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Seasonal Incidence of mustard flea beetle, *Phyllotreta cruciferae on Brassica* species in relation to weather parameters at different dates of sowing

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Abstract
The present field experiment was carried out to study the incidence of flea beetle on *Brassica* species in different dates of sowing at Norman E. Borlaug Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar, India during *Rabi* 2015-16 and 2016-17. Eight *Brassica* species including *B. rapa* cv. BSH-1and YST-151, *B. alba, B. carinata, B. nigra*, *E. sativa* cv. T-27, *B. juncea* cv. Varuna and *B. napus* cv. GSC-6 were sown on five dates of sowing starting from October 3 to December 3, 2015 and 2016 at fifteen days interval. The results showed that *E. sativa* harboured highest population of *P. cruciferae* (5.79 and 19.2 bettles/ m^2) while it was lower on *B. carinata* (2.08 and 6.1 bettles/ m^2) during consecutively for two years, 2015-16 and 2016-17. the population of flea beetle recorded on different *brassica* species in present study different significantly with respect to different dates of sowing in both the years. regarding the date of sowing, overall mean population of *P. cruciferae* was found maximum in first, second and third sowing date of sowing while minimum in fourth and fifth date of sowing during 2015-16. however, the flea beetle population was found higher in fourth and fifth date of sowing during 2016-17.

Keywords: Phyllotreta cruciferae, brassica, mustard, seasonal incidence

1. Introduction

The mustard flea beetle, *Phyllotreta cruciferae* Goeze (Coleoptera: Alticinae) are the most abundant and most economically damaging insect pest in *Brassicas* and show diverse adaptation to wide range of environmental conditions and habitats [15]. They are also highly specialized insects feeding on a wide range of plant groups and are important both ecologically and economically due to their worldwide distribution and distinct host range [3, 7].

The adults are active leaf-feeders that can, in large numbers, rapidly defoliate and kill plants. Symptoms of flea beetle feeding are small, rounded, irregular holes; heavy feeding makes leaves look as if they had been peppered with fine shot [9]. They are mostly oligophagous, occasionally polyphagous and rarely monophagous [13]. Flea beetles are one of the most difficult-to-manage pests of egg plant and cole crops [8] and cause substantial damage on host plants by feeding on the leaves, especially in early stages of development [16] when it is most vulnerable. The cotyledons of these crops are very attractive to flea beetles. Heavy damage at the early stage of cotyledons may destroy a plant completely. But as plants develop the leaves become waxier. The waxy surface is more difficult for beetles to grasp and feed upon as a result beetles feed mostly at the leaf margins once true leaves have developed. They are also a problem on seedlings of tomatoes, potatoes, peppers, turnips, radishes and maize. They occasionally damage flowers, shrubs and even trees. The adults are active leaf-feeders that can in large numbers rapidly defoliate and kill plants [5, 9]. They can invade a field very quickly in huge numbers, can cause irreversible plant damage in a short time, yield losses of 10% or more are not uncommon where flea beetles are present in relatively high numbers [11]. Potential loss due to flea beetle injury is the highest during the first two to three weeks after crop emergence; yield loss can be minimized if adult beetles are controlled during those weeks [18]. The aim of this study was to collect information on occurrence and abundance of flea beetle associated with *Brassica* species with respect to different dates of sowing in Uttarakhand.

Materials and Methods

Field trials were conducted in Randomized block design (R.B.D.) to record the incidence of *P. cruciferae* on *Brassica* species including and *Brassica rapa* ecotype. brown *sarson* (BSH-1), *B. rapa* ecotype yellow *sarson* (YST-151), *B.* (PSB-I), *B. carinata* (CCN-06-1), *B. nigra* (Surya), *B. juncea* (Varuna), *B. napus* (GSC-6) and *Eruca sativa* (T-27) at Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (India) during *rabi* season of 2015-16 and 2016-17. Five sowing dates *viz*., October 3 (First sowing), October 18 (Second sowing), November 3 (Third sowing), November 18 (Fourth sowing) and December 3 (Fifth sowing) were selected for raising the crop except spray of insecticides. The plot size was 4.2m x 3m and the row to row and plant to plant space of 30 cm and 10 cm, respectively. Each treatment was replicated thrice. The observations on number adults were made weekly from five sites of one meter square area in each treatment. The required meteorological data such as maximum and minimum temperature, morning and afternoon RH and rainfall was recorded from the meteorological observatory of G.B. Pant University of Agriculture and Technology, Pantnagar.

Statistical analysis

The data subjected to the analysis of variance using Randomized block design (R.B.D.) programme. Correlation between weather parameters and population of flea beetle were carried out.

Results

The data on incidence of flea beetle are presented in Table 1. In fist sowing (Oct 3), maximum population of beetle was recorded on *B. nigra* (3.85 beetles/m^2) followed by *B.rapa* (BSH-1) (3.23 beetles/m^2) while minimum was noted on *B. carinata* (1.37 beetles/m^2). In second sowing (Oct 18), the beetle population was found to be markely higher and recorded maximum on *B. nigra* (7.26 beetles/m^2). The next species, having higher population were *B.rapa* (YST-151) (6.46 beetles/m^2) and *E. sativa* (6.39 beetles/m^2) whereas lower population was noted again on *B. carinata* (3.79 beetles/m^2). In third sowing (Nov 3), the beetle population again increased up to 12.75 beetles/m^2 on *E. sativa*. *B. alba* (8.85 beetles/m^2) and *B. juncea* (6.8 beetles/m^2) were the next harbouring higher population of beetle whereas lowest population was noted once again on *B. carinata* (2.85 beetles/m^2). In forth sowing (Nov 18), the beetle population began to decline up to 0.33/m^2 in *B.rapa* (BSH-1). However, it was still considerably higher on *E. sativa* (7.1 beetles/m^2). In fifth sowing (Dec 3), population was again decreased and noted zero on *B. napus*, *B. alba* and *E. sativa*. However, the population was present in relatively higher number on *B.rapa* (YST-151) (1.33 beetles/m^2) and *B. carinata* (1.1 beetles/m^2). During 2016-17, in first sowing (oct, 3) maximum mean population of *p. cruciferae* was recorded on *E. sativa* (14.2 beetles/ m^2). It was followed by BSH-1(9.5 beetles/ m^2), *B. nigra*, *B. alba* and YST-151(7.9 and 7.7 beetles/ m^2) while least population was recorded on *B. carinata* (2.6 beetles/m^2). the population of flea beetle of considerably higher in second date of sowing (oct, 18) than the first date of sowing. the maximum population was found on T-27 (23.6 beetles/m^2), *B. alba* (22.3 beetle/m^2) followed by BSH-1(17.5 beetles/m^2), varuna (12.8 beetles /m^2), YST-151 (11.0 beetles/m^2) while minimum on *B. carinata* (5.6 beetles/m^2). the population of *p. cruciferae* was found lower in third date of sowing (Nov, 3) than the second dateof sowing. The maximum population was found again on T-27 (19.9 beetles /m^2) followed by *B. alba* (13.4 beetles/m^2), *B. nigra* (11.6 beetles /m^2) while least population was again found on *B. carinata* (3.8 beetles /m^2). in fourth sowing (Dec 3), the population of *P. cruciferae* was found slightly higher than third date of sowing (Nov 3). The maximum population was found on GSC-6(54.1 beetles/m^2) followed by T-27(23.5 beetles /m^2), *B. alba* (14.5 beetles /m^2), varuna (10.5 beetles/m^2), (9.7 beetles/m^2) in BSH-1 and YST-151 while minimum in *B. carinata* (4.9 beetles/m^2). however, the flea beetle population was considerably higher in fifth date of sowing as compared to the previous sowing. The beetle population was found higher on *B. nigra* (22.0 beetles/m^2), YST-151 (21.0 beetles/m^2), BSH-1 (19.8 beetles /m^2), *B. alba* (15.7 beetles /m^2), *B. juncea* (14.9 beetles/m^2), T-27 (14.6 beetles /m^2), *B. carinata* (13.5 beetles/m^2) whereas lowest on *B. napus* (12.0 beetles /m^2).On the basis of overall mean, *E. sativa* harboured maximum population of *P. cruciferae* while it was lower in *B. carinata*. the population of flea beetle recorded on *brassica* species in present study different significantly with respect to different dates of sowing consecutively for two years, 2015-16 and 2016-17. regarding the date of sowing, overall mean population of *P. cruciferae* was found maximum in first, second and third dates of sowing while minimum in fourth and fifth date of sowing during 2015-16. however, the flea beetle population was found higher in fourth and fifth date of sowing during 2016-17. The population of *P. cruciferae* exhibited significant negative correlation with maximum and minimum temperature,wind velocity while positive correlation with morning and evening relative humidity and rainfall in all *brassica* species during 2015-16 and 2016-17(Table 2 and 3).

Table 1: Population of flea beetle on *Brassica* species in different dates of sowing during *Rabi* 2015-16 and 2016-17.

DOS/ *Brassica species*	2015-16								2016-17							
	BSH-1	YST-151	Varuna	GSC-6	*B. carinata*	*B. nigra*	T-27	*B. alba*	BSH-1	YST-151	Varuna	GSC-6	*B. carinata*	*B. nigra*	T-27	*B.alba*
D1	3.23	2.95	2.71	2.47	1.37	3.85	2.75	2.94	9.5	7.7	5.6	3.5	2.6	7.9	14.2	7.9
D2	4.06	6.46	4.99	5.59	3.79	7.26	6.39	4.39	17.5	11.0	12.8	5.9	5.6	9.6	23.6	22.3
D3	4.85	4.47	6.80	5.42	2.85	6.37	12.75	8.85	5.8	5.5	5.1	5.2	3.8	11.6	19.9	13.4
D4	0.33	1.33	0.55	1.66	1.33	1.33	7.10	2.44	9.7	9.7	10.5	54.1	4.9	16.3	23.5	14.5
D5	0.55	1.33	0.55	0.0	1.10	0.55	0.0	0.0	19.8	21.0	14.9	12.0	13.5	22.0	14.6	15.7
Mean	2.60	3.30	3.12	3.02	2.08	3.87	5.79	3.72	12.5	10.9	9.8	16.1	6.1	13.5	19.2	14.7
Sem	0.75	0.80	1.01	0.89	0.43	1.08	1.76	1.20	2.16	2.18	1.58	7.84	1.57	2.08	1.68	1.89
C.D. at 5%	3.53	3.77	4.74	4.17	2.02	5.10	8.29	5.62	10.16	10.26	7.45	36.86	7.39	9.80	7.89	8.87
CV	70.72	59.32	79.05	71.84	50.46	68.55	74.51	78.63	42.45	48.74	39.65	118.98	63.23	37.86	21.45	31.32
F-test	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s

* DOS- Date of sowing

Table 2: Correlation between the population of *P. cruciferae* and weather parameters on *Brassica* species in different dates of sowing during *Rabi* 2015-16.

***Brassica* spp.**	**DOS**	**T_{max}**	**T_{min}**	**RH1**	**RH2**	**RF**	**SS**	**WS**	***Brassica* spp.**	**DOS**	**T_{max}**	**T_{min}**	**RH1**	**RH2**	**RF**	**SS**	**WS**
BSH-1	I	-0.49	-0.60	0.57	-0.43	0.74	0.09	0.09	*B. carinata*	I	-0.38	-0.35	0.32	-0.24	0.82	-0.11	0.45
	II	0.65	-0.39	0.07	-0.87	-0.20	0.79	0.22		II	0.46	-0.55	0.26	-0.72	-0.21	0.78	0.13
	III	0.83	0.74	-0.74	-0.29	0.00	0.23	-0.41		III	0.81	0.58	-0.60	-0.41	0.00	0.46	-0.60
	IV	-0.89	-0.74	0.89	0.61	-0.50	-0.16	-0.95		IV	-0.97	-0.74	0.89	0.61	-0.50	-0.16	-0.95
	V	-0.86	-0.89	0.29	0.61	0.0	-0.71	0.23		V	0.61	0.48	-0.41	-0.61	0.00	0.34	0.11
YST-151	I	-0.51	-0.62	0.59	-0.49	0.77	0.11	0.08	*B. nigra*	I	-0.77	-0.94	0.89	-0.83	0.42	0.32	0.07
	II	0.06	-0.75	0.75	-0.48	-0.27	0.66	-0.77		II	0.65	-0.52	0.36	-0.92	-0.10	0.98	-0.41
	III	0.66	0.76	-0.73	-0.02	0.0	0.0	-0.09		III	0.86	0.76	-0.51	-0.26	0.0	0.18	-0.51
	IV	-0.96	-0.74	0.89	0.61	-0.50	-0.16	-0.95		IV	-0.90	-0.74	0.89	0.61	-0.50	-0.16	-0.95
	V	-0.86	-0.89	0.29	0.61	0.00	-0.71	0.23		V	-0.05	-0.10	0.50	0.24	0.0	-0.38	-0.69
Varuna	I	-0.46	-0.42	0.48	-0.23	0.80	-0.30	0.20	T -27	I	-0.48	-0.48	0.52	-0.42	-0.46	0.14	-0.73
	II	-0.14	-0.52	0.63	-0.09	-0.05	0.37	-0.71		II	0.29	-0.10	0.16	-0.15	0.45	0.49	-0.42
	III	0.83	0.74	-0.75	-0.28	0.0	0.20	-0.39		III	0.98	0.81	-0.76	-0.47	0.0	0.12	-0.55
	IV	-0.95	-0.74	0.89	0.61	-0.50	-0.16	-0.95		IV	-0.66	0.01	0.93	1.00	0.32	-0.84	-0.41
	V	0.16	0.33	0.19	0.09	0.00	0.31	-0.36		V	0.00	0.0	0.0	0.0	0.0	0.0	0.0
GSC- 6	I	-0.36	-0.66	0.55	-0.54	-0.05	0.65	-0.34	*B. alba*	I	-0.84	-0.78	0.80	-0.69	0.53	0.05	-0.47
	II	0.10	-0.90	0.83	-0.71	-0.57	0.73	-0.71		II	-0.21	-0.56	0.62	-0.02	-0.09	0.32	-0.55
	III	0.87	0.56	-0.78	-0.58	0.00	0.52	-0.62		III	0.88	0.64	-0.74	-0.48	0.0	0.44	-0.58
	IV	-0.19	0.52	0.61	0.89	0.76	-0.96	0.11		IV	0.04	0.70	0.42	0.77	0.88	-0.98	0.34
	V	0.00	0.0	0.0	0.0	0.0	0.0	0.0		**V**	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Tmax (Maximum temperature °C), Tmin (Minimum temperature °C), RH1 (Morning relative humidity, %), RH2 (Evening relative humidity, %),RF (Rainfall, mm), SSH (sunshine hours),WS(wind speed),DOS-Date of sowing.
** bold values indicates the Significant correlation

Table 3: Correlation between the population of *P. cruciferae* and weather parameters on *Brassica* species in different dates of sowing during *Rabi* 2016-17.

***Brassica* spp.**	**DOS**	**T_{max}**	**T_{min}**	**RH1**	**RH2**	**RF**	**SS**	**WS**	***Brassica* spp.**	**DOS**	**T_{max}**	**T_{min}**	**RH1**	**RH2**	**RF**	**SS**	**WS**
BSH-1	I	0.62	0.31	-0.62	-0.12	0.0	0.57	-0.21	*B. carinata*	I	0.20	-0.10	-0.25	-0.38	0.0	0.35	-0.12
	II	-0.92	-0.86	0.90	0.30	0.0	-0.94	0.66		II	-0.63	-0.54	0.61	0.70	0.0	-0.90	0.24
	III	0.62	0.60	-0.34	-0.21	-0.17	-0.12	-0.93		III	-0.01	0.04	0.43	0.34	0.09	-0.46	-0.59
	IV	0.001	0.22	-0.37	0.08	-0.01	-0.19	0.02		IV	0.35	0.36	-0.03	-0.002	0.76	-0.03	-0.36
	V	0.34	0.08	-0.47	-0.45	-0.13	0.56	-0.35		V	-0.20	-0.62	0.21	-0.52	0.33	0.38	-0.08
YST-151	I	0.18	-0.09	-0.48	-0.42	0.0	0.31	-0.42	*B. nigra*	I	0.04	-0.19	-0.59	-0.52	0.0	0.54	-0.90
	II	-0.80	-0.73	0.79	0.51	0.0	-0.97	0.47		II	-0.66	-0.57	0.64	0.68	0.0	-0.92	0.28
	III	0.32	0.12	0.03	-0.15	-0.19	-0.10	-0.80		III	-0.02	-0.12	0.20	-0.12	-0.81	0.06	-0.24
	IV	-0.23	-0.61	0.33	-0.15	-0.50	0.03	-0.15		IV	-0.61	-0.64	0.29	0.15	-0.26	0.07	0.81
	V	-0.05	-0.16	0.25	-0.20	0.34	0.38	-0.19		V	-0.04	-0.46	0.04	-0.50	-0.23	0.33	0.60
Varuna	I	0.71	0.44	-0.84	-0.03	0.0	0.52	-0.44	T -27	I	0.20	-0.17	-0.60	-0.59	0.0	0.77	-0.95
	II	-0.76	-0.68	0.74	0.57	0.0	-0.96	0.41		II	-0.96	-0.95	0.94	0.01	0.0	-0.95	0.85
	III	0.47	0.46	-0.19	-0.07	-0.12	-0.24	-0.89		III	0.47	0.23	-0.03	-0.52	-0.51	0.48	-0.41
	IV	-0.47	-0.45	0.07	0.06	-0.12	0.18	0.85		IV	0.49	0.46	-0.76	-0.44	-0.32	0.22	-0.41
	V	0.54	-0.02	-0.23	-0.50	0.75	0.48	0.09		V	-0.13	-0.46	0.38	-0.39	-0.10	0.20	0.39
GSC- 6	I	0.34	0.17	-0.56	-0.11	0.0	0.11	-0.33	*B. alba*	I	-0.37	-0.49	0.19	-0.47	0.0	-0.18	-0.21
	II	-0.67	-0.58	0.65	0.66	0.0	-0.93	0.29		II	-0.97	-0.93	0.97	-0.30	0.0	-0.80	0.97
	III	0.18	0.25	0.02	0.17	-0.19	-0.46	-0.76		III	0.03	-0.94	0.49	0.16	0.74	0.06	0.002
	IV	-0.44	-0.57	0.38	0.15	0.77	0.08	0.66		IV	-0.34	-0.38	0.37	0.11	-0.24	0.08	0.43
	V	-0.32	-0.49	0.49	-0.23	0.37	0.10	0.05		V	-0.11	0.09	0.13	0.09	0.28	0.19	0.46

*Tmax (Maximum temperature °C), Tmin (Minimum temperature °C), RH1 (Morning relative humidity, %), RH2 (Evening relative humidity, %), RF (Rainfall, mm), SSH (sunshine hours),WS(wind speed),DOS-Date of sowing.
** bold values indicates the Significant correlation

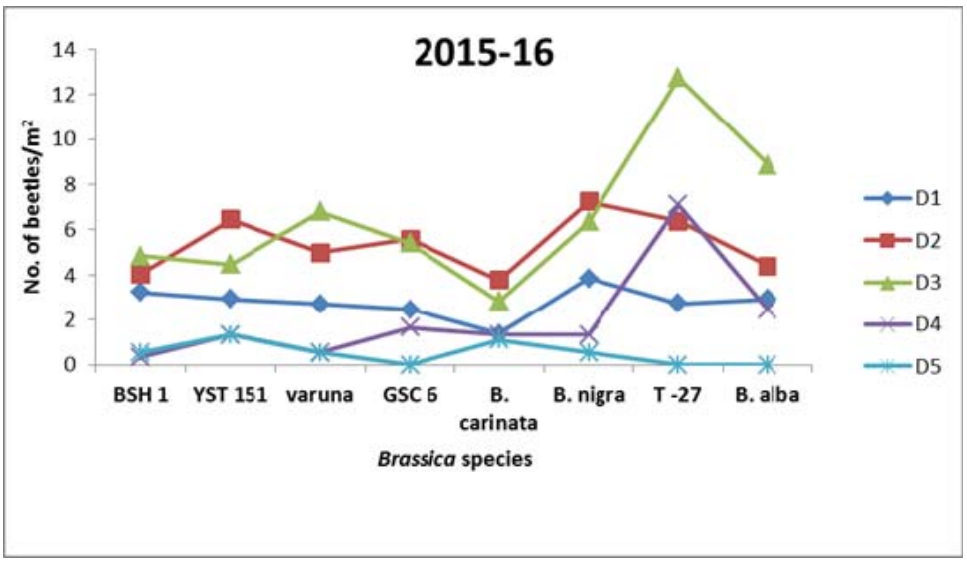

Fig 1: population of flea beetle on *Brassica* species in different dates of sowing during crop season 2015-16.

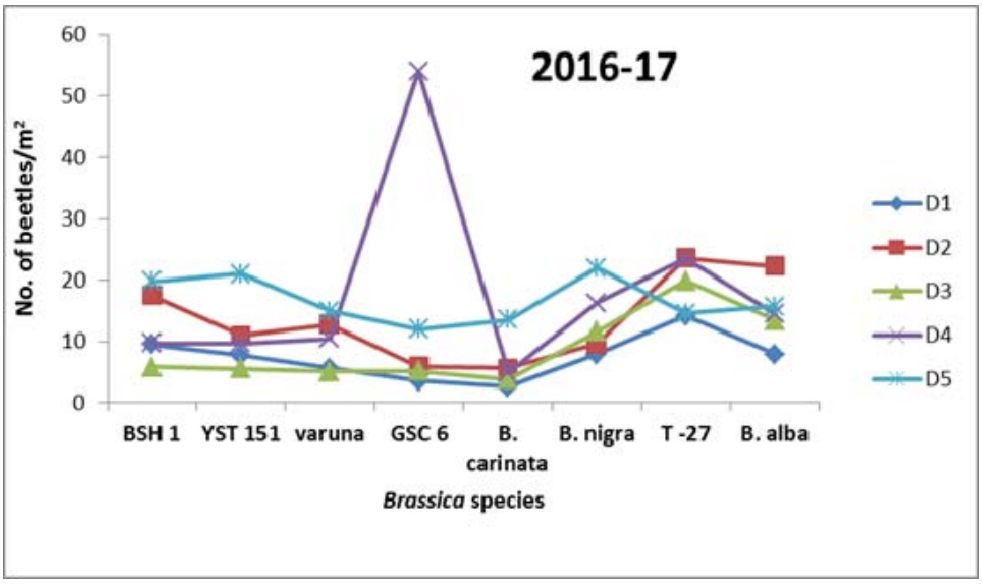

Fig 2: population of flea beetle on *Brassica* species in different dates of sowing during crop season 2016-17.

Discussion

Flea beetles are an important pest of cruciferous vegetables and cause a significant damage at both the phenological stages of the crops i.e. cotyledonary and true leaf stage, thereby causing seedling mortality, reduced plant growth, delayed and uneven maturity and finally the marketability of the crops. The highest severity of foliage damage at cotyledonary stage as compared to that recorded at true leaf stage. Seedlings do not tolerate high population of flea beetles with a threshold of only 1-5 flea beetles per plant. The injury due to flea beetles cause uneven crop emergence and maturity, thin plant shoots, increases weed competition, delay crop development, create wounds on leaves and reduce yields [1, 7] found that the susceptibility of flea beetles on *B. alba* was more in compare to *B. rapa* and *B. napus* [14]. Noted that incidence of mustard flea beetle, *P. cruciferae* (Goeze) on the last fortnight of December, reaching its peak during February on mustard [4]. Observed that flea beetle activity started during December infesting the early vegetative stage but later decreased probably due to the cooler temperature of January as well as hardening of the leaf tissues.Whereas, later increase in population at pod formation stage of crop and rising of temperature the population increased gradually and reached its peak during last week of February. However, the degree of infestation was higher during 2016-17 as compared to that during 2015-16. [2] reported that flea beetle emergence, movement and feeding are greatest during periods of warm, sunny, dry and calm weather. Cool weather conditions reduce movement, feeding and intensity of attack. Mean maximum and minimum temperature was observed to have direct impact on the population build up of *P. cruciferae*. Similar results were observed by [12, 17, 19], while studying the population dynamics of the pest.

Conclusion

The present study concluded that the flea beetle was quite active during October, November and December infesting the early vegetative stagewith respect to different sowing date, but later decreased significantly probably due to the cooler temperature of January as well as hardening of the leaf tissues. *B. alba, B.nigra* and T-27as a group harboured relatively higher population of flea beetle than other *Brassica* species. These finding can be used by the farmers for an efficient and effective control measure to minimize the crop losses.

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