"Effect of Trap Cropping of *Brassica juncea* (Linn.) on the Management of *Lipaphiserysimi* (Kalt.) on *B. oleracea var. capitata* (Linn.)"

Abstract

Indian mustard cv. Laha 101was used as a trap cropto manage the mustard aphid, *Lipaphis erysimi*(Kalt.) on cabbage cv. K-1 during the rabi season 2022-23. Trap cropping ratios showed significantly lower aphid densities compared to sole crop (cabbage). The lowest density of aphids (4.60 aphid/plant) was recorded in cabbage under trap cropping ratio (3:2)andpeakinfestation occurred (19.05 aphid/plant)on mustard of the same trap cropping ratio when compared with other trap cropping ratioson 7th SMW (February 11th). Even with highest (28.13 aphid/plant) on the sole crop (cabbage) which yielded (49.23 t/ha), with a benefit cost ratio (2.07) due to two sprays of insecticide (Malathion 50 EC), which was not done in the trap cropping ratios. Thus, trap cropping ratio (3:2) (2.31) has the best cost benefit ratio followed by the trap cropping ratio (1:1) (2.19) having second best cost benefit ratio, withrecorded produce of (42.61 t/ha), (41.29 t/ha) respectively.

Keywords: Mustardaphid *Lipaphis erysimi* (Kalt.), trap crop,sole crop,*Brassica*, density,benefit Cost Ratio

INTRODUCTION

Themustardaphid,*Lipaphiserysimi*(Kalt.)(Homoptera:Aphididae)hasemerged as a prominent pest of *Brassica* species in India (Yue and Liu, 2000). They have evolved to consume phloem saprather than macerate plant tissue as chewing herbivores. Short generation durations and highasexual fertility cause a sharp rise in aphid population density (Gill*etal.,*2013).They feed by sucking sap from its host and cause damage,ranging from 50 to 100% (Andeka *et al.,* 2021). Indirect losses include sooty mold formation on honeydew secretions and transmission of plant viruses as a vector (Blackman and Eastop, 2000; Ng and Perry, 2004).

Development of insecticide resistance, and of thestimulatory effects of sublethal dosages of some insecticides on aphid reproduction (Arora 1999) along with thedetection of high residues of insecticides in plant producehave exposed the limit ofexclusive reliance on a broad spectrum synthetic organic insecticides for controlling this nefariousinsect (Dhaliwal and Ramesh 2001). Therefore, considering only chemical management is not an ecologically, and financially sound option.

Isolation of certain kinds of insects from the group by the trap cropping, which enables the use of biological control, selective pesticide application, a decrease in the use of

treatments such as insecticides and others without affecting each other. (Hokkanen1991). Indianmustardis usedastrapcropfor diamondback moth in cabbage fields(SrinivasanandMoorthy1991, Ansari *et al.,*2010). Indian mustard is used as a trap crop in cabbage fields in Guam for the control of mustard aphids (Muniappan and Maruthi 1992;Muniappan*et al.,* 1997).Indianmustard isattractivetodiamondbackmothsand used asatrapcrop for cabbage(CharlestonandKfir 2000).

For the benefit of resource-constrained farmers, particularly in developing nations, theprofitability of any agricultural production methods should be carefully viewed. Furthermore,sustainable crop production with low-cost along with ecologically safe technology must also be taken into consideration.

In this study, we assessed the advantages of Indian mustard as a trap crop on cabbagefor the management of aphid.

MATERIALAND METHODS

Field experimentswereconducted to manage the *L. erysimi* on cabbage crop when trap cropped with Indian mustard in the Department of Plant Protection, Aligarh Muslim University, Aligarh during*rabi* seasonof 2022-2023.

Agronomical practices

Seed of cabbage cv. K-1 (150 grams) was used for growing in the nursery bed. Raised beds measuring 3 x 0.6 m with a height of10-15 cm was prepared and the seed was broadcasted on 7th November 2022. Intercultural practices were performed: FYM well-decomposed @ 35g/m, sprinkler was used,weeding was done time to time asand when requiredand 70cmspacewasmaintainedbetweentwobeds.Thesurface of the beds was maintained in smooth and levelled manner. Raised bed was maintained to minimize water logging. It was drenched with Bavistin (15-20g) to prevent the seedling mortalityowingto damping off.

The field measuring 234 m^2 area was prepared by ploughing followed by levelling. 6 weeks-old seedlings of cabbage cv. K-1 were transplanted withspacing of 30 X 30 cm in 18 plots on 15th December 2022, along with a single crop (cabbage) with same spacing between rows and between plants in a randomized block designed (RBD) plots.Being scanty winter rainfallseason habitants, immediate irrigation was followed right aftertransplantation. A week later i.e., 22nd December, booster dose (N- 4.68, P-2.92, k-3.51kgs) was given for better growth and

immediate irrigation was given for better uptake ofnutrients.

After a week i.e., on 31st December 2023 Indian mustard cv. Laha 101 with a seed rate of 200grams were sown between the rows of cabbage with spacing of 15 cm in different plots as a trap crop. An immediate irrigation was given for ensuring better germination.All recommended agronomic practices and intercultural operations like gap filing, thinningand handweeding were adopted timely during the growth periodof theplants andinsecticide spraying was done on sole crop (cabbage).

Water requirements for cabbage and mustard i.e., (cabbage 4 times), (mustard 2times)were fulfilled. The 2 irrigations for cabbage were given priortoplanting of mustard for better growth, and the remaining 2 irrigations (1st after 2nd booster dose application of fertilizer, 2nd on pod formation of mustard) was givenafterplantingthemustardbetweentherowsofrespectivetrapcroppingratio.Insolecrop(cabbage) all agronomic practices including spraying were done on general schedule forensuringbetteryield.

Evaluation of density of mustard aphid on different treatments oftrapcroppingratios(1:1,2:1,3:2)incabbagewithIndian mustard

Fordensity evaluationofmustard aphid in treatmentsofdifferenttrapcropping-ratios, the weeklymeanvaluedataobtainedfromeachplot by counting the number of aphids, from seven randomly chosen tagged plants per plot of each treatment and then were averaged with the sample number, replication number, and weekdays for an efficacious mean value. Comparison between the treatments for the significant difference in density ofmustard aphid between the different trap cropping ratios (1:1, 2:1, 3:2) along with a sole crop (cabbage) wasdonebyonefactoranalysis with anequalnumberofreplications.

According to Dotasara*et al*. (2017), the numerical count approach was used to estimate the aphid population in cabbage.

Treatments combinations

T1 –1:1, trapcroppingratio (aphid densityon cabbage)

T2–1:1, trapcroppingratio (aphid densityonmustard)

T3–2:1, trapcroppingratio (aphid density oncabbage)

T4–2:1,trapcroppingratio (aphid densityonmustard)

T5–3:2,trapcroppingratio (aphid densityoncabbage)

T6 – 3:2,trapcroppingratio (aphid densityonmustard)

Statisticalanalysis

Thedata for the averagedensityofaphidsoneachexperimentalunitwere converted to square root values and analyzed using Fisher and Yates (1963) “Analysis of variance” approach. To measure the effectiveness of each trap cropping ratio, at a 5% level of probability, the Standard Error of Difference ($S.E_d$) and critical difference (C.D.) were determined.

(1). StandardErrorofDifference ($S.E_d$) = $\frac{\sqrt{Ems}}{r}$

Ems (±) = Error mean, sum of square

r = replications number, which are equal for all treatments under comparison

(2). Critical difference (CD) = SE_d× tablet-value at 5 percent level of significance and error d.f.

Least significant difference (LSD): CD values at the 5% significance level (table t-value at 5%)

Cost-effectiveness assessment of selected trap cropping ratios with a sole crop (cabbage)

Each treatment's marketable produce was gathered and weighed separately. The costof the insecticides used in this experiment was recorded throughout the*rabi*seasonof 2022–2023. Pesticides were purchased from nearby markets. Treatment costs, sprayer rentalcosts, and labor costs for spraying were all included in the overall cost of plant protection. Twosprays took place throughout the research period, and the sum of plant protection costs wascalculated.ItistechnicallypossibletocalculatetheB:Cratio.

Benefit Cost Ratio = Netreturns*/* costs

Totalreturn, equal to marketableyieldXmarketprice*/*kg

The netreturniscalculatedasGrossreturnminus the cost ofcultivation.

RESULTS AND DISSCUSION

1) Estimation on peak stage of*L. erysimi* density on theratios of trap planting

The density of mustard aphid in treatments of different trap cropping ratios was recorded. Interestingly, duringthe7th SMWi.e.,on11thFebruary2023,meanaphidpopulationdensityreachedpeakstage in all treatments along with sole crop (cabbage). The findings of Zia and Hasseb (2019) and Kumar *et al.* (2000) support the present findings.They reported that from the 3rd SMW (January 2nd week) through the 11th standard week (March 2nd week) mustard aphid incidencewas observed in the field. According to their study, the population of mustard aphid’s peak stage in the7th SMW (February). Research by Bhavaniand Punnaiah (2006) also supports the recent findings.Theyreported

that,accordingtoseasonalvariationsin thepestpopulations,themonthsofJanuaryand Februaryareidealfor thegrowthfor themaininsectpestsofcabbage.ThesecondweekofFebruaryholdsthelargestmustardaphidpopulation,whilethel astweekofMarch hasthe lowestnumber. Studies conducted by Ansari et al., (2007) also support the present findings in the aspect of initial incidence (January 1st week), peak stage (7th SMW), and decline phase of mustard aphid (after March 3rd week).

The trap ratio (3:2) (4.60 aphid/plant) showed its effectiveness at the peak stage (7th SMW) with lower densities of aphids on cabbage compared to other trap ratios and single crop (cabbage). The highest aphid density (19.05 aphid/plant) was found in mustard of the same trap cropping ratio when compared with other trap cropping ratios.

a) Comparison of *L. erysimi*densityon cabbage in different trapping ratios

A one factorial analysis was carried out between trap planting proportions of cabbage, and it was found that in the seventh (SMW), that is, on February 11, 2023, there were significant differences in the average population density of cabbage between different treatments. On 7th (SMW) i.e., 11th February 2023, thetreatmentoftrapcropping ratio(3:2)harboredlessmeanabsolutemustardaphiddensity (4.60 aphid/plant)andshowsa significant difference ($p>0.02$) with the treatment of trap cropping ratio (1:1) (12.61 aphid/plant). treatment of trapcropping ratio (3:2) also shows a significant difference ($p>0.03$) with the trap cropping ratio (2:1) (10.29 aphid/plant).

b) Comparison of *L. erysimi* density on mustard in different trapping ratios

A factorial analysis was carried out among different trap planting proportions of mustard, and it was found that in the seventh (SMW), that is, on February 11, 2023, there were significant differences in the average population density of mustard between different treatments. On 7th (SMW) i.e., 11th February 2023, the treatment oftrap cropping ratio (3:2) harbored high mean aphid density (19.05 aphid/plant) and shows a significantdifference ($p>0.01$) with the treatment of trap cropping ratio (1:1) (11.64). treatment of trap cropping ratio(3:2) also shows a significant difference ($p>0.01$) with the trap cropping ratio (2:1) (10.75 aphid/plant).

2) Cost-effectiveevaluationbetweendifferenttreatmentsoftrapcroppingratioswith asolecrop (cabbage)

a) Effectof insecticidetreatmenton theyieldofcabbage

Table-5 shows the total produce data of treatments along with a solecrop (cabbage) (49.23 t/ha). Variation in production data between treatments and sole crop (cabbage) isdueto Malathion50EC spraying twice in sole crop (i.e., on 8th (SMW) (February 18th, 2023) and 9th (SMW) i.e., 11th March 2023) which

was not done in the trap cropping ratios. Trap cropping ratio (3:2) had the highest cabbage production(42.61 t/ha), between different treatments of trap cropping ratios.Studies conducted by Zorempuii and Kumar (2019) supported the present findings oncost-effectiveevaluation betweendifferenttreatmentsoftrapcroppingratios(1:1),(2:1), and(3:2)withsolecrop(cabbage).Theyfound that the application ofMalathion50EC showed thebestyield (66.66 t/ha) compared to other treatment applications for a single crop (cabbage).

b) Benefit Cost Ratio

In Comparing for benefit cost ratio between different treatments of trap cropping ratios (1:1, 2:1, 3:2) with a sole crop(cabbage). it was recorded that best benefit cost ratio (2.31) was observed in the trap cropping ratio(3:2)overtrapcroppingratio(1:1)(2.19),trapcroppingratio(2:1)(2.02)andsolecrop(cabbage)(2.07), even though sole crop (cabbage) was recorded the yield (49.23 t), the highest totalpriceoftheyield(1,23,075 \-)andhighestnetreturn(83,072 \-),while thetrapcroppingratio(3:2) was recorded the yield of (42.61 t), (1,06,525 \-) total price of the yield and (74,422 \-) of netreturn.

c) Additionalincomegeneratedbyadoptingtrapcropping ratio.

The datain Table-6on extrarevenue returns beyondsolocrop (cabbage),demonstrated that each trap cropping ratio (1:1, 2:1, 3:2) generated (7,700 \-) rupees asadditionalincomeduetonoapplicationofinsecticides. The campaign was carried out twice in a single crop (cabbage).

SUMMARY AND CONCLUSION

The minimum aphid densitywas recorded in trap cropping ratio (3:2) (5.60), when compared with trap cropping ratios (1:1) (12.61), (2:1) (10.75), and a sole crop (cabbage) (28.13) during peak aphid population stage at 7th (SMW) i.e.,11thFebruary2023.

Several trap cropping ratios (1:1, 2:1, 3:2) were compared with a single crop (cabbage). Itwas found that the ratio of trapping planting (3:2) had the highest benefit-cost ratio (2.31), higher than the ratio of trappingplanting (1:1) (2.19), trappingplanting ratio (2:1) (2.02) andsingle crop (cabbage) (2.07). The additional income returnbeyond a single crop (cabbage) showsthattrapplantingratios(1:1,2:1,3:2) yielded(Rs. 7,700/-)moredueto the absence of insecticide treatment income, performed twice in a single crop (cabbage).

From the above critical studies, it was concluded that trap cropping ratio (3:2) shown the best efficacy in terms of beingcost effective and management of mustard aphid, when compared with other treatments of Trap cropping ratios (1:1), (2:1) and sole crop (cabbage).

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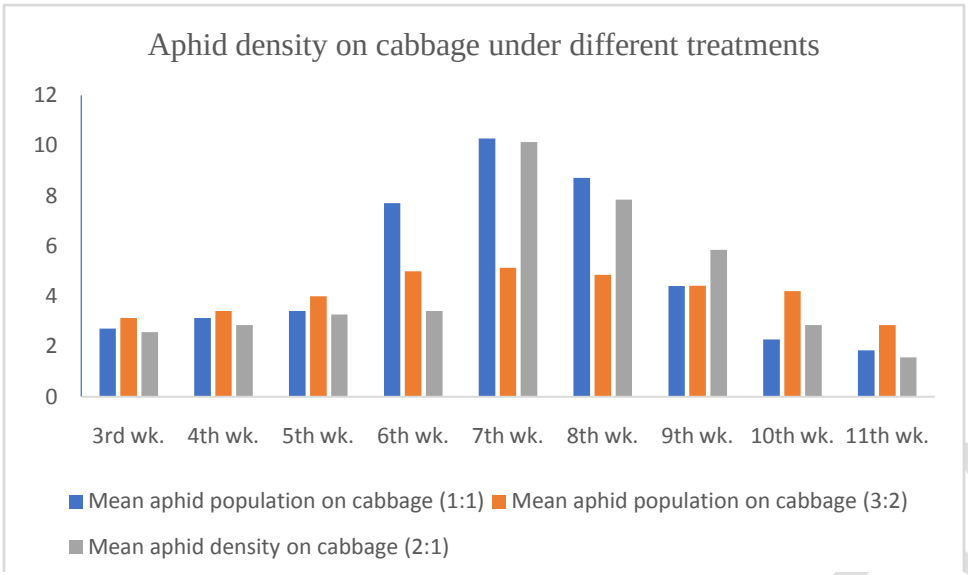

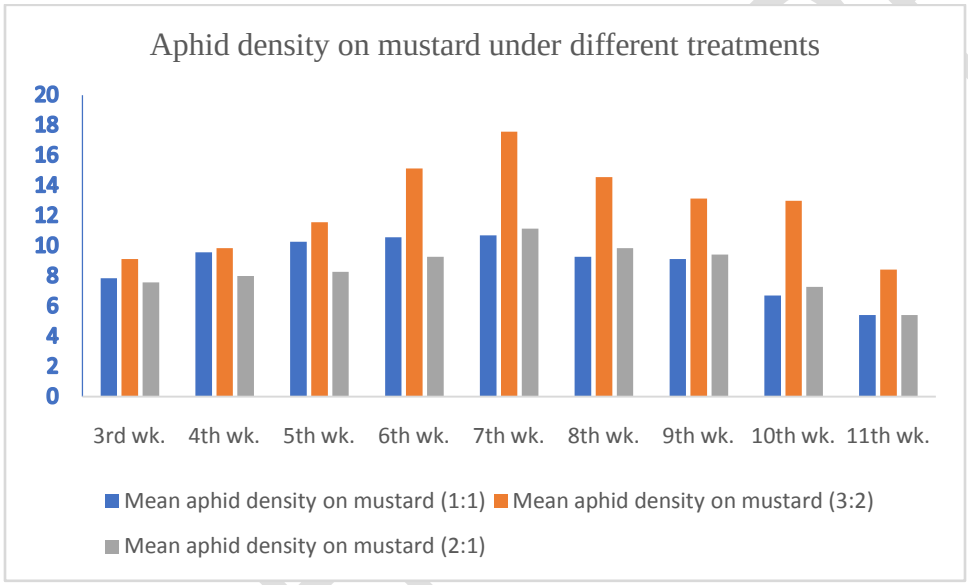

Fig 1 :Densityof*L.erysimi*on cabbage andmustardunder differenttrapcroppingratiosfrom 3rd standardweek(14thJanuary2023)to 11thstandardweek(11thMarch2023)

Table-1 Densityof*L.erysimi*on trap cropping ratios on cabbage in 2022-23

Treatments	3rd SMW January 14	4th SMW January 21	5th SMW January 28	6th SMW February 4	**7th SMW February 11**	8th SMW January 18	9th SMW January 25	10th SMW March 4	11th SMW March 11
Sole crop (cabbage)	11.75 (3.42)	11.84 (3.44)	16.44 (4.05)	19.91 (4.46)	**28.13[a] (5.30)**	20.92 (4.57)	3.47 (1.86)	2.02 (1.42)	1.17 (1.29)
Trap cropping ratio (1:1)	2.90 (1.70)	2.80 (1.67)	3.12 (1.76)	6.81 (2.60)	**12.61[ab] (3.55)**	9.23 (3.03)	4.69 (2.16)	4.10 (2.02)	2.01 (1.41)
Trap cropping ratio (2:1)	3.11 (1.76)	2.71 (1.83)	3.41 (1.84)	3.25 (1.80)	**10.29[bc] (3.20)**	9.42 (3.06)	5.85 (2.41)	4.54 (2.13)	2.42 (1.55)
Trap cropping ratio (3:2)	2.73 (1.65)	3.01 (1.64)	4.07 (2.01)	3.83 (1.95)	**4.60[d] (2.13)**	3.62 (1.90)	3.71 (1.92)	3.76 (1.93)	2.84 (1.68)
C.D.					**3.387**				
SE (d)					**1.358**				
C.V.					**11.952**				
D.F.					**4,10**				

Table-2 Densityof*L.erysimi*on trap cropping ratios of mustard in 2022-23

Treatments	3rd SMW January 14	4th SMW January 21	5th SMW January 28	6th SMW February 4	**7th SMW February 11**	8th SMW January 18	9th SMW January 25	10th SMW March 4	11th SMW March 11
Trap cropping ratio (1:1)	8.57 (2.92)	8.21 (2.86)	9.68 (3.11)	10.56 (3.24)	**11.64[a] (3.41)**	8.40 (2.89)	8.56 (2.92)	5.60 (2.36)	4.83 (2.19)
Trap cropping ratio (2:1)	8.43 (2.90)	7.60 (2.75)	8.43 (2.90)	8.67 (2.94)	**10.75[ab] (3.27)**	8.50 (2.91)	8.91 (2.98)	7.82 (2.79)	4.64 (2.15)

Trap cropping ratio (3:2)	8.14 (2.85)	8.52 (2.91)	10.70 (3.27)	14.52 (3.81)	**19.05[c] (4.36)**	13.64 (3.69)	12.49 (3.53)	11.57 (3.40)	8.63 (2.93)
C.D.					**2.771**				
SE (d)					**0.972**				
C.V.					**8.615**				
D.F.					**3,7**				

Figures in parenthesis are square root transformed values.

Figures in 7th SMW (peak stage) followed by same letters are not significantly different.

SMW (standard meteorological week)

Table-3 Multiplecomparisons in density of *L. erysimi*intrapcroppingratios(7thSMW) oncabbage

Treatments	Density of *L. erysimi*(cabbage) in trapcroppingratio(2:1)	Density of *L. erysimi*(cabbage) in trapcroppingratio(3:2)
Density of *L. erysimi*(cabbage) in trapcroppingratio(1:1)	0.62	0.02*
Treatments	Density of *L. erysimi*(cabbage) in trapcroppingratio(1:1)	Density of *L. erysimi*(cabbage) in trapcroppingratio(3:2)
Density of *L. erysimi*(cabbage) in trapcroppingratio(2:1)	0.62	0.03*
Treatments	Density of *L. erysimi*(cabbage) in trapcroppingratio(1:1)	Density of *L. erysimi*(cabbage) in trapcroppingratio(2:1)
Density of *L. erysimi*(cabbage) in trapcroppingratio(3:2)	0.02*	0.03*

LSD= p<0.05*

Table-4 Multiplecomparisons in density of *L. erysimi*intrapcroppingratios(7thSMW) onmustard

Treatments	Density of *L. erysimi*(mustard) in trapcroppingratio(2:1)	Density of *L. erysimi*(mustard) in trapcroppingratio(3:2)

Density of *L. erysimi*(mustard) in trapcroppingratio(1:1)	0.78	0.01*
Treatments	Density of *L. erysimi*(mustard) in trapcroppingratio(1:1)	Density of *L. erysimi*(mustard) in trapcroppingratio(3:2)
Density of *L. erysimi*(mustard) in trapcroppingratio(2:1)	0.78	0.01*
Treatments	Density of *L. erysimi*(mustard) in trapcroppingratio(1:1)	Density of *L. erysimi*(mustard) in trapcroppingratio(2:1)
Density of *L. erysimi*(mustard) in trapcroppingratio(3:2)	0.01*	0.01*

LSD= p<0.05*

Table-5 Effect of trap cropping on cabbage (sole crop) in relation to yield and benefit costratio

Treatments	**Yield T/ha**	**Price of theyieldRs/q**	**Totalprice ofthe yieldRs/T**	**TC**	**TCP(TCP+TC)**	**Netreturn (/-)**	**B.C.R**	**Additionalincome**
Trapcroppingratio(1:1)	41.29	2500/-	1,03,225/-		32,353/-	70,872	1:2.19	7,700/-
Trapcroppingratio(2:1)	39.32	2500/-	98,300/-		32,503/-	65,795	1:2.02	7,700/-
Trapcroppingratio(3:2)	42.61	2500/-	1,06,525/-		32,103/-	74,422	1:2.31	7,700/-

Solecropping(cabbage)	49.23	2500/-	1,23,075/-	7,700/-	40,003/-	83,072	1:2.07	

Table-6 Economicsoftreatments

Treatment	**1st spray**	**2nd spray**	**Cost ofinsecticide**	**cost ofinsecticidefor 2sprays**	**Laborcharges forspray(350/- /spray)**	**Totalcost oftreatment**
Trapcroppingratio(1:1)	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
Trapcroppingratio(2:1)	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
Trapcroppingratio(3:2)	-NA-	-NA-	-NA-	-NA-	-NA-	-NA-
Sole crop(cabbage)	Malathion 50EC(5 L/ha	Malathion50EC(5 L/ha	700/- /L	7,000/- /10L	700/-	7,700/-