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# Phytochemicals in wild crucifers affect development and reproduction of mustard aphid *(Lipaphis erysimi*)

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## ABSTRACT

The study was carried out during 2019–2021 at ICAR-Indian Agricultural Research Institute, New Delhi to identify sources of resistance and elucidate the mechanisms of resistance in wild crucifers against the mustard aphid, *Lipaphis erysimi* (Kaltenbach). A total of 32 genotypes, including 29 wild crucifer spp. and three *B. juncea* genotypes as checks, were cultivated. Significant differences were observed in the phytochemical composition of 29 wild crucifer genotypes and 3 *Brassica juncea* check genotypes, which influenced various biological traits of *L. erysimi*. The total nymphal duration of *L. erysimi* was significantly longer on *Crambe abyssinica* and *Eruca sativa* compared to other genotypes, including *B. juncea* cultivars. Additionally, aphids exhibited extended reproductive and total developmental periods on *Diplotaxis viminea* and *Enarthrocarpus lyratus*, while *Lepidium sativum* showed reduced fecundity and poor progeny survival. Genotypes such as *E. sativa*, *D. assurgens*, and *C. abyssinica* had significantly higher levels of total proteins, sugars, phenols, tannins, total antioxidants, and FRAP. Total proteins and sugars showed a positive correlation with the nymphal period, developmental duration, and fecundity, whereas phenols, tannins, antioxidants, and FRAP exhibited significant negative correlations with these traits and aphid survival. Furthermore, phenols and tannins had the strongest negative impact, explaining 78.14% of the variability in fecundity and 55.93% in offspring survival. Wild crucifers with elevated biochemical defenses, particularly *E. sativa*, *B. tournefortii*, *L. sativum*, *C. abyssinica*, and *D. assurgens*, effectively reduced aphid reproduction and survival, highlighting their potential for breeding aphid-resistant Indian mustard varieties.

**Keywords**: *Brassica juncea, Lipaphis erysimi,* Secondary metabolites, Wild crucifer

*Brassica juncea* is one of India's most important oilseed crops, being used as edible oil, medicinal and bio-industrial purposes (Rai *et al.* 2022). It covers an area of around 8.06 million hectares and yields a production of 11.75 million tonnes (ASG 2022). Among the biotic stresses, the mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Aphididae: Hemiptera) is the primary pest, causing up to 10–90% yield loss based on crop growth stage, population build-up intensity, and meteorological circumstances (Dhillon *et al.* 2022). Both adult and nymph suck the sap from the vegetative, blooming, and pod formation stage of mustard plant leading to curled leaves, poor seed development, low oil content and honeydew secretion that fosters sooty mold growth and impending photosynthesis (Dhillon *et al.* 2018)

Presently, *L. erysimi* management practices mainly rely on insecticide sprays, so introducing insect-resistant cultivars against this pest might be an important advancement in pest management. Crop plants in this family have a wide range of crop weed relative (CWR), interspecific, and intraspecific phenol-morphological diversity due to high levels of genetic variability (Stahl *et al.* 2018). Under these circumstances, host plant resistance can be a highly efficient method for screening and identifying of desirable pest resistance traits from wild species for minimising the losses caused by this pest. In response to the insect's attack, the plant defends itself by producing a variety of chemical compounds, which play an important role in resistance (Kumar and Banga 2017). Furthermore, lack of nutritional components, as well as the presence of toxic antinutritional factors, can all have a negative impact survival of insect pests (Chandrakumara *et al.* 2024). Several biochemical constituents, such as tannin and antioxidants, have been demonstrated to exert an adverse influence on the reproductive stage, growth, and longevity of mustard aphids in *B. juncea* (Samal *et al.* 2021). The present research aims to investigate the variation in the biological attributes of *L. erysimi*a across various wild crucifer genotypes and to examine the role of constitutive biochemical substances in plant’s defence mechanism against *L. erysimi*.

## MATERIALS AND METHODS

*Planting materials*: The study was carried out during 2019–2021 at ICAR-Indian Agricultural Research

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Institute (28.08°N, 77.12°E), New Delhi. A total of 32 genotypes, including 29 wild crucifer species [*B. chinensis* L., *B. fruticulosa*, *B. fruticulosa* (Spain), *Sisymbrium* (BWMR), *B. tournefortii* (RBT 2002), *B. tournefortii* (RBT 2003), *Camelina sativa*, *Capsella bursa-pastoris* (Early), *C. bursa-pastoris* (L.), *Diplotaxis assurgens*, *D. erucoides*, *D. gomezcampoi*, *D. muralis*, *D. siettiana*, *D. tenuisilique*, *D. viminea*, *Enarthrocarpus lyratus*, *Erucastrum canariense*, *Lepidium sativum*, *Sisymbrium* spp., *Crambe abyssinica* (EC400058), *C. abyssinica* (EC694069), *C. abyssinica* (EC694071), *C. abyssinica* (EC694075), *C. abyssinica* (EC694090), *C. abyssinica* (EC694125), *Eruca sativa* (IC57705), *E. sativa* (IC60468), and *E. sativa* (IC62597)] and three *B. juncea* genotypes as checks, were cultivated. The *B. juncea* checks represented three distinct quality categories, Double zero (low erucic acid and glucosinolate content; Pusa Double Zero Mustard 31: PDZM 31), Single zero (low erucic acid content; Pusa Mustard 30: PM 30), and Conventional type (high erucic acid and glucosinolate content; RH 725). The experiment was designed using a randomized complete block design (RCBD) with four replications. Each genotype was planted in four-row plots, with each row measuring 5 m in length. The spacing between rows was maintained at 30 cm, and individual plants were spaced 15 cm apart within the rows. A 60 cm buffer gap was provided between adjacent four-row plots of different genotypes to minimize interference. Sowing was conducted in the last fortnight of November during the *rabi* seasons of 2019–20 and 2020–21. All recommended agronomic practices were followed throughout the experiment, except for the use of insecticides.

*Developmental biology of* L. erysimi: The biological studies of *L. erysimi* were conducted under controlled laboratory conditions to assess its development and reproductive performance on different test genotypes. The experimental setup was maintained at a temperature of 17 ± 3°C, relative humidity of 60–70%, and a photoperiod of 12 h light and 12 h dark. This lower temperature range was deliberately selected, as *L. erysimi* is a winter pest and optimal development occurs at cooler temperatures. The selected conditions were standardized following the methodologies described by Samal *et al.* (2021) and Chandrakumara *et al.* (2023). Field-collected aphids were initially reared on fresh mustard leaves to establish a uniform colony. Excised mustard leaves were placed in glass Petri dishes (2 cm in diameter and 10 cm in height) lined with moistened filter paper to maintain leaf turgidity. For bioassays, one newly hatched first-instar nymph was carefully transferred onto a leaf disc of each test genotype using a fine camel hairbrush. Each genotype was tested with 10 replicates in a completely randomized design (CRD). Observations were recorded at 6 h intervals to monitor key biological parameters, including nymphal duration, reproductive period, total developmental time, fecundity (number of offspring produced), and offspring survival rate, adhering to the protocols established by Samal *et al.* (2021) and Chandrakumara *et al.* (2023).

*Biochemical estimation*: The top third leaves from the labeled plants of each test genotypes were collected and brought to the laboratory for further processing. The leaves were crushed in liquid nitrogen to obtain 2 g tissue samples, which were then mixed with 10 ml of phosphate buffer (50 mM, *p*H=7.8). The mixture was centrifuged at 12000 rpm for 20 min at 4°C and the supernatant was carefully collected and stored at -20°C in 2.5 ml Eppendorf tubes for biochemical analysis. The total proteins, sugars, phenols, antioxidants, tannins and ferric ion reducing power (FRAP) content were measured using standard protocols: Bradford (1976), Dubois *et al.* (1956), Prieto *et al.* (1999), Amorim *et al.* (2008), Singleton and Rossi (1965), and Benzie and Strain (1999), respectively. A completely randomised design (CRD) was used, with three replications for each biochemical constituent's test and results are expressed in mg/g of plant tissue.

*Statistical data analysis*: The biological and biochemical data were analyzed using variance analysis within a completely randomized design. The F-test was used to determine the significance differences across the test genotypes and treatment mean were compared using the least significant difference (LSD) at a 5% significance level ($p$=0.05) with SPSS® version 16. Pearson's correlation, multiple linear regression and stepwise regression were used to investigate the association between phytochemicals and *L. erysimi* biological attributes.

## RESULTS AND DISCUSSION

*Biology of* L. erysimi *on wild crucifer and* B. juncea *genotypes*: The study on the biology of *L. erysimi* across several test genotypes revealed significant differences in various biological parameters, including nymphal duration (92.8–127.7 h), reproductive period (109.6–160.5 h), developmental period (275.2–397.9 h), fecundity (24.2–60.8 nymphs/female), and offspring survival rate (33.2–70.2%). The nymphal stage (F=4.0; df=31,319; $p<0.001$) of *L. erysimi* significantly longer on *C. abyssinica* (EC694069, EC694071, EC694075), *D. tenuisilique*, and *E. sativa* (IC62597) than on other wild crucifer genotypes, including *B. juncea* genotypes (Table 1). In contrast, the nymphal stage was significantly shorter on *E. sativa* (IC57705) compared to other test genotypes. The reproductive period of *L. erysimi* was significantly longer (F=5.1; df=31,319; $p<0.001$) on *D. viminea* and *E. lyratus* compared to the other wild crucifer genotypes and *B. juncea* cultivars. Furthermore, the overall developmental period (F=11.4; df=31,319; $p<0.001$) was significantly longer on *D. tenuisilique*, *D. viminea*, *E. lyratus*, *E. canariense*, and *L. sativum* (Table 1). However, fecundity (F=42.7; df=31,319; $p<0.001$) and offspring survival rate (F=10.2; df=31,319; $p<0.001$) were significantly lower in *L. sativum* compared to the wild crucifer genotypes, though they remained significantly higher in *B. juncea* cultivars such as PM 30, PDZM 31, and RH 725 (Table 1). The findings aligned with Kumar *et al.* (2011) who demonstrated that 65 wild crucifer genotypes tested against *L. erysimi* showed that *B. fruticulosa* exhibited significant antibiosis,

Table 1 Developmental biology of *Lipaphis erysimi* on leaves of wild crucifer genotypes

| Genotypes | Total nymphal period (h) | Total reproductive period (h) | Total development period (h) | Fecundity (nymphs/ female) | Offspring survival (%) |
|---|---|---|---|---|---|
| *Brassica chinensis* | 101.4 | 115.6 | 335.0 | 26.9 | 54.4 |
| *Brassica fruticulosa* | 100.2 | 130.0 | 325.6 | 29.5 | 48.1 |
| *Brassica fruticulosa* (Spain) | 101.2 | 118.0 | 311.1 | 34.1 | 55.7 |
| *Sisimbrium* (BWMR) | 102.1 | 114.4 | 316.9 | 27.3 | 44.1 |
| *Brassica tournefortii* (RBT 2002) | 104.9 | 109.6 | 316.9 | 27.5 | 45.0 |
| *Brassica tournefortii* (RBT 2003) | 98.9 | 113.2 | 314.0 | 30.8 | 51.1 |
| *Camelina sativa* | 114.0 | 126.8 | 340.7 | 29.0 | 46.8 |
| *Capsella bursapastoris* (Early) | 100.2 | 126.4 | 331.0 | 28.8 | 46.6 |
| *Capsella bursapastoris* (Late) | 105.1 | 124.4 | 334.4 | 28.4 | 46.9 |
| *Diplotaxis assurgens* | 111.3 | 125.2 | 336.4 | 31.7 | 52.1 |
| *Diplotaxis erucoides* | 110.1 | 119.2 | 332.9 | 28.9 | 47.9 |
| *Diplotaxis gomez-campoi* | 111.1 | 113.2 | 332.5 | 28.0 | 46.2 |
| *Diplotaxis muralis* | 109.3 | 119.8 | 333.5 | 25.7 | 40.4 |
| *Diplotaxis siettiana* | 111.0 | 126.2 | 335.1 | 28.5 | 47.0 |
| *Diplotaxis tenuisilique* | 127.3 | 143.0 | 385.8 | 27.2 | 44.4 |
| *Diplotaxis viminea* | 122.1 | 160.5 | 397.9 | 28.0 | 46.1 |
| *Enarthrocarpus lyratus* | 120.8 | 152.8 | 396.4 | 34.6 | 56.4 |
| *Erucastrum canariense* | 111.1 | 119.6 | 354.1 | 29.2 | 48.4 |
| *Lepidium sativum* | 115.7 | 133.8 | 364.3 | 24.2 | 33.2 |
| *Sisimbrium* spp. | 112.3 | 121.0 | 344.3 | 35.3 | 55.3 |
| *Crambe abyssinica* (EC400058) | 116.3 | 117.4 | 351.1 | 29.9 | 47.4 |
| *Crambe abyssinica* (EC694069) | 127.7 | 112.6 | 359.7 | 28.5 | 47.0 |
| *Crambe abyssinica* (EC694071) | 125.8 | 116.2 | 360.9 | 28.0 | 45.9 |
| *Crambe abyssinica* (EC694075) | 117.8 | 129.8 | 364.5 | 26.6 | 43.0 |
| *Crambe abyssinica* (EC694090) | 98.2 | 129.4 | 349.0 | 29.0 | 47.7 |
| *Crambe abyssinica* (EC694125) | 110.5 | 127.4 | 359.8 | 28.4 | 46.3 |
| *Eruca sativa* (IC57705) | 92.8 | 128.2 | 337.9 | 27.9 | 44.4 |
| *Eruca sativa* (IC60468) | 108.3 | 122.2 | 351.1 | 26.5 | 40.1 |
| *Eruca sativa* (IC62597) | 118.9 | 116.2 | 360.3 | 27.5 | 44.3 |
| *Brassica juncea* (RH 725) | 95.4 | 134.6 | 298.0 | 52.2 | 65.1 |
| *Brassica juncea* (PDZM 31) | 94.8 | 149.0 | 289.2 | 56.8 | 67.7 |
| *Brassica juncea* (PM 30) | 97.2 | 137.0 | 275.2 | 60.8 | 70.2 |
| F-probability | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| LSD ($p$=0.05) | 13.56 | 15.00 | 22.73 | 3.67 | 6.72 |

negatively impacting aphid development, reproduction, and lifespan compared to the susceptible check, BSH-1. Similarly, Samal *et al.* (2021) observed reduced fecundity and offspring survival in *L. erysimi* on the low-erucic acid *B. juncea* genotype, RLC 3. These differential impacts on development and survival are attributed to genetic variation and plant defense biochemical expression (Chandrakumara *et al.* 2024). Singh *et al.* (2014) identified *B. fruticulosa*, *B. spinescens*, *C. abyssinica*, and *L. sativum* as resistant to *L. erysimi*, while Imran and Singh (2015) found BSH-1 had the shortest nymphal and reproductive periods, the longest lifespan, and the highest fecundity. Changes in insect development, reproduction, and survival are linked to genetic variations and plant defense mechanisms. Furthermore, resistance is also tied to the genetic composition of plants, particularly in *B. juncea* introgression lines derived from wild relatives (Palial *et al.* 2022). Several studies have shown that host plant quality influences herbivore life histories, such as growth and fecundity, with nutritionally deficient plants leading to reduced fertility (Samal *et al.* 2021, Chandrakumara *et al.* 2024). Host plant characteristics significantly impact pest population dynamics, with a faster development rate on certain cultivars leading to a rapid population increase (Bhoi *et al.* 2020).

*Biochemical components of wild crucifer and* B. juncea *genotypes*: The test genotypes exhibited variations in biochemical contents, with total protein varying from 1.0–4.5 mg/g, total sugars from 9.3–17.2 mg/g, total phenols from 1.8–5.0 mg/g, total tannins from 0.1–0.6 mg/g, total antioxidants from 3.0–6.2 mg/g, and FRAP from 0.5–2.9 mg/g (Table 2). Total proteins (F=31.4; df=31,95; $p$<0.001) and sugars (F=41.8; df=31,95; $p$<0.001) were significantly higher in *E. sativa* (IC62597, IC60468, IC57705) but lower in *B. tournefortii* (RBT 2002, RBT 2003) compared to other wild crucifer genotypes and check genotypes. Previous studies by Kumar *et al.* (2020) observed elevated sugar content in aphid-susceptible *B. juncea* genotypes, while Chandrakumara *et al*. (2024) found higher protein content in *B. juncea* cultivars exhibiting tolerance to aphids. The total phenols (F=68.7; df=31,95; $p$<0.001) were highest in *E. sativa* (IC62597), while lower in *B. tournefortii* (RBT 2003) and *B. fruticulosa*. Tannin levels were notably higher in *Crambe abyssinica* (EC694069, EC694071, EC694075, EC694090) and *Diplotaxis assurgens*, and lower in *B. juncea* cultivar PM 31. Additionally, certain lines, such as NDRS-9-2 and NDRS2001-1, exhibited lower phenol content and higher aphid infestation (Mishra *et al.* 2019). Biochemical constituents influence the growth, development, longevity, and food preferences of phytophagous insects, affecting the host plant's resistance or susceptibility (Awmack and Leather 2002). Secondary metabolites and nutrient balance in plants impact herbivorous insect populations (Samal *et al.* 2021). Specific nutrient levels are crucial for insect survival, growth, and reproduction (Bhoi *et al.* 2020). Furthermore, total antioxidants (F=80.7; df=31,95; $p$<0.001) and FRAP (F=98.5; df=31,95; $p$<0.001) content were significantly higher in *E. sativa* (IC62597) and *Diplotaxis muralis*, respectively, compared to other wild crucifer genotypes, including *B. juncea* cultivars, and lower in *B. tournefortii* (RBT 2002, RBT 2003). Samal *et al.* (2021) and Chandrakumara *et al.* (2024) highlighted that resistant *B. juncea* genotypes contain higher biochemical levels, contributing to their defense against *L. erysimi*. The nutritional quality of host plants, determined by their biochemical components, affects insect populations, influencing survival, growth, reproduction, and overall fitness. Secondary chemicals, such as phenolics, tannins, and terpenoids, render plants unfit for consumption by herbivores, thereby deterring insect pests (Bhoi *et al.* 2020).

*Association between constitutive biochemical factors and biological parameters of* L. erysimi: The amount of protein in the leaves of the test genotypes had a substantial and positive relationship with the total nymphal period (r=0.49*****), total developmental duration (r=0.37*****), and fecundity (r=0.31*****), while it showed a negative association with the percentage of survival (r= -0.38*****). In addition, there was a strong and positive association between the amount of sugar in the leaves and both the overall nymphal duration (r=0.38*****) and fecundity (r=0.41*****). Previous research has also documented a positive relationship between the total sugars content and the proliferation of *L. erysimi* (Samal *et al.* 2024). Chandrakumara *et al.* (2023) found a significant positive correlation between total proteins and the stage of development of *L. erysimi.* A significant and negative relationship was observed between the total phenols in the leaves of the test genotypes and the total nymphal time of mustard aphid (r = -0.58******), total development period (r = -0.73****)**, and fecundity (r = -0.85******). Chandrakumara *et al.* (2023) reported that total phenols and tannins had a significant and negative association with aphid infestation. Total tannins, antioxidants and FRAP showed significant and negative correlation with fecundity (r= -0.63$^{**}$), reproductive period (r= -0.83$^{**}$), total developmental period (r= -0.64$^{**}$), offspring survival (r= -0.37$^{*}$) and total nymphal period (r= -0.44*), respectively. Moreover, highly significant and negative correlation was recorded between phenol content and aphid multiplication (Samal *et al.* 2021). The result of multiple linear regression analysis of total protein ($X_1$) total sugars ($X_2$), total phenols ($X_3$), total tannins ($X_4$), total antioxidants ($X_5$) and FRAP ($X_6$) in test genotypes leaves indicated that these compounds contribute to 34.6%, 32.1%, 42.2%, 78.6% and 58.7% variability for total nymphal period ($143.41+15.57X_1-3.49X_2-5.13X_3-19.69X_4-0.01X_5+0.001X_6$; $R^2 = 34.6$), reproductive period ($104.97-2.37X_1+0.23X_2+15.11X_3-10.76X_4-0.29X_5-10.09X_6$; $R^2 = 32.1$), total developmental period ($381.29+46.46X_1-13.91X_2-11.21X_3-24.45X_4+22.64X_5-16.38X_6$; $R^2 = 42.2$), fecundity ($26.96-15.60X_1+3.19X_2-13.54X_3-0.88X_4-12.06X_5+5.64X_6$; $R^2 = 78.6$) and offspring survival (%) ($52.13-11.62X_1+2.52X_2+9.38X_3+0.15X_4-10.76X_5-4.87X_6$; $R^2 = 58.7$). In addition, Samal *et al.* (2024) had found that pest population was significantly and negatively correlated with tannins and phenols in the same way, population increase of *L. erysimi* was also negatively correlated with tannins and phenols in the *B. juncea* genotypes. Chandrakumara *et al.* (2023) observed a rise in total antioxidants in *B. juncea* cultivars after infestation of mustard aphid. Some of the biochemicals have also been stated to be efficient for providing protection against several insect pests (Bhoi *et al.* 2020). The endogenous and/or exogenous plant secondary metabolites regulate the insect-plant relationship that culminates in plant resistance to insects (Samal *et al.* 2021). Quality of host plant may be defined by the presence of allelochemicals, nutrients and anatomical characteristics of the host plant. The total of all the morphological, biochemical and anatomical

Table 2 Constitutive phytochemicals in the leaves of wild crucifer genotypes

| Genotype | Total proteins (mg/g) | Total sugars (mg/g) | Total phenols (mg/g) | Tannins (mg/g) | Total antioxidants (mg/g) | FRAP (mg/g) |
|---|---|---|---|---|---|---|
| *Brassica chinensis* | 3.2 | 14.2 | 3.4 | 0.4 | 4.7 | 2.6 |
| *Brassica fruticulosa* | 1.4 | 10.2 | 1.9 | 0.3 | 3.2 | 0.8 |
| *Brassica fruticulosa* (Spain) | 1.7 | 11.0 | 2.1 | 0.4 | 3.3 | 1.2 |
| *Sisimbrium* (BWMR) | 1.6 | 10.7 | 2.2 | 0.3 | 3.4 | 1.1 |
| *Brassica tournefortii* (RBT 2002) | 1.0 | 9.3 | 2.1 | 0.2 | 3.3 | 0.5 |
| *Brassica tournefortii* (RBT 2003) | 1.0 | 9.4 | 1.8 | 0.1 | 3.0 | 0.5 |
| *Camelina sativa* | 2.1 | 11.7 | 2.6 | 0.3 | 3.9 | 1.5 |
| *Capsella bursapastoris* (Early) | 2.3 | 12.4 | 2.9 | 0.2 | 4.1 | 1.8 |
| *Capsella bursapastoris* (Late) | 1.8 | 11.1 | 2.6 | 0.4 | 3.8 | 1.3 |
| *Diplotaxis assurgens* | 2.0 | 11.5 | 2.7 | 0.5 | 3.9 | 1.5 |
| *Diplotaxis erucoides* | 1.5 | 10.4 | 2.3 | 0.3 | 3.5 | 0.9 |
| *Diplotaxis gomez-campoi* | 3.3 | 14.4 | 3.7 | 0.1 | 5.0 | 2.7 |
| *Diplotaxis muralis* | 3.4 | 14.8 | 4.1 | 0.1 | 5.3 | 2.9 |
| *Diplotaxis siettiana* | 3.3 | 14.5 | 4.0 | 0.2 | 5.2 | 2.8 |
| *Diplotaxis tenuisilique* | 3.0 | 13.9 | 3.7 | 0.1 | 5.0 | 2.5 |
| *Diplotaxis viminea* | 2.8 | 13.5 | 3.6 | 0.1 | 4.8 | 2.3 |
| *Enarthrocarpus lyratus* | 1.5 | 10.6 | 2.7 | 0.1 | 4.0 | 1.0 |
| *Erucastrum canariense* | 1.6 | 10.8 | 2.8 | 0.3 | 4.0 | 1.1 |
| *Lepidium sativum* | 2.2 | 12.0 | 3.1 | 0.3 | 4.3 | 1.7 |
| *Sisimbrium* spp. | 1.6 | 10.7 | 2.2 | 0.1 | 3.4 | 1.1 |
| *Crambe abyssinica* (EC400058) | 2.4 | 13.7 | 2.9 | 0.2 | 4.1 | 1.9 |
| *Crambe abyssinica* (EC694069) | 3.1 | 12.3 | 2.8 | 0.4 | 4.0 | 2.6 |
| *Crambe abyssinica* (EC694071) | 2.9 | 12.7 | 3.0 | 0.4 | 4.2 | 2.4 |
| *Crambe abyssinica* (EC694075) | 2.8 | 14.4 | 3.0 | 0.4 | 4.2 | 2.2 |
| *Crambe abyssinica* (EC694090) | 2.9 | 13.7 | 3.7 | 0.6 | 4.9 | 2.4 |
| *Crambe abyssinica* (EC694125) | 3.2 | 14.4 | 3.9 | 0.3 | 4.3 | 2.7 |
| *Eruca sativa* (IC57705) | 3.7 | 15.4 | 4.3 | 0.3 | 5.6 | 3.2 |
| *Eruca sativa* (IC60468) | 3.8 | 15.6 | 4.4 | 0.3 | 5.7 | 3.3 |
| *Eruca sativa* (IC62597) | 4.5 | 17.2 | 5.0 | 0.3 | 6.2 | 4.0 |
| *Brassica junce*a (RH 725) | 1.5 | 11.9 | 3.5 | 0.3 | 3.6 | 1.8 |
| *Brassica juncea* (PDZM 31) | 2.1 | 14.9 | 4.1 | 0.1 | 4.2 | 1.7 |
| *Brassica juncea* (PM 30) | 2.0 | 13.7 | 3.9 | 0.2 | 4.2 | 1.6 |
| F-probability | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| LSD (*p*=0.05) | 1.66 | 1.69 | 1.52 | 0.96 | 0.52 | 1.85 |

plant characteristics gives a long-lasting resistance against insect pests and some anti-nutritional factors such as lignin and phenolic compounds also act as barriers to herbivory. However, the stepwise regression study suggested that total proteins, total sugars, total phenols, and total anti-oxidants explained 78.1% variability in fecundity ($26.74-10.24X_1+2.61X_2+15.68X_3-13.44X_5$; $R^2 = 78.1$). Total proteins, phenols and anti-oxidants explained 55.9% variability in offspring survival ($69.04-3.93X_1+15.15X_3-13.63X_5$; $R^2 = 55.9$), suggesting that these phytochemicals in test wild crucifers' genotypes contribute to varying effects on development, reproduction, and survival of *L. erysimi*. Previous work also found adverse effects of overall antioxidants and total tannins on the duration of development, generation of offspring, and survival of mustard aphid on Indian mustard (Chandrakumara *et al.* 2023). Previous studies have found that these antinutritional components in *B. juncea* have a negative correlation with embryonic and reproductive biology of *L. erysimi* (Samal *et al.* 2021).

The current research has revealed that the wild crucifer genotypes, *E. sativa* (IC57705, IC60468, IC62597), *B. tournefortii* (RBT 2002, RBT 2003), *L. sativum, C. abyssinica* (EC694069, EC694071, EC694075, EC694090) and *D. assurgens,* exhibit elevated levels of biochemical constituents. These heightened levels negatively impacted the survival and development of *L. erysimi.* Therefore, these genotypes hold significant potential for use in breeding programmes aimed at developing aphid-resistant Indian mustard verieties.

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