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Assess the biochemical resistance against mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard crop

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Abstract
Determine bio-chemical constituent for their resistance against mustard aphid, *Lipaphis erysimi* (Kalt.) on *Brassica* genotypes under natural conditions of Kanpur UP. The study was carried out during Rabi 2015-16 at the oilseed research farm Kalyanpur and laboratory of the Oilseeds Section, Department of Entomology, CSA University Kanpur. Ten genotypes belonging to *Brassica* spp., viz., Basanti, Kranti, Urvashi, Vardan, Varuna, Rohani, Vaibhav, Pitambari, Varuna, BSH-1, and YST-151 were included Observations on the *L. erysimi* at Inflorescence stage and pod formation stage and aphid infestation index (A.I.I.) was computed. These data were correlated with biochemical parameters such as total phenols, sugars, amino acid content, and plant waxes. The genotypes viz., Basanti, Pitambari, and Kranti had plenty of phenol content on the base of the pooled mean of plant growth stages i.e. 1.51, 1.60, and 1.85%, respectively. The A.I.I. and total phenols were observed significantly negatively correlated (r = -0.92**). The effect of waxes in leaves and Inflorescence had a lethal effect (A.I.I. vs leaf waxes correlation being significantly negative with r = -0.91**). A.I.I. was observed significantly positively correlated with amino acid content (r =0.91**) and total sugar content (r= 0.98**). The present finding showed that a negative correlation has been observed between the phenol content and the aphid population.

Keywords: *Brassica* genotypes, *Lipaphis erysimi*, resistance, biochemicals, phenol, plant waxes, sugar, amino acid, correlation coefficients, aphid infestation index

Introduction
Rapeseed-mustard is one of the most important edible oilseed crops, which occupies the second position after groundnut contributing to about 27.8% of the Indian oilseed economy. Among different rapeseed-mustard species, *Brassica juncea* (L.) Czern. & Coss. occupies >80% of the mustard area in India, and is grown on 87.44 lakh million ha with a production of 109.5 million tones (ASG 2021). In India, the average productivity of rapeseed mustard is 1270 kg/ha. Among the constraints in productivity, the damage by insect pests is the most important. Rai (1976) [20] listed 24 species, while Bakhetia and Sekhon (1984) [5] enlisted 38 species. However, Purwar *et al.* (2004) [19] reported more than 43 species of insect pests out of which about a dozen are considered major pests. Among these aphids *Lipaphis erysimi* Kalt., *Brevicoryne brassicae* L. and *Myzus persicae* Sulzer (Hemiptera: Aphididae)] are the most destructive (Desh Raj et al., 1996; Sarangdevot *et al.*, 2006) [8, 22]. Of these, *L. erysimi* causes up to 9-96% yield and 31% seed weight loss, and a 5-6% reduction in oil content (Bakhetia and Sekhon, 1989; Singh and Sharma, 2002; Dhaliwal et al., 2004; Rana 2005; Shylesha *et al*., 2006; Parmar *et al*., 2007) [6, 28, 9, 21, 24, 18]. Such losses may go up to 100% in certain mustard-growing regions (Singh and Sachan, 1999) [25] due to infestation (Mandal *et al.*, 2012) [16]. Insecticides are mostly used against these aphids, but these are harmful to their natural enemies (Singh *et al*., 2007) [27], and also cause pollution, residues, and other hazards (Singh and Sharma, 2002) [28]. The Use of resistant cultivars is an eco-friendly alternative IPM strategy as it is compatible with other control methods. This study evaluates the effect of biochemical in *Brassica* spp., on aphid resistance.

Materials and Methods
Experiments were conducted at OilSEED Farm Kalyanpur C.S. Azad University of Agriculture and technology, Kanpur (U.p.) The crops were grown under sown (date of sowing 27.10.2015) conditions with Recommended Package of Practices (Anonymous, 2015) [3] Ten genotypes belonging to ten *Brassica* spp., Basanti, Kranti, Urvashi, Vardan, Varuna, Rohani, Vaibhav, Pitambari, Varuna, BSH-1, and YST-151 were evaluated in plots of 3x 3 m, with the spacing of 30x 10 cm, in RBD with three replications. were collected from different centers of

the All India Coordinated Research Project (AICRP) on Rapeseed and Mustard. Aphid Infestation Index (AII) was computed with the observations made on the population of *L. erysimi* at flower initiation, full flowering, and full pod formation/ setting stages. Ten plants were selected at random from each in each replication, and the number of aphids was observed from the top 10 cm portion of the terminal shoot (Bakhetia and Sandhu, 1973) [4]. Finally, the AII of the three stages was pooled and the pooled mean was calculated. For AII, the numbers of selected/ tagged plants falling in each grade were multiplied by the respective grade and the total was divided by plant population in each repeat of a genotype on which grading was done. The pooled mean of each genotype was worked out based on the mean of three replications.

$$A.I.I. = \frac{o \times a + 1 \times b + 2 \times c + 3 \times d + 4 \times e + 5 \times f}{a + b + c + d + e + f}$$

Where,
a, b, c, d, e, and f are the numbers of plants under each grade.
A.I.I. of each genotype based on 10 plants/ replication was estimated twice, first at the full flowering stage and second at the pod setting stage. Finally, the A.I.I. of each genotype determined at two stages of crop growth was pooled to compute the overall mean A.I.I. different genotypes were further grouped into three categories considering the lowest A.I.I. as resistant followed by moderately resistant and susceptible in lower to the higher order of A.I.I. as follows:

The lowest A.I.I. as resistant followed by moderately resistant and susceptible in lower to the higher order of A.I.I. as follows

Grade	Description
0	Free from aphid infestation. Plants show excellent growth.
1	Plants having 1-15 aphids/ inflorescence. Normal growth, no curling or yellowing of a few leaves, except only a few aphids along with little or no symptoms of injury.
2	Plants having 16-100 aphids/ inflorescence. Average growth, curling, and yellowing of a few leaves.
3	Plants having more than 100 aphids/ inflorescence. Growth is below average, with curling and yellowing of the leaves on some branches. Plants show some stunting, poor flowering, and little pod setting.
4	Heavy aphid colonies on plants. Very poor growth, heavy curling and the yellowing of leaves, stunting of plants, little or no flowering, and only a few pods forming.
5	Plants full of aphids. Heavy stunting of plants; curling, crinkling, and yellowing of almost all the leaves. No flowering and pod formation.

Plant biochemical constituents may have a role in imparting resistance to the plants against mustard aphids. So ten randomly selected competitive plants of each genotype were uprooted at the inflorescence and pod formation stage from the field. The samples were brought to the laboratory, kept in air-tight plastic containers, and stored at 4 °C. Total phenols, total sugars, amino content, and plant waxes were estimated by the methods suggested by Swain and Hills (1959) [29], Yemm and Willis (1954) [31] using anthrone reagent, Bates *et al.* (1973) [7], and Ebercon *et al.* (1977) [10] by colorimetric analysis, respectively. Correlation analysis of AII with biochemical parameters was done with Online Statistical Analysis Package (OPSTAT) by Sheoran *et al.* (1998) [23].

Results and Discussion

Biochemical constituents

The number of total sugars varied from 7.15% (Vaibhav) to 10.22% (Basanti) in the inflorescence and pod formation stage it varied from 8.12% (Vaibhav) to 11.43% (Pitambari) Table: 1. On the base of pooled mean total sugars content varied from 7.64% (Vaibhav) to 10.76% (Pitambari). The genotypes viz., Basanti, Kranti, Pitambari, Varuna, and BSH-1 had the highest amount of total sugars in the inflorescence stage i.e. 10.22, 10.09, 9.15,8.32 and 8,24% respectively whereas in pod formation stage *Brassica* genotypes viz., Basanti, Kranti, Pitambari, Varuna, and BSH-1 had the maximum amount of total sugars i.e. 11.43, 11.24, 10.01, 9.41 and 9.30%, respectively. The amount of phenol content in Inflorescence varied from a minimum of 1.25% in (Basanti) to a maximum of 3.04% in (Rohani) Table: 1. Similar trend was observed in the Pod formation stage of various *Brassica* genotypes with a minimum of 1.77% phenol content in Basanti to a maximum of 3.33% in genotype Rohani. Based on the pooled mean of plant parts, total phenols varied from a minimum of 1.51% Basanti to a maximum of 3.19% Rohani. The genotypes such as Vardan, YST-151, Vaibhav, and Rohani had phenol content more than the mean i.e. 2.29%. The genotypes viz., Basanti, Pitambari**,** and Kranti had plenty of phenol content on the base of the pooled mean of plant growth stages i.e. 1.51, 1.60, and 1.85%, respectively. The amount of wax content in the Inflorescence stage of *Brassica* genotypes varied from the minimum of 2.89% Basanti to the maximum of 5.72% YST-151. Table: 1 showed that the genotypes having high content plant waxes viz., Urvashi (4.92%), Vardan (5.35%), Vaibhav (5.39%), Rohani (5.45%) and YST-151 (5.72%) had a low infestation of mustard aphid (0.8-1.6 AAI). The genotypes such as Basanti, Kranti, Pitambari, and Varuna had the lowest plant surface wax (%) content i.e. 2.89, 3.1, 3.17, and 3.21%, respectively. Amino Acid (µmol/ g) Inflorescence stage content in *Brassica* genotypes varied from the minimum of 15.39 (Rohani**)** to the maximum of 18.25 µmol/g (Basanti)**,** whereas in the pod formation stage, it varied from the minimum of 9.45 µmol/g (Rohani**)** to maximum of 14.53 µmol/ g (Basanti). Based on pooled mean of plant growth stages, amino acid content varied from a minimum of 12.42 µmol/g (Rohani) to a maximum of 16.36 µmol/g (Basanti). Based on pooled mean, it is evident that the genotypes such as BSH-1, Urvashi, Kranti, Varuna, Pitambari and Basanti had amino acid content more than the mean i.e. 14.55 µmol/g. The genotypes such as Rohani, YST-151, Vaibhav, and Vardan had the lowest Amino Acid content i.e. 12.42, 13.02, 13.38, and 14.28 µmol/ g respectively.

Correlation of Aphid Infestation Index

The correlation analysis between various biochemical qualities present in the inflorescence stage and A.I.I. as shown in Table: 1 shows that total sugars and amino acid content positively and significantly correlated (r = 0.98** and r = 0.75**) with A.I.I. The correlation of A.I.I. was also significant and negative with phenols (r = -0.94*) and plant waxes (r =-0.91**). Similarly, the correlation analysis

between various biochemical qualities in the pod formation stage and A.I.I. presented in the Table:1 shows that A.I.I. and total sugar content positively and significantly correlated (r= 0.97**) and amino acid content (r= 0.84**) with each other, while the negative and significant correlation was found with phenols (r =0.88**) Also, the correlation analysis between various biochemical traits (pooled data) and A.I.I. presented in the Table:1 exposed that A.I.I. and amino acid content (r=0.91**) and total sugar content (r = 0.98**) were positively and significantly with each other, while the total phenols were negatively and significantly correlated (r= -0.92**) with each other.

Table 1: Biochemical constituent concerning mustard aphid resistance in *Brassica* genotypes

Genotypes	Aphid population (Av. No./ plant)	Inflorescence stage				Pod formation stage			Pooled data		
		Sugar content (%)	Amino Acid µmol/ g	Leaf waxes (%)	Phenol content (%)	Sugar content (%)	Amino Acid µmol/ g	Phenol content (%)	Sugar content (%)	Amino Acid µmol/ g	Phenol content (%)
Basanti	4.3	10.22	18.25	2.89	1.25	11.43	14.53	1.77	10.73	16.36	1.51
Kranti	2.9	9.15	16.57	3.1	1.66	10.01	13.93	2.04	9.58	15.25	1.85
Urvashi	1.6	8.18	16.8	4.92	1.97	9.23	13.16	2.08	8.71	14.98	2.03
Vardan	1.5	7.86	17.59	5.35	2.76	8.29	10.96	2.66	8.08	14.28	2.71
Varuna	2.2	8.32	16.07	3.21	2.01	9.41	14.46	2.13	8.87	15.30	2.07
Rohani	0.8	7.18	15.39	5.45	3.04	8.24	9.45	3.33	7.71	12.42	3.19
Vaibhav	1.1	7.15	15.95	5.39	2.76	8.12	10.81	2.95	7.64	13.38	2.86
Pitambari	3.6	10.09	17.39	3.17	1.34	11.24	14.21	1.85	10.76	15.80	1.6
YST-151	0.9	7.22	15.54	5.72	2.64	8.16	10.5	3.05	7.69	13.02	2.85
BSH-1	2.2	8.24	15.99	4.26	2.16	9.30	13.35	2.25	8.77	14.67	2.21
Mean	—	8.36	16.55	4.35	2.16	9.34	12.54	2.41	8.85	14.55	2.29
Range	—	7.15-10.22	15.39-18.25	2.89-5.72	1.25-3.04	8.12-11.43	9.45-14.53	1.77-3.53	7.64-10.76	12.42-16.36	7.64-10.76
C.D. at 5%	—	0.63	0.07	0.29	0.14	0.42	0.05	0.19	0.53	0.06	0.53
r	—	0.98	0.75	-0.91**	-0.94	0.97	0.84	-0.88	0.98	0.91	0.92

R2: Inflorescence stage 0.98, Pod formation stage 0.94, Pooled 0.97

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