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Research Article

Estimation of avoidable yield losses in Indian mustard (*Brassica juncea* L.) due to mustard aphid, *Lipaphis erysimi* (Kaltenbach) in Rewari district, Haryana, India

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Abstract

The Indian mustard (*Brassica juncea* L.) is a significant oilseed crop in India. The sap-sucking pest, mustard aphid (*Lipaphis erysimi*) emerged as a major threat to this crop, which can harshly reduce yield. The research experiment was carried out during the *Rabi* seasons, 2019-20 and 2020-21 at Rewari, Haryana to comprehend the influence of *L. erysimi* infestation on different yield parameters of *B. juncea* in the field. The two cultivars of *B. juncea* namely, RH 725 and RB 50 were raised in a paired plot design with two different sets viz., protected and unprotected and thirteen replications each set were kept. The protected set was sprayed with insecticide Dimethoate 30 EC @ 625 ml ha^{-1} one time only, whereas unprotected set was kept free from insecticidal application for natural infestation of the pest. The present investigation revealed that under unprotected conditions, the yield parameters viz., weight of 100 siliquae, 100 siliquae husk, 10 main apical shoots (10 cm) and 1000 seeds, as well as seed yield, were significantly ($P<0.01$) affected by the *L. erysimi* infestation, while parameter, seed germination percentage influenced non-significantly ($P>0.01$). The maximum seed yield losses were registered in genotype RH 725 (26.25 %) when compared with RB 50 (25.92 %). All other yield parameters exhibited the same pattern except for three parameters i.e. weight of 100 siliquae, 100 siliquae husk and 10 main apical shoots (10 cm). In conclusion, this research highlights the colossal yield losses inflicted by *L. erysimi* infestation in *B. juncea* in unprotected conditions and the utility of insecticidal application in the enhancement of crop yield by management of this insect pest in protected conditions.

Keywords: Avoidable yield losses, *Brassica,* Genotype, *Lipaphis erysimi,* Seed yield

INTRODUCTION

Indian mustard (*Brassica juncea* L.) is a winter (*Rabi*) season crop belonging to the family Brassicaceae or Cruciferae and group rapeseed and mustard is an important oilseed crop in India, Bangladesh, China, and Ukraine. Of the total edible oil production in India, it accounted for 27 %. It is primarily cultivated in the North-Western states of India and occupied 80 % of the total area under rapeseed and mustard cultivation (Dixon, 2007; Ram *et al*., 2014; Ram *et al*., 2017; Jat *et al*., 2019). Mustard is predominantly cultivated in tropical and temperate climates and it has grown in regions where about 100-250 °C temperature and annual rainfall of 625-1000 mm (Reddy, 2015). Mustard seeds contain 4.51 g of carbohydrate, 1.41 g of sugar, 2g of fat, and 2.56 g of protein 100^{-1} g. Its seed is oil-rich with an oil content of 37-49% (Bhowmik *et al*., 2014; Barfa, 2016).

Internationally, India holds 3rd position concerning mustard acreage and production. India's total area under rapeseed and mustard is 6.69 million hectares with a production of 10.11 million tonnes and productivity of 1511 kg ha^{-1}. In Haryana, it occupies 0.63 million hectares area with production and productivity of 1.28 million tonnes and 2027 kg ha^{-1}, respectively. Attributing to huge losses caused in the crop yield by aphid pest, India's average mustard yield is lower than other mustard-growing countries (Pandey *et al*., 2013; Rao *et al*., 2014; Anonymous, 2021).

Aphids are small sap-sucking insects of the family Aphididae; these are one of the most notorious, cosmopolitan louse-like and obligate ectoparasites, which are responsible for excessive qualitative and quantitative loss of *Brassica* crops in the world (Biswas and Das, 2000; Koirala, 2020). The mustard aphid, *Lipaphis erysimi* (Kaltenbach) is a most destructive insect pest of rapeseed and mustard causing yield losses in the range of 66-96% (Singh and Sachan, 1997). As per the reports of Yadava and Singh (1999), yield losses up to 97.0 % due to *L. erysimi*. The *L. erysimi* infestation was attributable to causing yield losses up to 10-90 % in *B. juncea* (Rana, 2005). It also causes a reduction in oil content of mustard seed in the range of 5-6 % (Shylesha *et al*., 2006) and 4.92-8.14 % (Sharma *et al*., 2019).

The *L. erysimi* harms the rapeseed and mustard from the seedling to the maturity stage. It sucks the cell sap of the different parts of the plant, such as petioles, tender stems, leaves, pods, and inflorescences. Its heavy infestation in *B. juncea* causes a reduction in plant height, siliqua per plant, and the number of branches per plant. Furthermore, it is also accountable for the curling of leaves, weak pod formation, and undersized grains. It is to be reported that it infested the roots of plants at depths of 2–15 cm. It also secretes the honeydew, which is responsible for the development of sooty mould and reduces the photosynthetic rate (Singh and Singh, 1988; Bakhetia and Sekhon, 1989; Malik and Deen, 1998). The prerequisite for edible oil has been cumulative gradually in India. Therefore, to fulfil the demands of the ever-amassed population, there is a necessity to enhance the productivity of rapeseed and mustard by evading the losses triggered by *L. erysimi*. Keeping the above background, the present investigation was made to estimate the yield losses in *B. juncea* caused by *L. erysimi* pest.

MATERIALS AND METHODS

Experimental site

The present study was carried out at the farmer's field, Kolana village, Aravalli Hills Region, Rewari, Haryana, India (28°12'24.7"N latitude, 76° 21'11.0"E longitude, and 296 m altitude) during the *Rabi* seasons of years 2019-20 and 2020-21. The investigational area comes under semi-arid regions of the country and the soil textures of this locality are sandy loam.

Source of seeds

Seeds of the *B. juncea* genotypes viz., RH 725 and RB 50 were taken from the Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Regional Research Station (RRS), Bawal, Rewari, Haryana, India.

Experimental layout and insecticide application

The field trial of each genotype was laid out in a paired plot design (Leclerg, 1971) with 2 sets, i.e., protected (sprayed with Dimethoate 30 EC @ 625 ml ha^{-1} one time only) and control unprotected (unsprayed) and 13 replications per set were kept. The seeds of genotypes (RH 725 and RB 50) were sown on the 20th of October of 2019 and 2020. Each experimental plot consisted of 4.2×3 m with a distance of 10 cm between plants and 30 cm between rows. The spray of the insecticide Dimethoate 30 EC @ 625 ml ha^{-1} was applied by using a knapsack sprayer when *L. erysimi* population attained the economic threshold level.

Pest population

The *L. erysimi* population was recorded from 10 cm main apical shoot of 10 randomly selected and tagged plants in each plot. The Per cent reduction in the pest

Fig. 1. *(a) Healthy plant of B. juncea; (b-c) L. erysimi infested plants of B. juncea; (d) Healthy siliquae and (e) L. erysimi damaged siliquae*

population was calculated as mentioned below by using formula:

Population reduction % = [(U-P)/U] x 100 ….. Eq. 1

Where,

U = mean pest population under unprotected set.

P = mean pest population under protected set.

Estimation of yield parameters of *B. juncea*

The weight of randomly collected samples of yield parameters viz., 100 siliquae, 10 main apical shoots (10 cm), 1000 seeds and 100 siliquae husk from protected and unprotected plots of each genotype were measured. The seed yield was recorded from each plot and converted into kilogram hectare^{-1} (Kg ha^{-1}), and seed germination percentage was also calculated.

Per cent seed germination

The seed germination percentage was calculated using wet paper method. Forty seeds from each replication were taken at random and placed on moist filter paper in Petri plates. After seven days, the germination count was done. Mean germination percentages for each set were calculated (Sharma, 2016).

Statistical analysis

The per cent avoidable yield loss in each genotype was computed on the basis of formula described by Khosla (1977):

Per cent avoidable loss = [(A-B)/A] x 100 …..Eq. 2

Where,

A= mean yield under protected set.

B= mean yield under unprotected set.

Data recorded on different parameters were analyzed statistically using t- test at 1% level of significance using statistical software OPSTAT (Sheoran *et al*., 1998).

RESULTS AND DISCUSSION

Population of *L. erysimi* in protected and unprotected plots of *B. juncea*

The obtained results during the *Rabi* seasons of 2019-20 and 2020-21 are presented in Tables 1,2,3 and 4 indicating that the population of *L. erysimi* (Fig. 1) was significantly (P<0.01) high in unprotected plots as compared to protected plots of *B. juncea*. Per cent reduction in pest population in 2019-20 was 89.97 and 89.86 % in genotype RH 725 and RB 50, whereas it was 84.85 and 87.40 % in 2020-21, respectively. The pooled data given in Tables 5 and 6 showed that the genotype RB 50 harboured a minimum pest population of 34.13 aphids plant^{-1}, while the maximum population was found on RH 725 (39.51 aphids plant^{-1}) in unprotected plots. In the protected plots, a very low population of 5.20 and 3.97 aphids plant^{-1} was registered on RH 725 and RB 50, respectively. The % decrease in pest population was computed to be 86.84 and 88.37 per cent in RH 725 and RB 50, respectively.The present results are in consensus with the findings of the field research performed by Sharma *et al*. (2019) at Rohtak, Haryana, India and they reported that under timely sown conditions, the population of *L. erysimi* was higher in unprotected plots (19.62, 22.03 and 30.41 aphids 10^{-1} cm apical shoot) compared to the protected plots (1.85, 1.97 and 3.48 aphids 10^{-1} cm apical shoot) of *B. napus* cv. HNS 0901, *B. juncea* cv. RH 0749 and *B. rapa* cv. BSH 1, respectively.

Furthermore, these studies also agree with the outcomes of Kular and Kumar (2011), who conducted a field experiment at Ludhiana, Punjab, India and found that the *L. erysimi* population varied from 2.1-32.4 aphids plant^{-1} on different genotypes of rapeseed-mustard (*B. juncea*, *B. napus*, *B. carinata*, *B. rapa* and *Eruca sativa*) and it was maximum on *B. rapa* (32.4 aphids plant^{-1}) and minimum on *Eruca sativa (*2.1 aphids plant^{-1}) in the unprotected set. A field study was carried out at Ludhiana, Punjab, India by Kumar (2017), who suggested that the *B. juncea* var. PBR 91 harboured the maximum *L. erysimi* population (90.3 aphids plant^{-1}) afterwards NRCDR 2 (70.8 aphids plant^{-1}). However, a minimum population was observed on *B. rapa* cv. BSH 1 (35.0 aphids plant^{-1}) in unprotected set.

Impact of *L. erysimi* infestation on yield of *B. juncea* under protected and unprotected conditions

Weight of 100 siliquae

The results of years *Rabi*, 2019-20 and 2020-21 given in Tables 1,2,3 and 4 showed that attributable to the infestation of *L. erysimi*, the weight of 100 siliquae (Fig. 1) was significantly (P<0.01) low in unprotected plots as compared to protected plots. The RB 50 genotype (34.71 and 37.54 %) detected higher yield losses than RH 725 (30.26 and 28.31 %) during 2019-20 and 2020-21, respectively. The pooled data (Tables 5 and 6) clearly revealed that in the unprotected plots, the weight of 100 siliquae was registered 25.89 and 21.19 grams in RH 725 and RB 50, respectively; however, the weight in the protected plots was 36.60 and 33.16 grams. The yield losses were found to be higher in genotype RB 50 (36.10 %) than RH 725 (29.26 %) (Fig. 2). There seems to be no literature available regarding this yield parameter.

Weight of 100 siliquae husk

In seasons 2019-20 and 2020-21, the weight of 100 siliquae husk significantly (P<0.01) differed in protected and unprotected plots (Tables 1,2,3 and 4). Pooled data of 2 years indicated (Tables 5 and 6) that the weight of 100 siliquae husk was 12.15 and 9.08 grams (unprotected) and 18.22 and 16.70 grams (protected) under RH 725 and RB 50, respectively as well as high yield losses (Fig. 2) noticed in RB 50 (45.63 %) than RH 725 (33.32 %). There seems to be no literature available regarding this yield parameter.

Weight of 1000 seeds

As presented in Tables1, 2, 3 and 4, during the 2019-20 and 2020-21 seasons under unprotected plots, the weight of 1000 seeds was significantly (P<0.01) low than in protected plots. Among the two genotypes, in 2019-20, RH 725 exhibited high yield losses (15.34 %), while in 2020-21, it was observed maximum in RB 50 (16.24 %). On the basis of pooled data results (Tables 5 and 6), the weight of 1000 seeds was lower in unprotected plots (6.33 and 6.83 grams) against protected plots (7.36 and 7.98 grams) in RB 50 and RH 725, respectively. The yield losses of 14.41 % (Fig. 2) were recorded in RH 725 higher as compared to RB 50 (13.99 %). There seems to be no literature available regarding this yield parameter.

Weight of 10 main apical shoots (10 cm)

The weight of 10 main apical shoots (10 cm) measured in protected and unprotected plots during the study differed from each other significantly (P<0.01) (Tables 1, 2,3 and 4). The yield losses were higher in RH 725 as compared to RB 50 during 2019-20, whereas it was the contrary during 2020-21. From the results of pooled data (Tables 5 and 6), the weight of 10 main apical shoots (10 cm) was 0.68 and 0.83 grams in unprotected plots and 1.02 and 1.18 grams in protected plots in RB 50 and RH 725, respectively. The yield losses were higher in the case of RB 50 (33.33 %) than RH 725 (29.66 %) (Fig.2). There seems to be no literature available regarding this yield parameter.

Seed germination percentage

During both years of investigations, seed germination percentage was non-significantly (P>0.01) influenced by the infestation of *L. erysimi* in protected and unprotected plots (Tables 1, 2, 3 and 4). As pooled data presented in Tables 5 and 6, the seed germination in pro-

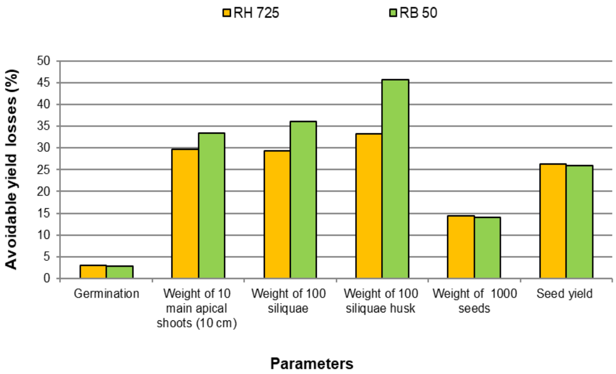

Fig. 2. *Avoidable yield losses due to L. erysimi in B. juncea genotypes (Pooled data of Rabi, 2019-20 and 2020-21)*

Table 1. Effect of *L. erysimi* infestation on yield of *B. juncea* genotype RH 725 during *Rabi*, 2019-20

Parameters	Unprotected	Protected	Per cent reduction in *L. erysimi* population	Avoidable yield losses (%)	t-calculated value
L. erysimi population	30.81	3.09	89.97	-	50.51*
Germination (%)	89.23	91.35	-	2.32	1.23
Weight of 10 main apical shoots (10 cm) (gram)	0.76	1.13	-	32.74	3.56*
Weight of 100 siliquae (gram)	25.08	35.96	-	30.26	10.26*
Weight of 100 siliquae husk (gram)	11.54	17.79	-	35.13	6.55*
Weight of 1000 seeds (gram)	6.68	7.89	-	15.34	4.43*
Seed yield (kg ha^{-1})	1265	1613	-	21.57	28.56*

*The t-value significant at P=0.01

Table 2. Effect of *L. erysimi* infestation on yield of *B. juncea* genotype RB 50 during *Rabi*, 2019-20

Parameters	Unprotected	Protected	Per cent reduction in *L. erysimi* population	Avoidable yield losses (%)	t-calculated value
L. erysimi population	27.23	2.76	89.86	-	30.05*
Germination (%)	88.08	90.19	-	2.34	1.21
Weight of 10 main apical shoots (10 cm) (gram)	0.66	0.98	-	32.65	4.21*
Weight of 100 siliquae (gram)	22.18	33.97	-	34.71	14.33*
Weight of 100 siliquae husk (gram)	9.15	16.54	-	44.68	11.01*
Weight of 1000 seeds (gram)	6.42	7.26	-	11.57	4.89*
Seed yield (kg ha^{-1})	1124	1509	-	25.51	65.89*

*The t-value significant at P=0.01

Table 3. Effect of *L. erysimi* infestation on yield of *B. juncea* genotype RH 725 during *Rabi*, 2020-21

Parameters	**Unprotected**	**Protected**	**Per cent reduction in *L. erysimi* population**	**Avoidable yield losses (%)**	**t-calculated value**
L. erysimi population	48.20	7.30	84.85	-	46.96*
Germination (%)	89.04	92.50	-	3.74	2.47
Weight of 10 main apical shoots (10 cm) (gram)	0.89	1.22	-	27.05	4*
Weight of 100 siliquae (gram)	26.69	37.23	-	28.31	13.99*
Weight of 100 siliquae husk (gram)	12.76	18.64	-	31.55	8.27*
Weight of 1000 seeds (gram)	6.98	8.07	-	13.51	3.68*
Seed yield (kg ha^{-1})	1322	1895	-	30.24	59.41*

*The t-value significant at P=0.01

Table 4. Effect of *L. erysimi* infestation on yield of *B. juncea* genotype RB 50 during *Rabi*, 2020-21

Parameters	**Unprotected**	**Protected**	**Per cent reduction in *L. erysimi* population**	**Avoidable yield losses (%)**	**t-calculated value**
L. erysimi population	41.03	5.17	87.40	-	45.52*
Germination (%)	87.50	90.58	-	3.40	2.09
Weight of 10 main apical shoots (10 cm) (gram)	0.70	1.05	-	33.33	4.27*
Weight of 100 siliquae (gram)	20.20	32.34	-	37.54	10.30*
Weight of 100 siliquae husk (gram)	9	16.85	-	46.59	13.66*
Weight of 1000 seeds (gram)	6.24	7.45	-	16.24	5.20*
Seed yield (kg ha^{-1})	1240	1682	-	26.28	58.37*

*The t-value significant at P=0.01

Table 5. Effect of *L. erysimi* infestation on yield of *B. juncea* genotype RH 725 (Pooled data of *Rabi*, 2019-20 and 2020-21)

Parameters	**Unprotected**	**Protected**	**Per cent reduction in *L. erysimi* population**	**Avoidable yield losses (%)**	**t-calculated value**
L. erysimi population	39.51	5.20	86.84	-	58.48*
Germination (%)	89.14	91.93	-	3.03	2.75
Weight of 10 main apical shoots (10 cm) (gram)	0.83	1.18	-	29.66	4.59*
Weight of 100 siliquae (gram)	25.89	36.60	-	29.26	14.60*
Weight of 100 siliquae husk (gram)	12.15	18.22	-	33.32	9.47*
Weight of 1000 seeds (gram)	6.83	7.98	-	14.41	5.59*
Seed yield (kg ha^{-1})	1293.5	1754	-	26.25	58.25*

*The t-value significant at P=0.01

Table 6. Effect of *L. erysimi* infestation on yield of *B. juncea* genotype RB 50 (Pooled data of *Rabi*, 2019-20 and 2020-21)

Parameters	**Unprotected**	**Protected**	**Per cent reduction in *L. erysimi* population**	**Avoidable yield losses (%)**	**t-calculated value**
L. erysimi population	34.13	3.97	88.37	-	81.88*
Germination (%)	87.79	90.39	-	2.88	2.19
Weight of 10 main apical shoots (10 cm) (gram)	0.68	1.02	-	33.33	5.16*
Weight of 100 siliquae (gram)	21.19	33.16	-	36.10	16.49*
Weight of 100 siliquae husk (gram)	9.08	16.70	-	45.63	16.49*
Weight of 1000 seeds (gram)	6.33	7.36	-	13.99	6.56*
Seed yield (kg ha^{-1})	1182	1595.5	-	25.92	85.54*

*The t-value significant at P=0.01

tected and unprotected plots of RH 725 was 91.93 and 89.14 per cent, respectively, whereas concerning RB 50, seed germination was 90.39 (protected) and 87.79 per cent (unprotected). The yield losses in respect of seed germination (Fig. 2) were more in RH 725 (3.03 %) as compared to RB 50 (2.88 %). These findings are in line with the observations of Sharma *et al*. (2019), who validated that the infestation of *L. erysimi* did not significantly influence the seed germination percentage in various *Brassica* species (*B. napus* cv. HNS 0901, *B. juncea* cv. RH 0749 and *B. rapa* cv. BSH 1).

Seed yield

The findings of seasons 2019-20 and 2020-21 displayed in Tables 1, 2, 3 and 4 evinced that the infestation of *L .erysimi* inflicted significantly ($P<0.01$) heavy seed yield losses in unprotected plots as compared to protected plots. In season 2019-20, the RB 50 genotype showed more seed yield losses than RH 725, while in 2020-21, it was contrasted to the previous year's results. The pooled data (Tables 5 and 6) inferred that the seed yield was lower in unprotected plots (1182 and 1293.5 kg ha^{-1}) as compared to the protected plots (1595.5 and 1754 kg ha^{-1}) of RB 50 and RH 725, respectively. The yield losses (Fig. 2) were high with regards to RH 725 (26.25 %) against RB 50 (25.92 %) genotype. These results are in conformity with the earlier reports of Kumar (2020), who carried out a research experiment at Muzaffarpur, Bihar, India and explored that the seed yield losses triggered by *L. erysimi* in mustard varieties (NRCDR-2, BSH-1 and Rajendra Sufalam) varied from 32.09-36.91%. These findings are also consistent with the inferences of Sharma *et al*. (2019), who reported that under timely sown conditions, the average avoidable seed yield losses due to *L. erysimi* infestation was for the *B. rapa* cv. BSH1 variety with 17.48 % followed by *B. juncea* cv. RH 0749 with 11.79 % and *B. napus* cv. HNS 0901 with 9.26 %. Earlier, Dotasara *et al*. (2022) conducted an experiment at Jobner, Rajasthan, India and informed that the insect pests of Indian mustard resulted in its avoidable yield loss of 41.14 %. The inferences of an experiment carried out at Bharatpur, Rajasthan revealed that the *L. erysimi* inflicted avoidable yield losses of 88.72 and 90.52 % (Singh *et al*., 2010).

Conclusion

Our investigation has revealed that under unprotected conditions, the infestation of *Lipaphis erysimi* significantly ($P<0.01$) impacted all the yield parameters of *Brassica juncea* genotypes (RH 725 and RB 50) except seed germination percentage ($P>0.01$). On the pooled data basis, in terms of yield parameters like the weight of 100 siliquae, the weight of 10 main apical shoots (10 cm) and the weight of 100 siliquae husk genotype RB 50 showed high avoidable losses than RH 725. On the other hand, regarding parameters viz., seed germination percentage, the weight of 1000 seeds and seed yield genotype RH 725 evinced higher avoidable losses as compared to RB 50. This research will be helpful in the development of management strategies against this pest to evade crop yield losses under semi-arid conditions in Haryana.

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Conflict of interest

The authors declare that they have no conflict of interest.

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