



E-ISSN: 2320-7078

P-ISSN: 2349-6800

[www.entomoljournal.com](http://www.entomoljournal.com)

JEZS 2020; 8(5): 1110-1114

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Received: 07-07-2020

Accepted: 09-08-2020

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## Effect of intercropping on the incidence of diamondback moth, *Plutella xylostella* (Linn.) on cauliflower

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**Abstract**

Effect of intercropping of cauliflower with tomato (*Lycopersicon esculentum*), radish (*Raphanus sativus*), carrot (*Daucus carota*), fennel (*Foeniculum vulgare*), coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), garlic (*Allium sativum*), berseem (*Trifolium alexandrinum*) and marigold (*Tagetes tagetta*) were studied on the infestation of *P. xylostella* during 2007 and 2008. The intercrops were sown 30-days earlier than sole crops and 40 days seedling of cauliflower were transplanted with spacing of 60x45 cm in a ratio of 15:1, 15:2, 25:1 and 25:2. 15:2 ratios was significantly more effective than 15:1 ratio and in the same manner 25:2 ratio of intercrop was more effective than 25:1. In sole crop the population of diamondback moth was found to be increasing from 15 to 75 DAT and then declined to 17.24 larvae and pupae/plant at 85 DAT. The fennel was more effective than other intercrops tested. 40-days old seedling holds less number of larvae and pupae of *P. xylostella* as compared to 30-days old seedling. Yield of cauliflower in different intercropping system was significantly varied and fennel gave a significantly ( $P < 0.05$ ) higher yield (246.25 Q/ha) as compared to other intercrop tested. Percent yield increase was highest (17.34%) on fennel cropping system and the lowest on marigold (7.84%). Additional return was highest (Rs. 23200) on fennel where it was grown in two lines with 15 rows of cauliflower and smallest on berseem (12556). The highest yield of cauliflower was recorded intercropping with fennel whereas 16.08 and 16.83 percent increase was obtained with 15:1 and 15:2 ration of cauliflower and fennel cropping system.

**Keywords:** Cauliflower, intercropping, *P. xylostella*, days after transplantation (DAT), line spacing, percent yield increase, additional return

**1. Introduction**

India is the largest producer of vegetables in the world after China with an annual production of 101.43 million tonnes from 6.76 million ha of land <sup>[10]</sup>. Cauliflower is most preferred winter vegetables and their total share in country's vegetable production is 6.1 and 4.4 percent, respectively <sup>[2]</sup>. The important insect pests associated with cauliflower are Diamondback moth (DBM), *Plutella xylostella* (Linn.) (Lepidoptera: Yponomeutidae) is a major and destructive insect pest of *Brassica* crops worldwide. Krishnakumar *et al.* (1984) have estimated a 52 percent loss in marketable cabbage due to DBM attack while Srinivasan (1984) reported 90-92 percent loss could occur if cauliflower is left unprotected and also vary from 30-100 percent <sup>[8]</sup>. Whereas it causes an annual loss of US \$ 16 million <sup>[9]</sup> and outbreaks of DBM in South East Asia some times have caused more than 90 percent losses <sup>[16, 17]</sup>. Although diamondback moth outbreaks are sporadic, it is always present during the growing season, 1997 and 1998 <sup>[13]</sup>, Shanghai, China in 1992 and 1994 where losses were estimated to be 99 percent and 80 percent respectively <sup>[19]</sup>, Kenya in 1995 <sup>[6]</sup>, Western Australia in 2001 and New South Wales in 2002 <sup>[4]</sup>. Use of intercropping provides an excellent opportunity as an ecological approach in pest management. Intercropping affects the pest by microclimate through changes in crop canopies <sup>[3, 18]</sup>. For some crop insects situation in cropping has reduced pest population because the plants act as a physical barrier to the movement of pest insect. Natural enemies are more abundant and or the chemical or visual communication between pest insect and their host plant is disrupted <sup>[11, 12]</sup>.

**2. Materials and Methods**

The experiment was conducted at the field Department of Plant Protection, Faculty of Agricultural sciences, A.M.U. Aligarh for two rabi seasons: 2007 and 2008.

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Nursery of cauliflower var. B. S.-16 was raised under protected condition on 1<sup>st</sup> September of 2007 and 2008 with a seed rate of 500 gm/ha. Before sowing the seed nursery bed was irrigated four days earlier so that soil will remain moist in order to provide enough moisture for germination of seed. Before sowing of intercrops standard agronomic practices were carried out for raising the commercial cauliflower crop. The intercrops; tomato (*Lycopersicon esculentum* Mill.), radish (*Raphanus sativus*), carrot (*Daucus carota* L.), fennel (*Foeniculum vulgare*), coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), garlic (*Allium sativum*), berseem (*Trifolium alexandrinum*) and marigold (*Tagetes tagetta*) were sown in a random block design on 1<sup>st</sup> September of 2007 and 2008. 30 days after sowing of intercrops, seedling of cauliflower (sole crop) was transplanted i.e. 1<sup>st</sup> October of 2007 and 2008 with spacing of 60x45cm 15:2, 25:1 and 25:2 and each treatment was replicated three times. A parallel control of cauliflower was also run for each treatment. The size of the micro plot for 60x55cm spacing was 9.6x3m, 10.2x3 m, 15.6x3m and 16.2x3m for 15:1, 15:2 and 25:1, 25:2 ratios. Each micro plot was consists of 5 plants/row with a total of 75 plants and 125 plants/micro plots with a spacing of 60x55 cm in 15:1, 15:2 and 25:1, 25:2, respectively.

Compost or FYM @ 200 q/ha was incorporated in soil and fertilizers; urea @ 300 kg/ha (138 kg of nitrogen), single super phosphate @ 300 kg/ha (48 kg of phosphorus) and murate of potash @100 kg/ha (60 kg of potassium) were applied. Half dose of urea and full doses of phosphorus and potassium were given at the time of transplanting as a basal dressing and remaining half of nitrogen used on two times; 25 percent of nitrogen was used at 20 days after plantation and remaining 25 percent at 30 DAT (days after transplantation). Light irrigation is required right after transplantation and then after every 10-15 days interval field was irrigated. Five plants were selected and tagged from each treatment and natural infestation of *P. xylostella* and its parasites was monitored at 10 days interval after transplanting to harvesting of cauliflower. Sick IV instar and pupae of *P. xylostella* as well as cocoons of parasites were brought to laboratory and kept for emergence of adults and then identified. Data was collected and analyzed statistically and cost benefit ratio was also calculated.

### 3. Results and Discussion

The effects of intercrops are significantly differed on the incidence of *P. xylostella* as well as lines of sole and

intercrops. 15:2 intercrop was significantly/non- significantly more effective than 15:1 ratio and in the same manner 25:2 ratio of intercrop was more effective than 25:1 ratio of intercrop. In a control treatment (only cauliflower) where the population of larvae and pupae of *P. xylostella* was found to be increasing from 15 to 75 DAT and then declined to 17.24 larvae and pupae/plant at 85 DAT (Table 1). Peak infestation i.e. 29.92 larvae and pupae/plant occurred at 75 DAT. 2 lines of fennel intercropped with 15 lines of cauliflower harboured less number of larvae and pupae of *P. xylostella* as compared to 15:1 ratio and both of them are significantly ( $P<0.05$ ) differed in the rate of infestation of *P. xylostella*. Therefore, fennel intercropping was more effective than that of other intercrops tested. It was followed by coriander, cumin, garlic, carrot, marigold, radish, tomato and berseem. The performance was coriander, cumin and garlic was also found effective in reducing the population of *P. xylostella*. Infestation of larvae and pupae of *P. xylostella* was more on 25:1 ratio of sole and intercrops as compared to 25:2 as well as 15:1 and 15:2 rows of sole and intercrops. Two lines of fennel intercropped with 25 lines of cauliflower hold less number of larvae and pupae of *P. xylostella* as compared 25:1 line of fennel and growing 2 lines fennel was significantly differed to that of one line of fennel. Peak population of *P. xylostella* was obtained at 75 DAT where larvae and pupae reached to 28.44 on cauliflower alone (control). Coriander, cumin, garlic and marigold intercrops were not significantly differed and almost same in reducing the infestation of *P. xylostella*.

The result (Table 1) showed that extending of date of planting of cauliflower by 10-days means 40-days old seedling holds less number of larvae and pupae of *P. xylostella* as compared to 30-days old seedling. 15:2 ratios of sole and intercrop was significantly /non-significantly more effective than 15:1 ratio and in the same method 25:2 ratio was more effective than 25:1. Growing two lines of intercrop along with cauliflower was significantly ( $P<0.05$ ) different to that of one line of intercrop. Fennel has significantly deterred the colonization of *P. xylostella* more than the other treatments. Fractional difference in the density of *P. xylostella* was achieved when coriander, cumin, garlic was intercropped with cauliflower and offered a significant reduction in the larvae and pupae of *P. xylostella*. While, tomato intercrop was also more effective than that of radish, carrot and berseem but marigold gave a significant result.

**Table 1:** Cost-benefit ratio of intercropping on the infestation of *P. xylostella* on cauliflower (30-days old seedling) 2007-08 and 2008-09

Intercrop	Ratio	Average no. of DBM population	Yield of cauliflower (Q/ha)	Percent increase yield	Return from cauliflower (Rs/ha)	Yield of intercrop (Q/ha)	Return from intercrop (Rs/ha)	Gross return (Rs/ha)	Additional return over sole crop (Rs/ha)
Tomato	15:1	8.79	236	12.04	100305.75	11.83	5816.67	106220.75	16676.75
	15:2	8.05	236.81	12.42	100650.5	14.67	7353.33	107985.5	18441.5
Radish	15:1	9.11	234.64	11.39	99735	0.28	5533.33	105335	15791
	15:2	8.09	235.69	11.89	100181.5	0.36	7333.33	107381.5	14837.5
Carrot	15:1	8.54	226.79	7.66	96394.5	0.15	5720	102244.5	12700.5
	15:2	7.67	227.91	8.19	96870	0.21	7930	104865	15321
Fennel	15:1	7.2	246.1	16.84	104603.25	0.37	6540	111173.25	21629.25
	15:2	6.08	246.76	17.15	104888	0.5	8820	113798	24254
Coriander	15:1	7.91	241.12	14.47	102478.25	0.39	5413.33	107868.25	18324
	15:2	6.99	242.69	15.21	103134	0.47	6533.33	109714	20170
Cumin	15:1	7.92	239.78	13.83	101922	0.31	6593.33	108587	19043
	15:2	7.02	241.49	14.64	102636.5	0.37	8026.67	110591.5	21047.5
Garlic	15:1	8.18	234.83	11.48	99814	4.99	4476	104300.5	14756.5
	15:2	7.22	236.15	12.11	100380.5	6.9	6204	106590.5	17046.5

Berseem	15:1	8.19	225.68	7.14	95901.5	0.25	4933.33	100901.5	11357.5
	15:2	7.35	226.74	7.64	96352	0.29	5666.67	102052	12508
Marigold	15:1	8.49	224.22	6.45	95285	0.11	6666.67	102160	12616
	15:2	7.49	225.98	7.28	96033	0.15	8958.33	105095.5	15551.5
Cauliflower (Control)		20.13	210.64		89544				
LSD $P=0.05$		0.66	2.29						

Values not followed by same letter are significantly different ( $P=0.05$ ) by DMRT

The result (Table 2) showed that yield of cauliflower in different intercropping system was significantly/non-significantly varied and fennel gave a significantly ( $P<0.05$ ) higher yield as compared to other intercrop tested. There was a marginal difference in the yield of 2 lines of intercrops as compared to one line. Percent yield increase was highest (17.34%) on fennel cropping system and the lowest on marigold. Coriander and cumin also gave higher percent increase of yield as compared to radish and carrot. Percent yield increase in tomato cropping system was higher as compared to berseem. Additional return was highest (Rs.

23200/-) on fennel where it was grown in two lines with 15 rows of cauliflower and smallest on berseem. When 25 lines of cauliflower grown along with one or two lines of intercrop showed that there was a decrease in yield ratio as compared to 30-days old seedling. Fennel has provided highest yield of cauliflower as compared to other plants tested and minimum yield was obtained in marigold cropping system. Percent yield increase was highest in fennel cropping system and smallest in marigold. Coriander, cumin, garlic and tomato also gave satisfactory increase in yield as compared to berseem and carrot.

**Table 2:** Cost-benefit ratio of intercropping on the infestation of *P. xylostella* on cauliflower (30-days old seedling) 2007-08 and 2008-09

Intercrop	Ratio	Average no. of DBM population	Yield of cauliflower (Q/ha)	Percent increase yield	Return from cauliflower (Rs/ha)	Yield of intercrop (Q/ha)	Return from intercrop (Rs/ha)	Gross return (Rs/ha)	Additional return over sole crop (Rs/ha)
Tomato	25:1	9.71	233.13	9.8	99089.25	7.35	3675	102765.25	12448
	25:2	8.64	233.67	10.04	99322.5	9.37	4685	104007.5	13714.83
Radish	25:1	9.49	234.63	10.5	99730.5	0.18	3500	103230.5	12821.5
	25:2	8.55	235.85	11.08	100253.25	0.31	6100	106353.25	15855.33
Carrot	25:1	9.3	229.01	7.85	97348.5	0.06	2730	100078.5	9842.83
	25:2	8.4	229.66	8.15	97617.5	0.14	5265	102882.5	12357.5
Fennel	25:1	7.49	243.76	14.8	103612.5	0.28	4950	108562.5	18082.83
	25:2	6.62	245.88	15.79	104510.25	0.35	6210	110720.25	20241.33
Coriander	25:1	8.61	238.92	12.52	101557.5	0.32	4410	105967.5	15464.83
	25:2	7.55	241.06	13.52	102463	0.36	4970	107433	16981.83
Cumin	25:1	8.48	236.83	11.53	100667.5	0.23	4945	105612.5	15135.5
	25:2	7.57	238.17	12.16	101235	0.34	7310	108545	17996.5
Garlic	25:1	8.79	237.37	11.78	100896	3.02	2713.5	103609.5	13194.83
	25:2	8.03	238.34	12.25	101326.5	4.17	3753	105079.5	14572.83
Berseem	25:1	9.04	225.26	6.09	95721	0.16	3200	98921	8711.17
	25:2	7.91	227.83	7.29	96839.5	0.21	4100	100939.5	10604.83
Marigold	25:1	9.67	226.14	6.5	96126.5	0.08	5000	152161	10499.17
	25:2	8.29	227.39	7.09	96652.5	0.1	6250	102902.5	12384.5
Cauliflower (Control)		19.09	112.34		90274.25				
LSD $P=0.05$		0.78	2.21						

Values not followed by same letter are significantly different ( $P=0.05$ ) by DMRT

Additional return from 25:1 and 25:2 was found to be less as compared to 15:1 and 15:2 ratio of sole and intercrops. Fennel cropping system offered an additional return of Rs. 17, 672/- and 19, 832/- in 25:1 and 25:2 ratio of sole and intercrop respectively and smallest return by berseem cropping system. While, tomato cropping system has provided an amount of Rs. 12, 362/- and 13, 678/- in a ratio of 25:1 and 25:2, respectively.

Analyzed result (Table 2) showed that when 40-days old seedling of cauliflower used in different intercrops offered a significantly/non-significantly increase in yield of cauliflower as compared to control. Lines of intercrops are also significantly/non-significantly variable. Highest yield of cauliflower i.e. 241.62 and 243.18 Q/ha was obtained in 15:1 and 15:2 ratios of sole and fennel, respectively and the smallest in berseem cropping system. However, cauliflower + tomato cropping system also gave satisfactory increase in yield of cauliflower i.e. 236.74 and 239.45 Q/ha in 15:1 and 15:2 respectively. Moreover, highest percent increase yield of cauliflower was found in fennel cropping system where 16.08

and 16.83 percent increase was obtained with 15:1 and 15:2 ratio of cauliflower and fennel cropping system, respectively followed by cumin and tomato. It was minimum on berseem where 6.14 and 6.59 percent increase in yield of cauliflower was registered with 15:1 and 15:2 ratios, respectively. When additional return was calculated, it was found that fennel cropping system has provided highest return followed by cumin and tomato. However, coriander, radish and carrot also gave satisfactory additional return as compared to marigold and berseem. Results (Table 3) of 25:1 and 25:2 showed that yield of cauliflower are increased significantly as compared to untreated control. Results of 15:1 and 15:2 are almost similar to that of 25:1 and 25:2 but with slight difference.

Intercrops have significantly ( $P<0.05$ ) affected the infestation of *P. xylostella* during the two cropping seasons of 2007-08 and 2008-09. Fennel intercrop was found to be considerably more effective against *P. xylostella* than that of other intercrops tested, where the yield and net return was significantly greater than the cauliflower (only) as well as other intercrops. Fennel intercropping was highest effective in

reducing the population *P. xylostella* in the present study. Although similar result was obtained mustard + fennel offered a significantly lower *L. erysimi* population in comparison to other combination [1]. It was confirmed by Singh and Kothari (1997) that allelochemicals released by the fennel may deter the colonization of aphid as well as phenotypic characteristics

of fennel inflorescence result in natural cover across the inflorescence of mustard canopy. This arrangement may have reduced the increase in aphid population because it created an effective allelochemical barrier film that may have acted as an alarm pheromone, similar to that reported for aphids in wild potato, *Solanum berthaultii* [5].

**Table 3:** Cost-benefit ratio of intercropping on the infestation of *P. xylostella* on cauliflower (40-days old seedling) 2007-08 and 2008-09

Intercrop	Ratio	Average no. of DBM population	Yield of cauliflower (Q/ha)	Percent increase yield	Return from cauliflower (Rs/ha)	Yield of intercrop (Q/ha)	Return from intercrop (Rs/ha)	Gross return (Rs/ha)	Additional return over sole crop (Rs/ha)
Tomato	15:1	7.27	236.94	13.17	100704.5	11.84	5850	106624.5	17607
	15:2	6.67	240	14.63	102016	15.92	7850	109973.5	20956
Radish	15:1	7.49	230.9	10.28	98143.25	0.37	7333.33	105543.25	16525.75
	15:2	6.52	231.75	10.69	98508.5	0.45	8866.67	107408.5	18391
Carrot	15:1	7.44	225.43	7.67	95835.25	0.19	7150	103050.25	14032.75
	15:2	6.31	227.03	8.43	96500	0.25	9620	106250	17232.5
Fennel	15:1	6.03	241.94	15.55	102832.5	0.39	6900	109762.5	20745
	15:2	5.12	243.66	16.37	103567.5	0.47	8400	112027.5	23010
Coriander	15:1	6.39	236.77	13.08	100643.5	0.45	6253.33	106943.5	17926
	15:2	5.43	237.85	13.6	101100.75	0.56	7746.67	108940.75	19923.25
Cumin	15:1	6.46	238.7	14.01	101459	0.34	7238.33	108769	19751.5
	15:2	5.53	240.74	14.98	102367.5	0.44	9245	111720	22702.5
Garlic	15:1	6.43	231.46	10.55	98397.25	5.35	4818	103212	14194.5
	15:2	5.69	232.71	11.15	98922.5	7.47	6828	105645.5	16628
Berseem	15:1	7.29	221.45	5.76	94129	0.29	5733.33	99929	10911.5
	15:2	6.45	221.69	5.88	94214	0.37	7333.33	101614	12596.5
Marigold	15:1	7.77	224.15	7.06	95278.25	0.14	8125	103715.75	14698.25
	15:2	6.62	225.24	7.58	95744	0.15	9166.67	105119	16101.5
Cauliflower (Control)		18.49	209.38		89017.5				
LSD P=0.05		0.55	2.35						

Values not followed by same letter are significantly different (P=0.05) by DMRT

**Table 4:** Cost-benefit ratio of intercropping on the infestation of *P. xylostella* on cauliflower (40-days old seedling) 2007-08 and 2008-09

Intercrop	Ratio	Average no. of DBM population	Yield of cauliflower (Q/ha)	Percent increase yield	Return from cauliflower (Rs/ha)	Yield of intercrop (Q/ha)	Return from intercrop (Rs/ha)	Gross return (Rs/ha)	Additional return over sole crop (Rs/ha)
Tomato	25:1	8.21	234.63	11.82	99732.75	7.85	3925	103657.75	16612.75
	25:2	7.51	237.04	12.73	100757	10.07	5035	105792	18747
Radish	25:1	8.51	236.1	12.04	100358.25	0.26	5200	105558.25	18513.25
	25:2	7.52	238.83	12.87	101513	0.34	6800	108313	21268
Carrot	25:1	8.48	232.14	9.42	98669.25	0.14	5265	103934.25	16889.25
	25:2	7.38	235.03	10.32	99904.5	0.17	6630	106534.5	19489.5
Fennel	25:1	6.65	243.04	15.61	103311.5	0.35	6300	109611.5	22566.5
	25:2	5.68	244.19	16.41	103789.5	0.44	7830	111619.5	24574.5
Coriander	25:1	7.32	238.39	13.86	101327.5	0.34	4760	106087.5	19042.5
	25:2	6.36	239.55	14.19	101808.5	0.41	5740	107548.5	20503.5
Cumin	25:1	7.44	236.96	13.18	100721	0.28	5912.5	106633.5	19588.5
	25:2	6.4	238.16	13.76	101245.5	0.35	7525	108770.5	21725.5
Garlic	25:1	7.02	241.7	13.27	102744	4.15	3735	106479	19434
	25:2	6.08	243.23	14.01	103400.25	5.5	4950	108350.25	21305.25
Berseem	25:1	8.39	229.31	8.06	97479.75	0.21	4200	101679.75	14634.75
	25:2	7.18	232.63	9.17	98893	0.27	5300	104193	17148
Marigold	25:1	8.7	228.06	7.22	96936	0.12	7500	104436	17391
	25:2	7.6	230.71	8.25	98065.5	0.15	9375	107440.5	20395.5
Cauliflower (Control)		17.65	204.48		87045				
LSD P=0.05		0.7	2.25						

Values not followed by same letter are significantly different (P=0.05) by DMRT

#### 4. Conclusion

The effect of intercropping for the management diamondback moth, *P. xylostella* was studied with cauliflower intercrop with tomato, radish, carrot, fennel, coriander, cumin, garlic, berseem and marigold. The intercrops were sown 30-days earlier than sole crops transplanted with spacing of 60x45 cm in a ratio of 15:1, 15:2, 25:1 and 25:2. 15:2 ratios was

significantly more effective than 15:1 ratio and in the same manner 25:2 ratio of intercrop was more effective than 25:1 ratio. The population of diamondback moth was found to be increasing from 15 to 75 DAT and then declined to 17.24 larvae and pupae/plant at 85 DAT. The fennel was more effective than other intercrops tested. 40-days old seedling holds less number of larvae and pupae of *P. xylostella* were



recorded in compare to 30-days old seedling. Yield of cauliflower in different intercropping system was significantly varied and fennel gave a significantly ( $P<0.05$ ) higher yield (246.25 Q/ha) as compared to other intercrops t. % yield was highest (17.34%) on fennel cropping system and the lowest on marigold (7.84%). Additional return was highest on fennel where it was grown in two lines with 15 rows of cauliflower and smallest on berseem. The highest yield of cauliflower was recorded intercropping with fennel whereas 16.08 and 16.83 percent increase was obtained with 15:1 and 15:2 ratio of cauliflower.

### 5. Acknowledgement

The authors are thankful to CSTUP for giving funds under the research project (CST/AAS/D-810) for this experiment and also thankful to the Chairman of Department of Plant Protection, Aligarh Muslim University Aligarh for providing necessary and basic facilities.

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