriander (2:1), and the maximum incidence of *S. litura* was observed in the T_1-Cabbage + Onion treatment (2:1). The yield was the highest in the T_6-Cabbage+ Coriander (2:2) treatment (257.33 q/ha main crop, 3.30 q/ha), followed by the T_5-Cabbage+ Coriander 2:1 treatment (233.33 q/ha main crop, 1.83 q/ha) and the T_3-Cabbage+ Radish treatment (2:1) (197.33 q/ha main crop, 25.32 q/ha).

Introduction

Cabbage, *Brassica oleracea* var. capitata L., a member of the Brassicaceae family, is an exotic leafy vegetable native to Europe (FAO, 2000). Cabbage is a widely grown vegetable worldwide, and it is one of the most popular food crops (Legwaila *et al*., 2014). After China, India is the world's largest producer of vegetables, accounting for 3.00% of the total area and 11.40% of the total production. In India, cabbage fields cover 82000 hectares and produce 1260 million tons per year (NHB, 2018). Poor cabbage yields in India are influenced by many factors, the most crucial of which is damage caused by a variety of insect pests from the vegetative to maturity stages. In India, cabbage is attacked by approximately 35 insect pests; due to the high nutritional value and succulent

Corresponding author E-mail: drsameerent@nduat.org
Doi:https://doi.org/10.36953/ECJ.26022746

nature of cabbage, it has attracted several insect pests that feed on it (Chalfant *et al*., 1979; Shelton *et al*., 1982; Mochiah *et al*., 2011). The insect pests associated with cabbage include the Diamondback moth, *Plutella xylostella* L.; the cabbage aphid, *Brevicoryne brassicae* L.; the Mustard aphid, *Lipaphis erysimi*; the Indian mustard aphid, *Lipaphis erysimi pseudobrassicae*; the green peach aphid, *Myzus persicae*; the cabbage webworm, *Hellula undalis*; and the cabbage looper, *Trichoplusia ni*. ; grasshopper, *Zonocerus variegatus*; flea beetle, *Phyllotreta* spp.; and whitefly, *Bemisia tabaci* (Müller, 1986; Obeng–Ofori *et al*., 2007; Fenning *et al*., 2014). In India, insect pests alone cause field losses of approximately 15-20%, which will account for nearly 150 crores of rupees, but in the case of severe outbreaks, the losses reach up to 90%. The presence of *P. xylostella* on cabbage causes yield losses ranging from 50 to 97% from transplanting to till harvesting (Devjani *et al*., 1998; Ayalew *et al*., 2005; Grzywacz *et al*., 2010; Mochiah *et al*., 2011; Sarma *et al*., 2018; Mane *et al*., 2021). Monocultures are low-diversity agroecosystems that may be more prone to outbursts of pests or diseases. The practice of growing two or more crops concurrently on the same land in a definite row pattern is called intercropping. The appropriateness of intercropping plants should be considered in the agricultural or horticultural regime in which they are placed. Insects with a narrow host range, such as those pests that attack only cruciferous crops, are more readily reduced in number when host crops are mixed with nonhost crops. Onion and other plants in the Allium family release strong volatiles, which can reduce the attraction of phytophagous insects. Onion repels lepidopterans in cabbage (Mahendran *et al*., 2016). The diversity of crops planted reduces the insect population. The ability of intercropping systems to reduce pest prevalence due to enhanced botanical diversity is a significant advantage. To effectively manage cabbage pests without the use of insecticides, conservation biocontrol or habitat management should aim to preserve natural enemies in crop ecosystems (Kumar *et al*., 2013; Sarma *et al*., 2018). Crop diversity through intercropping must be included as a key activity to benefit from increasing the quantity of natural enemies in the crop ecosystem. In an intercrop system, different crops coexist and have mutual effects. These connections may be advantageous or harmful. Intercropping allows for the advantages of growing plants in close proximity. By discouraging insects and halting the development of diseases, appropriate vegetable crops and herbs can reduce the need for chemical pesticides in gardens (Ahmed *et al*., 1996). Keeping aforesaid truth, the present study was planned and conducted to determine the impact of intercrops on the incidence of insect pests on cabbage.

Material and Methods

The present research was conducted under field conditions at the Instructional Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumargani, Ayodhya, Uttar Pradesh, India, during *Rabi* 2021-22 on a cabbage cultivar, Pusa Drumhead and intercrops, i.e., the onion variety Gauran, the radish variety Japanese White and the coriander variety Narendra Coriander-1, in a randomized block design with three replications. In the experimental field, seven cropping systems were established in the treatment plots, each consisting of an area of 5×5 m. The interrow spacing was 45 cm, and the intrarow spacing was 30 cm. A total of 12 rows were established per experimental plot, with 17 plants per row. The plots were separated by 0.5 m and 1 m buffers between the treatment plots and replicates, respectively. Six cabbage-based intercropping systems were designed using three intercrops, viz., onion, radish and coriander, with single- and double-row patterns of planting (Table 1). The population buildup of insect pests was recorded from 5 randomly selected plants, and the number of insect pests was counted at weekly intervals on a standard meteorological week basis from the appearance of insect pests until harvesting. The insect population was estimated with the help of the “direct visual counting method” for the insect pests found to feed on cabbage crops. Insect pests, such as aphids, lepidopteran borers and other pest populations, were counted on a per-plant basis, and 5 plants were randomly selected from each plot. Observations were recorded at weekly intervals during morning hours between 6.00 and 7.00 am. In each treatment, the yields of the main crop and intercrop were noted separately and subjected to statistical analysis to test the significance of the

mean yield of the main crop and intercrop in the various treatments. The yield was subjected to statistical analysis to test the significance of the mean yield. The plot yield was then converted to yield for each treatment on a hectare basis.

Table 1: Details of the main crops and intercrops used in the present study

Treatments	Details of Treatments	Pattern
T_1	Cabbage + Onion	2 rows of main crop+ 1 row of inter crop
T_2	Cabbage + Onion	2 rows of main crop+ 2 rows of inter crop
T_3	Cabbage + Radish	2 rows of main crop+ 1 row of inter crop
T_4	Cabbage + Radish	2 rows of main crop+ 2 rows of inter crop
T_5	Cabbage + Coriander	2 rows of main crop+ 1 row of inter crop
T_6	Cabbage + Coriander	2 rows of main crop+ 2 rows of inter crop
T_7	Cabbage	Sole crop

Results and Discussion

Effects of different intercrops on the incidence pattern of insect pests in cabbage incidence of the Diamondback moth, *P. xylostella*

The incidence Diamondback moth was first recorded on the 51st standard meteorological week during *Rabi* 2021-22 (Table 2). The highest incidence of infection in the Diamondback moth, *P. xylostella,* was recorded at the 8th standard meteorological week. During the cropping period, we observed the incidence pattern of *P. xylostella* in different intercrops during the whole cropping period, and the minimum incidence of *P. xylostella* was recorded in the T_6-Cabbage + Coriander (2:2) treatment (2.59 larvae/plant), and the maximum incidence of *P. xylostella was* recorded in the intercrop T_3-Cabbage + Radish (2:1) treatment (3.53 larvae/plant). The results of all the intercropping treatments were superior to those of the sole cabbage (T_7) crop, in which the maximum incidence of *P. xylostella* was observed (4.24 larvae/plant). These findings are also similar to those of Sarma *et al.* (2018), who reported on cabbage intercropped with mustard at the attack of *P. xylostella,* in which the values were 1.72 and 1.65 larvae/plant, respectively. The highest number of *P. xylostella* infected with cabbage was in the sole crop, at 2.28 larvae/plant. The lowest population was recorded for cabbage intercropped with nonhost plants due to the confusing olfactory and visual cues received. Research has indicated that insects with a narrow host range, such as the insect pest diamondback moth (*P. xylostella*), which attacks only cruciferous crops, are more readily reduced in number when host crops are mixed with nonhost crops (Andow, 1991). When an herbivore encounters a plant that it cannot feed on, it must spend additional time and energy searching for an acceptable plant (Hooks and Johnson, 2003). These findings are also supported by Ali *et al.* (2020), Narode *et al.* (2018) and Saikumar *et al.* (2021).

Incidence of Tobacco caterpillar, *S. litura*

The occurrence of the tobacco caterpillar *S. litura* was recorded for the first time at the 51st standard meteorological week during *Rabi* 2021-22 (Table 3). The maximum incidence of the tobacco caterpillar *S. litura* was reached at the 8th standard meteorological week. During the cropping period, the incidence pattern of *S. litura* associated with the different intercrops was observed. The minimum incidence of *S. litura* was recorded for the T_6-Cabbage + coriander treatment (2:2), with 1.42 larvae/plant, and the maximum incidence of *S. litura* was recorded for the T_1-Cabbage +Onion treatment (2:1), with 2.31 larvae/plant. All the intercropping treatments had superior effects on all the cabbage crops, i.e., T_7-Cabbage (2.83 larvae/plant). Onion and other plants in the Allium family release strong volatiles, which can reduce the attraction of phytophagous insects (Renwick, 1999). Onion repels lepidopterous pests in cabbage (Anonymous, 2004a, Debra and Misheck, 2014). These findings are also supported by Baidoo *et al.* (2012), who found the best results in reducing the population of *P. xylostella*, *Trichoplusia ni, Bemisia tabaci* and *Hellula undalis in a* 2:2 ratio of cabbage to onion compared to a 1:1 cabbage to onion ratio.

Incidence of Aphids

The incidence of aphids was recorded for the first time during the 2nd standard meteorological week of *Rabi* 2021-22 (Table 4-5).

Table 2: Effects of different intercrops on the incidence pattern of *Plutella xylostella* in cabbage during *Rabi* 2021-22

Mean larval population of *P. xylostella*/Plant *																
Tr. No.	**Treatment**	**Pattern**	**51 SMW**	**52 SMW**	**1 SMW**	**2 SMW**	**3 SMW**	**4 SMW**	**5 SMW**	**6 SMW**	**7 SMW**	**8 SMW**	**9 SMW**	**10 SMW**	**11 SMW**	**Over all Mean**
T_1	**Cabbage + Onion**	**2:1**	0.53 (1.02)	0.80 (1.14)	0.63 (1.06)	0.57 (1.03)	0.70 (1.10)	1.17 (1.29)	2.10 (1.61)	4.27 (2.21)	6.93 (2.76)	9.77 (3.20)	6.80 (2.70)	3.60 (2.02)	2.57 (1.75)	3.13 (1.91)
T_2	**Cabbage + Onion**	**2:2**	0.43 (0.97)	0.60 (1.05)	0.57 (1.03)	0.47 (0.98)	0.63 (1.06)	1.07 (1.25)	1.97 (1.57)	4.13 (2.15)	6.77 (2.70)	9.50 (3.16)	6.60 (2.66)	3.93 (2.11)	2.33 (1.68)	2.98 (1.87)
T_3	**Cabbage + Radish**	**2:1**	0.67 (1.08)	0.93 (1.20)	0.93 (1.20)	0.90 (1.18)	1.10 (1.26)	1.53 (1.43)	2.77 (1.81)	4.77 (2.18)	7.43 (2.73)	10.40 (3.30)	7.33 (2.80)	4.20 (2.17)	2.87 (1.83)	3.53 (2.01)
T_4	**Cabbage + Radish**	**2:2**	0.60 (1.05)	0.87 (1.17)	0.73 (1.11)	0.70 (1.10)	0.80 (1.14)	1.23 (1.32)	2.40 (1.70)	4.40 (2.29)	7.13 (2.82)	10.13 (3.26)	7.1 (2.76)	4.03 (2.13)	2.63 (1.77)	3.29 (1.95)
T_5	**Cabbage + Coriander**	**2:1**	0.35 (0.92)	0.53 (1.02)	0.47 (0.98)	0.43 (0.97)	0.53 (1.02)	1.00 (1.22)	1.87 (1.54)	3.80 (2.07)	6.50 (2.65)	9.30 (3.13)	6.43 (2.63)	3.47 (1.99)	1.97 (1.57)	2.82 (1.82)
T_6	**Cabbage + Coriander**	**2:2**	0.17 (0.82)	0.37 (0.93)	0.33 (0.91)	0.33 (0.91)	0.50 (1.00)	0.80 (1.14)	1.63 (1.46)	3.53 (2.01)	6.27 (2.60)	9.00 (3.08)	6.13 (2.58)	3.00 (1.87)	1.67 (1.47)	2.59 (1.76)
T_7	**Cabbage Sole crop**	**-**	0.97 (1.21)	1.60 (1.45)	1.27 (1.33)	1.17 (1.29)	1.53 (1.43)	1.90 (1.55)	3.50 (2.00)	6.40 (2.63)	8.80 (3.05)	11.60 (3.48)	7.73 (2.87)	5.07 (2.36)	3.53 (2.01)	4.24 (2.18)
SE(m)±			**(0.07)**	**(0.08)**	**(0.07)**	**(0.06)**	**(0.06)**	**(0.08)**	**(0.05)**	**(0.04)**	**(0.03)**	**(0.04)**	**(0.04)**	**(0.06)**	**(0.07)**	**(0.06)**
C. D@5%			**(0.21)**	**(0.24)**	**(0.23)**	**(0.19)**	**(0.20)**	**(0.23)**	**(0.16)**	**(0.13)**	**(0.10)**	**(0.11)**	**(0.12)**	**(0.17)**	**(0.22)**	**(0.02)**

The figures in parentheses are $\sqrt{x+0.5}$ transformed values, NS= nonsignificant, SMW=standard meteorological week, and *mean of three replications.

Table 3: Effects of different intercrops on the incidence pattern of *Spodoptera litura* in cabbage during *Rabi* 2021-22

Mean larval population of *Spodoptera litura*/Plant*																
Tr. No.	**Treatments**	**Pattern**	**51 SMW**	**52 SMW**	**1 SMW**	**2 SMW**	**3 SMW**	**4 SMW**	**5 SMW**	**6 SMW**	**7 SMW**	**8 SMW**	**9 SMW**	**10 SMW**	**11 SMW**	**Over all Mean**
T_1	**Cabbage + Onion**	**2:1**	0.70 (1.10)	0.87 (1.17)	0.70 (1.10)	0.50 (1.00)	1.03 (1.24)	1.50 (1.41)	1.97 (1.57)	2.83 (1.83)	4.80 (2.30)	6.93 (2.73)	4.37 (2.21)	2.47 (1.72)	1.30 (1.34)	2.31 (1.67)
T_2	**Cabbage + Onion**	**2:2**	0.60 (1.05)	0.67 (1.08)	0.57 (1.03)	0.37 (0.93)	0.87 (1.17)	1.20 (1.30)	1.67 (1.47)	2.43 (1.71)	4.43 (2.22)	6.53 (2.65)	4.00 (2.12)	2.27 (1.66)	1.07 (1.25)	2.05 (1.60)
T_3	**Cabbage + Radish**	**2:1**	0.63 (1.06)	0.63 (1.06)	0.40 (0.95)	0.47 (0.98)	0.73 (1.11)	0.90 (1.18)	1.60 (1.45)	2.30 (1.67)	4.23 (2.18)	6.40 (2.63)	3.90 (2.10)	1.90 (1.55)	0.90 (1.18)	1.92 (1.56)
T_4	**Cabbage + Radish**	**2:2**	0.43 (0.97)	0.50 (1.00)	0.30 (0.89)	0.27 (0.88)	0.57 (1.03)	0.77 (1.13)	1.47 (1.40)	2.00 (1.58)	4.03 (2.13)	6.17 (2.52)	3.67 (2.04)	1.73 (1.49)	0.60 (1.05)	1.73 (1.49)
T_5	**Cabbage + Coriander**	**2:1**	0.33 (0.91)	0.43 (0.97)	0.27 (0.88)	0.23 (0.86)	0.47 (0.98)	0.57 (1.03)	1.17 (1.29)	1.77 (1.51)	3.83 (2.08)	5.90 (2.53)	3.50 (2.00)	1.57 (1.44)	0.47 (0.98)	1.58 (1.44)
T_6	**Cabbage + Coriander**	**2:2**	0.23 (0.86)	0.30 (0.89)	0.23 (0.86)	0.20 (0.84)	0.23 (0.86)	0.37 (0.93)	0.97 (1.21)	1.53 (1.43)	3.67 (2.04)	5.53 (2.46)	3.30 (1.95)	1.40 (1.38)	0.40 (0.95)	1.42 (1.38)
T_7	**Cabbage Sole crop**	**-**	0.83 (1.15)	1.10 (1.26)	0.80 (1.14)	1.33 (1.35)	1.20 (1.30)	1.50 (1.41)	2.30 (1.67)	4.50 (2.24)	5.40 (2.43)	7.50 (2.83)	5.17 (2.38)	3.23 (1.93)	1.93 (1.56)	2.83 (1.82)
SE(m)±			**(0.05)**	**(0.07)**	**(0.05)**	**(0.07)**	**(0.08)**	**(0.08)**	**(0.08)**	**(0.06)**	**(0.05)**	**(0.03)**	**(0.04)**	**(0.07)**	**(0.06)**	**(0.01)**
C. D@5%			**(0.17)**	**(0.21)**	**(0.14)**	**(0.22)**	**(0.26)**	**(0.24)**	**(0.25)**	**(0.20)**	**(0.16)**	**(0.10)**	**(0.12)**	**(0.23)**	**(0.18)**	**(0.05)**

The figures in parentheses are $\sqrt{x+0.5}$ transformed values, NS= nonsignificant, SMW=standard meteorological indicator, and *mean of three replications.

Table 4: Effects of different intercrops on the incidence pattern of aphids in cabbage during *Rabi* 2021-22

Mean larval population of Aphids/Plant*													
Tr. No	**Treatment**	**Pattern**	**2 SMW**	**3 SMW**	**4 SMW**	**5 SMW**	**6 SMW**	**7 SMW**	**8 SMW**	**9 SMW**	**10 SMW**	**11 SMW**	**Over all Mean**
T1	**Cabbage + Onion**	**2:1**	23.33 (4.88)	22.33 (4.78)	26.33 (5.18)	70.0 (8.40)	103.3 (10.19)	150.00 (12.27)	191.67 (13.86)	135.00 (11.64)	80.00 (8.97)	40.00 (6.36)	84.20 (9.20)
T2	**Cabbage + Onion**	**2:2**	20.00 (4.53)	18.00 (4.30)	21.67 (4.71)	53.3 (7.34)	80.0 (8.97)	123.33 (11.13)	156.67 (12.54)	110.00 (10.51)	60.00 (7.78)	31.67 (5.67)	67.47 (8.24)
T3	**Cabbage + Radish**	**2:1**	30.00 (5.52)	27.67 (5.31)	29.33 (5.46)	81.7 (9.06)	125.0 (11.20)	175.00 (13.25)	210.00 (14.51)	160.00 (12.67)	96.67 (9.86)	50.00 (7.11)	98.53 (9.95)
T4	**Cabbage + Radish**	**2:2**	25.00 (5.05)	20.67 (4.60)	24.00 (4.95)	60.0 (7.78)	93.3 (9.69)	131.67 (11.50)	173.33 (13.18)	123.33 (11.13)	70.00 (8.40)	36.67 (6.10)	75.80 (8.73)
T5	**Cabbage+Coriander**	**2:1**	16.67 (4.14)	15.00 (3.94)	18.00 (4.30)	45.0 (6.75)	73.3 (8.59)	103.33 (10.19)	160.00 (12.67)	98.33 (9.94)	37.67 (6.18)	20.00 (4.53)	58.73 (7.70)
T6	**Cabbage+Coriander**	**2:2**	15.00 (3.94)	11.67 (3.49)	15.00 (3.94)	36.7 (6.10)	68.3 (8.30)	86.67 (9.34)	140.00 (11.85)	81.67 (9.06)	25.00 (5.05)	13.33 (3.72)	49.33 (7.06)
T7	**Cabbage Sole crop**	**-**	36.67 (6.10)	40.00 (6.36)	45.00 (6.75)	81.7 (9.06)	160.0 (12.67)	230.00 (15.18)	246.67 (15.72)	190.00 (13.80)	116.67 (10.82)	61.67 (7.88)	120.83 (11.02)
SE(m)±			**(0.43)**	**(0.55)**	**(0.44)**	**(0.39)**	**(0.38)**	**(0.47)**	**(0.40)**	**(0.48)**	**(0.84)**	**(0.65)**	**(0.52)**
C. D@5%			**(1.32)**	**(1.71)**	**(1.36)**	**(1.20)**	**(1.18)**	**(1.44)**	**(1.24)**	**(1.47)**	**(2.60)**	**(2.01)**	**(0.17)**

The data in parentheses are $\sqrt{x+0.5}$ transformed values, NS= nonsignificant, SMW=standard meteorological week, and *mean of three replications.

Table 5: Effects of different intercrops on yield of cabbage and yield of intercrop in *Rabi* 2021-22

Tr. No.	Treatments	Pattern	Yield of Main Crop (q/ha)	Yield of Intercrop Crop (q/ha)
T_1	**Cabbage +Onion**	**2:1**	212.00	38.25
T_2	**Cabbage +Onion**	**2:2**	228.00	72.00
T_3	**Cabbage +Radish**	**2:1**	197.33	25.42
T_4	**Cabbage +Radish**	**2:2**	205.33	42.32
T_5	**Cabbage +Coriander**	**2:1**	233.33	1.83
T_6	**Cabbage +Coriander**	**2:2**	257.33	3.30
T_7	**Cabbage Sole crop**	**-**	184.67	-
	S. Em. ±		**3.95**	
	CD @ 5%		**12.18**	-

The highest incidence of aphids was recorded at the 8th standard meteorological week. During the cropping period, the incidence patterns of aphids associated with different intercrops during the whole cropping period were observed, and the minimum incidence of aphids recorded under the T_6-Cabbage + coriander (2:2) treatment was 15.00 aphids/plant, and the maximum incidence of aphids recorded under the intercrop T_3-Cabbage +Radish (2:1) treatment was 30.00 aphids/plant. The maximum incidence of aphids recorded under the T_7-Cabbage treatment was greater than that recorded for the sole cabbage crop (36.67 aphids/plant). These findings are also similar to those of Mahendran *et al*. (2016), who reported that the diversity created by introducing intercrops, viz., onion, radish and coriander, via two different patterns of planting was significantly lower than that achieved with the cauliflower monocrop. A number of polyphenolic compounds, such as quercetin, kaempferol, rhamnetin and epigenin, have also been found. Phytochemical screening indicated the presence of a number of active compounds, such as quercetin 3-glucuronide, linalool, camphor, geranyl acetate, geraniol, triterpenes and coumarins, which play major roles in the repellence of insect pests and in the prevention of insect pests in coriander. (Eguale *et al*., 2007).

Effects of different intercrops on yield of cabbage

The yield was found to be highest in T_6-Cabbage + Coriander 2:1 (257.33 q/ha main crop while intercropped 3.3q/ha), followed by T_5-Cabbage + Coriander 2:1 (233.33 q/ha main crop while intercropped 1.83 q/ha), T_2-Cabbage + Onion 2:2 (228 q/ha main crop while intercropped 72 q/ha), T_1-Cabbage + Onion 2:1 (212 q/ha main crop while intercropped 38.25 q/ha), T_4-Cabbage + Coriander 2:1 (205.33 q/ha main crop while intercropped 42.32 q/ha) and T_3-Cabbage + Radish 2:1 (197.33 q/ha main crop while intercropped 25.42 q/ha). All the treatments had superior yields than did the untreated control (184.67 q/ha) (Table 5 & Figure 5).

Conclusion

This study investigated the impact of different intercropping techniques on the incidence and yield of insect pests during cabbage cultivation. The results indicated that intercropping cabbage with specific companion plants, such as coriander, at ratios of 2:2 and 2:1 significantly reduced the incidence of pests such as *Plutella xylostella* and aphids compared to sole cabbage cultivation and other intercropping methods. Conversely, intercropping with radish plants (2:1) was associated with a greater pest incidence, especially in association with *Plutella xylostella*. Interestingly, intercropping with coriander resulted in higher yields than did the other methods, demonstrating the potential of intercropping not only to mitigate pest pressure but also to improve cabbage yield. These findings underscore the potential of intercropping, particularly with coriander, as an effective strategy for pest management and enhancing cabbage productivity in agricultural systems.

Acknowledgement
The authors are highly thankful to the Head, Department of Entomology, College of Agriculture, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) India for providing essential facilities and support during the experimentation.

Conflict of interest
The authors declare that they have no conflicts of interest.

References

Ahmed, S. & Stoll G. (1996). Bio Pesticides, Biotechnology building on farmers knowledge, 1, London, McMillan education Ltd.

Ali, H., Ansari, S.M., Ahmad, T. & Fakri, M.S.A. (2020). Effects of Intercropping on the incidence of diamondback moth, *Plutella xylostella* on cauliflower. *Journal of Entomology and Zoology Studies*, 8(5), 1110-1114.

Andow, D. (1991). Vegetational diversity and arthropod population response. *Annual Review of Entomology*, 36,561–86.

Anonymous (2004a). Companion Planting. http://www.ghorganics.com/page2.html (Accessed July 11, 2013).

Anonymous (2018). Area and Production share of Cabbage in India. National Horticulture Board, Ministry of agriculture, pp:1.

Ayalew, G. (2005). Comparison of yield loss on cabbage from diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) using two insecticides. *Crop Protection*, 25, 915-919.

Baidoo, P.K., Mochiah, M.B. & Apusiga, K. (2012). Onion as a pest control intercrop in organic cabbage (*Brasssica oleracea*) production system in Ghana. *Sustainable Agriculture Research*, 1(1), 36-41.

Chalfant, R.B., Denton, W.H., Schuster, D.J., & Workman, R.B. (1979). Management of cabbage caterpillars in Florida and Georgia by using visual damage thresholds. *Journal of Economic Entomology,* 72, 411-413.

Debra, K.R. & Misheck, D. (2014). Onion (*Allium cepa*) and garlic (*Allium sativum*) as pest control intercrops in cabbage based intercrop systems in Zimbabwe. *IOSR Journal of Agriculture and Veterinary Science*, 7(2), 13-17.

Devjani, P. & Singh, T.K. (1998). Ecological succession of aphids and their natural enemies on cauliflower in Manipur. *Journal of Epidemiology,* 12(1-2), 45-5 l.

Eguale, T., Tilahun, A.G., Debella, A., Feleke, A. & Makonnen, E. (2007). In vitro and in vivo anthelmintic activity of crude extracts of *Coriandrum sativum* against *Hemonchus contortus*. *Journal of Ethnopharmacology*, 110, 428-433.

FAO (2000). Regional vegetable IPM programme in South and South–east Asia: http://www.vegetableipmasia.org/CropsSites.html.

Fenning, K.O., MacCarthy, D.S. & Tegbe, R.E. (2014). Effect of intercropping and soil amendment on the population dynamics of major pests and natural enemies of white cabbage. *West African Journal of Applied Ecology,* 28(1), 2020: 96–112.

Grzywacz, D., Rossbach, A., Rauf, A., Russell, D.A., Srinivasan, R., & Shelton, AM. (2010). Current control methods for diamondback moth and other brassica insect pests and the prospects for improved management with lepidopteran-resistant Bt. vegetable brassicas in Asia and Africa. *Crop Protection,* 29(1), 68-79.

Hooks, C.R.R. & M.W. Johnson (2003). Impact of agricultural diversification on the insect community of cruciferous crops. *Crop Protection*, 22,223–238.

Kumar, L.B., Yogi, M.K. & Jagadish, J. (2013). Habitat manipulation for biological control of insect pest: A Review. *Research Journal of Agriculture and Forestry Sciences*, 1(10), 27-31.

Legwaila, M.M., Munthali, D.C., Kwerepe, B.C. & Motshwari, O. (2014). Effectiveness of cypermethrin against diamondback moth (*Plutella xylostella* L.) eggs and larvae on cabbage under Botswana conditions. *African Journal of Agricultural Research*, 9 (51), 3704- 3710.

Mahendran, B., Sharma, R.K. & Sinha, S.R. (2016). Strategies for Insect Management in Cauliflower (*Brassica oleraceae var. botrytis*) Through Habitat Intervention. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences,* 88, 305–311

Mane, P.D., Singh, B.B. & Singh, P.K. (2021). Effects of different insecticides on the management of diamond back moth (*Plutella xylosetlla* Linn.) on winter cabbage. *Journal of Entomology and Zoology Studies,*9(2),1426-1428.

Mochiah, M.B., Baidoo, P.K., & Owusu-Akyaw, M. (2011). Influence of different nutrient applications on insect populations and damage to cabbage. *Journal of Applied Biosciences,* 38, 2564-2572.

Müller, F.P. (1986). The role of subspecies in aphids for affairs of applied entomology. *Journal of Applied Entomology,* 101, 295–303.

Narode, M., Thakur, S., Magar, A., Nawale, J. & Aditya (2018). Impact of intercrop on infestation and severity of army worm (*Spodoptera exigua*) and diamondback moth (*Plutella xylostella*) on cabbage (*Brassica oleracea* L.) *Journal of Entomology and Zoology Studies*, 6(4), 1889-1891.

NHB (2018). National Horticulture Board, India. http: nhb.gov.in/vegetable/cabbage/pdf.

Obeng-Ofori, D., Yirenkyi-Danquah, E. & Ofosu-Anim, J. (2007). Cabbage and cauliflower, In K. Ofori (ed.), Vegetable and Spice Crop Production in West Africa. City Publishers Ltd, Accra, Ghana, pp: 119–122

Renwick, J.A.A. (1999). Phytochemical modification of taste: an insect modelit. In: H. C. Cutler and S. J. Cutler (eds.), .

Biologically Active Natural Products: Agrochemicals. CRC Press, Boca Raton, USA, pp.221-229.

Saikumar, N., Emmanuel, N., CH, Chinnabbai & Umakrishna K. (2021). Impact of IPM and non-IPM practices on population variations, incidence, infestation of major pests and their natural enemies in cabbage. *The Pharma Innovation Journal*, 10(10), 178-183.

Sarma, D., Saikia, D.K. & Devee, A. (2018). Effects of different intercrops and border crops on major insects and natural enemies of cabbage. *Journal of Entomology and Zoology Studies,* 6 (3), 763-765.

Shelton, A.M., Andaloro, J.T., & Bernard, J. (1982). Effects of cabbage looper, imported cabbage worm and diamondback moth on fresh market and processing cabbage. *Journal of Economic Entomology.*75, 742-745.