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Impact of intercrop on infestation and severity of army worm (*Spodoptera exigua*) and diamondback moth (*Plutella xylostella*) on cabbage (*Brassica oleracea* L.)

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Abstract
The research project was undertaken at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India during *Rabi* 2017-18. The experiment was conducted in a Randomized Block Design with seven treatments; (T^1) cabbage + marigold, (T^2) cabbage + mustard, (T^3) cabbage + cowpea, (T^4) cabbage + onion, (T^5) cabbage + tomato, (T^6) cabbage + garlic and (T^7) cabbage sole each of which was three replications. The treatment T^6 least damage of army worm (*Spodoptera exigua*) (0.56) and the followed by T^4 (0.58), T^5 (0.96), T^3 (0.86), T^2 (1.36), T^1 (4.43) and highest in T^7 4.43. DBM (*Plutella xylostella*) infestation the treatment T^6 showed least damage of DBM (0.38) and followed by T^2 (0.56), T^3 (0.65), T^4 (0.75), T^5 (0.84), T^1 (4.42) and highest in T^7 (4.42). The maximum yield in T^6 3:2 (16708) and followed treatment in order of efficacy was T^5 3:2 (16333), T^7 3 (15318), T^1 3:2 (15017), T^4 3:2 (14440.30), T^2 3:2 (13140), and T^3 3:2 (11167.38) cabbage equivalent yield (kg/ha).

Keywords: Cabbage, intercrop, *Plutella xylostella*, Sole crop, *Spodoptera exigua*, yield

1. Introduction
The cabbage, *Brassica oleracea* L. *var. capitate* is one of the most popular and economically important cruciferous vegetables extensively grown all over the country. The word cabbage is derived from the French word 'Coboche', meaning head. It may be referred as cabbage, Shetland cabbage, Savoy cabbage, white cabbage or red cabbage and is believed to have originated from a wild cabbage ancestor in ancient Asia Minor. It is cultivated on area of 0.245 m ha with the total production of 5.617 MT and average productivity of 22.9 MT/ha [1]. The state of Maharashtra produces 5 per cent of the total production of cabbage in the country. The production of cabbage in the state is 0.36 m MT from an area of 0.02 m ha and having productivity of 20 MT/ha, which is the fourth highest in the country [2]. Like most of the other vegetables, cabbage is also very vulnerable to the attack of several pests [5]. Listed 42 insects causing economic injury to cruciferous crops in various parts of the world. With the above limitations of chemical control in pests of cabbage along with the environmental pollution and the development of resistance in insect pests, the idea of intercrops, muted in early years, became imperative to explore [12]. estimated 52 per cent loss in marketable yield of cabbage due to the attack of *P. xyllostella* Linn. alone. The short life cycle and abundance of food coupled with greater spreading ability have aggravated the pest problem during recent days. However, all crucifers being cash crops are grown under the pesticide umbrella by most farmers. Such alternatives incorporate simplicity of application and effectiveness against the pest. The method is also economical and sustainable for the farmer and sustainable perspective. Intercropping of cabbage with other crops could be an effective method of managing pests in cabbage. Some plant species are reported to either repel or make host finding difficult for the pests when intercropped with cabbage [20]. Tomato used as intercrop, is said to emit volatile compounds from its leaves, and repel the adult DBM from laying eggs on cabbage [17]. Similarly, the aromatic scent of Alliums has been reported to repel DBM [19, 14].

2. Materials and Methods

Studies in Allahabad region under field condition was be carried out at the Central field, SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), Allahabad, Uttar Pradesh, India during *Rabi* season 2017-18. The seeds of Cabbage variety **"**Golden Acer**"** was be to raise seedling in nursery. Chemical fertilizers were applied @ NPK 50:25:25 kg/ha and 20 tons FYM per hectare. Full dose of P, K, 33.3% N and FYM was be applied as basal application before sowing the seed and rest of the nitrogen was top dressed in two equal splits at 21 and 41 days after Transplanting. Five plants of cabbage intercrops per plot were selected randomly to record the observations on the incidence of the cabbage pests. The observations of the DBM *Plutella xylostella* as number of larvae + pupae on head of cabbage and top, middle and bottom leaves of intercrops were recorded. The shot holes made by the army worm *Spodoptera exigua* were counted from the head of cabbage. The observations were recorded at weekly interval till the harvesting of main crop. The cabbage crop was harvested after full head formation and yield per plot was recorded. Similarly, the yield of inter crops grown in the experiment were also recorded.

Since the sale price of the component crops viz, marigold, onion, tomato, Garlic, mustard and cowpea are different, for proper evaluation of the treatments, it was necessary that the produce of the component crop is expressed in terms of main crop. For this, the yield of the intercrops was converted into cabbage head equivalent yield based on the prevailing selling prices of the commodity by using following formula:

Cabbage head equivalent = Yield (kg/ ha)

Main crop Income = Actual yield of main crop (kg/ha) X Sale Price of main crop

Intercrop Income = Actual yield of Intercrop (kg/ha) X Sale Price of Component crop

Layout of One Plot

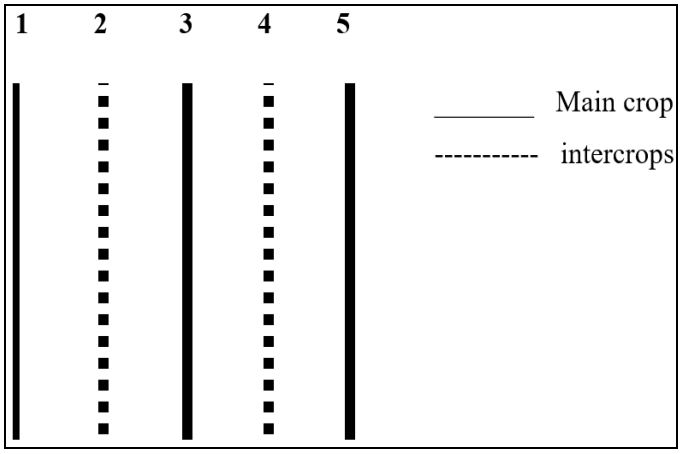

Fig 1: Layout of one plot

3. Results and Discussion

The data presented on incidence of army worm, and DBM in different weeks revealed that the infestation of army worm and DBM in different treatments of inter crops *viz.*, cabbage + marigold (3:2), cabbage + onion (3:2), cabbage + garlic (3:2), cabbage + tomato (3:2), cabbage + cowpea (3:2), cabbage + mustard (3:2) and sole cabbage was in the range of army worm in 1.10 to 4.06. Also DBM range in 0.90 to 4.42. The infestation was more in week 3 and less in week 1.

Tr. no	Treatment	No. of shot holes by army worm per leaf					No. of Larvae + Pupae per plant by Diamond back moth				
		First week	Second week	Third week	Fourth week	Fifth week	First week	Second week	Third week	Fourth week	Fifth week
T1	Cabbage + Marigold	1.10	2.34	3.34	3.64	4.43	0.89	1.29	2.29	3.4	4.4
T2	Cabbage + Mustard	1.09	2.34	3.34	3.30	4.43	0.36	0.40	1.33	1.28	0.56
T3	Cabbage + Cowpea	0.46	1.46	2.46	2.06	1.36	0.40	0.66	1.38	1.29	0.65
T4	Cabbage + Onion	0.37	0.74	1.41	0.99	0.58	0.56	0.80	1.46	1.50	0.75
T5	Cabbage + Tomato	0.44	0.75	1.74	1.21	0.96	0.63	1.13	2.06	2.04	0.84
T6	Cabbage + Garlic	0.33	0.59	1.19	0.73	0.56	0.20	0.38	0.80	0.71	0.38
T7	Sole Cabbage	1.10	2.34	3.34	3.64	4.06	0.90	1.29	2.63	3.42	4.42
	Overall mean	0.69	1.50	2.40	2.22	2.34	0.56	0.85	1.70	1.66	1.69
	F- Test	S	S	S	S	S	S	S	S	S	S
	CD 5%	0.37	0.50	0.72	0.73	0.84	0.34	0.55	0.90	1.30	0.79

The effect of various treatments was significant during 1st, 2nd 3rd and 4th week and the incidence was in the range of 0.33 to 1.10, 0.59 to 2.34, 1.19 to 3.34 and 0.73 to 3.64 respectively. Army worm infestation in fifth week of observation was in the range of 0.56 to 4.43 shot holes per leaf. The treatment garlic crop showed least damage of army worm (0.56) and the same treatment was significantly superior over rest of the treatments except onion, tomato cowpea, mustard and marigold as intercrop which recorded 0.58, 0.96, 0.86, 1.36, 4.43 and sole cabbage in the range of 4.43 shot hole per leaf respectively and all these treatments were at par with each other. Further the effect of treatments on army worm infestation in 4thand 5thweek was observed to be significant with cabbage head infestation and ranging from 0.73 to 3.64 to 2.53and 0.56 to 4.43 respectively.

The effect of various treatments was significant during 1st, 2nd 3rd and 4th week and the incidence was in the range of 0.20 to 0.89, 0.38 to 29, 0.80 to 2.29 and 0.71 to 3.42 respectively. DBM infestation in fifth week of observation was in the range of 0.38 to 4.42 Larvae + Pupae par plot. The treatment garlic crop showed least damage of DBM (0.38) and the same treatment was significantly superior over rest of the treatments except mustard, cowpea, onion, tomato and marigold as intercrop which recorded 0.56, 0.65, 0.75, 0.84, 4.42 and sole cabbage in the range of 4.42. Larvae + Pupae per plot respectively and all these treatments were at par with each other. Further the effect of treatments on DBM infestation in 4thand 5thweek was observed to be significant with cabbage head infestation and ranging from 0.71 to 3.42 and 0.38 to 4.42 respectively.

Table 1: Cabbage equivalent yield in the different treatments of intercrops.

Tr. No.	Treatments	Cabbage equivalent weight (kg/ha)			
		R1	R2	R3	Mean
T1	Marigold	15000	15110	15211	15107
T2	Mustard	13120	13100	13200	13140
T3	Cowpea	11100	11143	11200	11147.67
T4	Onion	14398	14480	14443	14440.33
T5	Tomato	16337	16452	16210	16333
T6	Garlic	16400	16590	16320	16708
T7	Sole cabbage	14987	15477	15490	15318

The maximum of 16708 cabbage equivalent yields was obtained from the treatment garlic as an intercrop at 3:2 ratios which was significantly superior over rest of the treatments except the treatment garlic as intercrop which recorded 16708 cabbage equivalent yield and both the treatments were at par with each other. The next best treatment in order of efficacy was garlic as intercrop at 4:1 which recorded 16333 cabbage equivalent yields (kg/ha).

4. Discussion

The present findings are more or less in conformity with the studies carried out by the earlier workers. Simmonds *et al.* (1992) reported that *Allium spp*. are very effective anti-feedants and have strong pungent repelling action. Garlic *A. sativum* and onion *A. cepa* have been found to contain highly volatile compounds that are extracted by water as it transpires from the crop plants. The resultant mixture of these compounds produces the characteristic pungent smell that is known of garlic and onion. The study produced somewhat inconsistent results with respect to the effects of the garlic and tomato on DBM populations. During the early growth stages of the cabbage (3rd and 4th weeks from transplanting), garlic, cowpea and tomato appeared to lower incidence. However, this phenomenon did not continue thereafter. Subsequent weeks of sampling were characterized by low DBM densities in all the cropping cultures. Cabbage monocrop recorded higher DBM incidence than garlic, cowpea, mustard and tomato in the 3rd and 4th weeks. In this way, previous finding has been confirmed [19]. Present results in which leek recorded some suppressing ability on DBM, appear to be at variance with other finding, in which no such indication was observed [19]. Even if mean DBM incidence per cabbage plant were generally low during the study period, relatively high leaf damage was recorded in all the treatments. Lower economic thresholds such as 0.1 DBM immatures/plant or 0.5 larvae/plant as suggested by [10, 15] may thus, need to be observed.

5. Conclusion

From the present study it can be concluded that for the management of army worm (*Spodoptera exigua)* and diamondback moth *(Plutella xylostella),* the inter cropping with garlic was found best and may be used. The intercropping with cowpea, tomato and onion trapped maximum number of DBM and these crops are suitable for management of DBM on cabbage. Whereas the cabbage equivalent yield is concerned the tomato intercrop at 3:2 crop and garlic intercrop at 3:2 was found to be profitable for the farmers.

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