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Comparative effectiveness and cost-benefit ratio of chosen organic-pesticides against mustard aphid (*Lipaphis erysimi*), (Kaltenbach)

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Abstract
The present study was conducted at the Students' Instructional Farm (SIF), CSAUA&T Kanpur during Rabi 2021-2022 and 2022-23. Ten treatments were evaluated against *Lipaphis erysimi*, i.e., Control (T_{10}), Cow urine 5% (T_1), Cow urine 10% (T_2), NSKE 5% (T_3), NSKE 10% (T_4), Castor leaf extract 5% (T_5), Castor leaf extract 10% (T_6), Lantana leaf extract 5% (T_7), Lantana leaf extract 10% (T_8) and *Verticillium lecanii* 1.5 kg/ha (T_9) were evaluated against mustard aphid (*Lipaphis erysimi*). Results revealed that, among the different treatments regarding the yield were proved significantly superior over control and ranged from 14.56 to 20.20 q/ha on pooled basis. The maximum grain yield of 20.20 q/ha was obtained from the field which was treated with NSKE 10%. The second-best treatment was NSKE 5% with the grain yield to the tune of 18.27 q/ha respectively. The highest net profit (₹ 31348.00 and 30309.00/ha) was obtained from the NSKE 10% for both the years i.e. 2021-2022 and 2022-2023, respectively, while the lowest net profit (₹ 9191.00 and 7987.00/ha) for both the years, respectively) was estimated from the treatment of Castor leaf extract. BC Ratio showed that the NSKE 5% ranked 1st with highest i.e. 1:8:5 and 1:8:4 for both the years, respectively, and minimum in Lantana leaf extract 10% i.e. 1:3:8 and 1:3:4, respectively, which was quite similar for both the years.

Keywords: Mustard aphid, B:C ratio, organic pesticides and net profit

Introduction
Rapeseed-mustard is a major oilseed crop grown in India, which produces good quality oil for cooking purposes and its cake is good feed for animals. Green leaves are used for preparing '*Saag*' and the plants are good green fodder for animals. India holds first place in growing of vegetables and exporter of vegetable oils in the world. India is a third largest producer of oilseeds in the world after China and Canada. India holds a premier position in rapeseed-mustard economy of the world with 2st and 3rd rank in area and production, respectively (Das and Sharma, 2012) [5]. This group of oilseed crops is gaining wide acceptance among the farmers because of adaptability for both irrigated as well as rainfed areas and suitability for sole as well as mixed cropping (Sharma, 2018) [9]. Rapeseed-mustard crops are commercially cultivated in more than 60 countries and major produces include China, Canada, India, Australia, France, Germany, United Kingdom, Poland, Ukraine, Russia, USA and Czech Republic. In the past the area under Rapeseed-mustard globally increased from 6.3 million hectare in 1961 to 34.3 million hectare in 2022 with a mean increment of 0.56 million hectare per annum. Production in the same period increased from 3.68 to 65.1 million tonnes at mean increment of 3.68 mt/annum. These crops occupy a prominent position as the second important oilseeds in the world as well as in India. Biology of *Brassica juncea* L. (Indian mustard) Ministry of Environment, Forest and Climate Change (MoEF&CC). The production of rapeseed-mustard is low in India as compared to other countries mainly due to damage caused by insect pest and diseases including other factors (Bakhetia and Sekhon 1989) [2].

More than 43 species of insect pests infest rapeseed-mustard crop in India, out of which about a dozen of species are considered as major pest (Purwar *et al.*, 2004) [7].Among all the insect pests, the mustard aphid, *Lipaphis erysimi* (Kaltenbach), (Homoptera: Aphididae) has gained the status of key pest of rapeseed-mustard in India. It feeds by sucking sap from its host and damage to the crop ranging from 9 to 96% in different agroclimatic conditions of India (Bakhetia, 1984, Chorbandi and Bakhetia, 1987; Singh and Sachan, 1994; Singh and Sachan, 1995; Parmar *et al.*, 2016) [1, 4, 10, 11, 6]. The loss may go up to 100% in certain mustard growing regions (Singh and Sachan, 1999) [12]. Large colonies of the aphid could cause the plant to become deformed due to curling and shrivelling of leaves. Under severe infestation, both sides of leaves are attacked (Yadav *et al.*, 1994) [14]. On mustard, *Lipaphis erysimi* prefers to feed on flowers as well as foliage of mustard (Singh *et al.*, 1991) [13]. Adult apterae of *Lipaphis erysimi* are small to medium sized yellowish green, grey green or olive-green aphids, with a faint white wax bloom. In humid conditions they may be more densely coated with wax. The aptera (see first picture below) has two rows of dark bands on the thorax and abdomen which unite into a single band near the tip of the abdomen. The siphunculi are pale with dark tips. The body length of adult *Lipaphis erysimi* apterae is 1.4-2.4 mm. Both the nymphs and adults suck sap from leaves, inflorescence, stems, flowers and pods; as a result, the plant shows stunted growth, flowers wither and pod formation are hindered. The losses of mustard due to aphids varied from 35 to 90 percent depending upon the seasons (Biswas and Das, 2000. Due to aphid infestation mainly leaves become curled and wrinkled. As a result, plants loss their vigour and ultimately became stunted growth and flowers fail to set pods, the affected pods get twisted and shrivelled. In case of severe infestation, the plant fails to develop pods, they do not mature and unable to produce healthy seeds. The *Lipaphis erysimi* (Kalt.) causes enormous qualitative and quantitative losses in rape seed and mustard crop as result in seed weight loss, viability and oil content get reduced. Cultivation of resistant or tolerant varieties is the very effective and cheapest method of cultural control to save mustard crop from insect pests. Due to screening resistance variety/germplasm against aphids get increase of production in aphid-infested area and save environment from insecticidal residues. Various varieties of rapeseed-mustard also regulate the population build up on the basis of their suitability. Hence, studying population dynamics provides an opportunity by manipulating the manageable ecological parameters in the form of planting or harvesting time adjustment, varietal selection and correct time of pesticide application. Several chemical and botanical insecticides have been accounted for astonishing grains in production, as the insecticides have reduced the hidden toll exacted by the aggregated attack of insect-pests. The mustard aphid, *Lipaphis erysimi* (Kalt.) is a major pest of Brassica crops.

Materials and Methods

The experiment was conducted at the Student' Instructional Farm of the Department of Entomology, Chandra Shekhar Azad University of Agriculture and Technology Kanpur, during the rabi season of 2021-2022 and 2022-23 in a RCBD (Randomized Completely Block Design) with ten treatments replicated three times using variety Giriraj (DRMRIJ31) from Chandra Shekhar Azad University of Agricultural & Technology, Kanpur, Uttar Pradesh, in a plot size of 4.5 m × 3 m with a recommended package of practices excluding plant protection. The site selected for experiment was uniform, cultivable with typical sandy loam soil having good drainage. The observations on population of sucking pest were recorded visually using a magnifying lens early on top 10 cm central apical twig per plant from five randomly selected and tagged plants in each plot. Aphid count was taken 24 hours before spraying at tagged plants per treatment, which was 10 further converted in to per plant population and subsequent observation was recorded at 1, 3, 5 and 7 days after spraying on same plants. The formula used for the calculation of percentage reduction of pest population over control using following formula giving by Henderson and Tilton (1955) [16] referring it to be modification of Abbott (1925) [17]. The healthy marketable yield obtained from different treatments was collected separately and weighed. The cost of insecticides used in this experiment was recorded during *Rabi* season of 2021-22 & 22-23. The cost of botanicals used was obtained from nearby market. The total cost of plant protection consisted of cost of treatments, sprayer rent and labour charges for the spray. There were two sprays throughout the research period and the overall plant protection expenses were calculated.

The B:C ratio can be calculated by formula
BCR = Gross returns / Total costs incurred

Where, BCR = Benefit Cost Ratio
Gross returns = Marketable yield × Market price
Net return = Gross return − Cost of cultivation.
(Zorempuii and Kumar, 2019) [15]

Result and Discussion

Year (2021-22) The results presented in revealed that all the treatments regarding the yield were proved significantly superior over control and ranged from 16.04 to 20.23 q/ha during *Rabi*, 2021-2022. The maximum grain yield of 20.23 q/ha was obtained from the field which was treated with NSKE 10%. The second-best treatment was NSKE 5%. With the grain yield to the tune of 18.24 q/ha respectively. Among the different treatments Cow urine 5%, the lowest grain yield of 16.04 q/ha was recorded in control field which differed significantly and inferior among all treatments.

Year (2022-23) the second-year yield of control the all treatments significantly superior over control and ranged from 16.01 to 20.17 q/ha during *Rabi*, 2022-2023. The maximum grain yield of 20.17 q/ha was obtained from the field which was treated with NSKE 10%. The second-best treatment was NSKE 5%. With the grain yield to the tune of 18.03 q/ha respectively. Among the different treatments Cow urine 5%, the lowest grain yield of 16.01 q/ha was recorded in control field which differed significantly and inferior among all treatments.

The pool data are all BC ratio the other treatments is respectively The data regarding (BC Ratio) proved that the highest net profit (₹ 31348.00 and 30309.00/ha) was obtained from the NSKE 10% for both the years i.e. 2021-2022 and 2022-2023, respectively, while the lowest net profit (₹ 9191.00 and 7987.00/ha) for both the years, respectively) was estimated from the treatment of Caster leaf extract ash by working out the B:C Ratio and also showed that the NSKE 5% ranked 1st with highest i.e. 1:8:5 and 1:8:4 for both the years, respectively, and minimum in Lantana leaf extract 10% i.e. 1::3:8 and 1:3:4, respectively, which was quite similar for both the years.

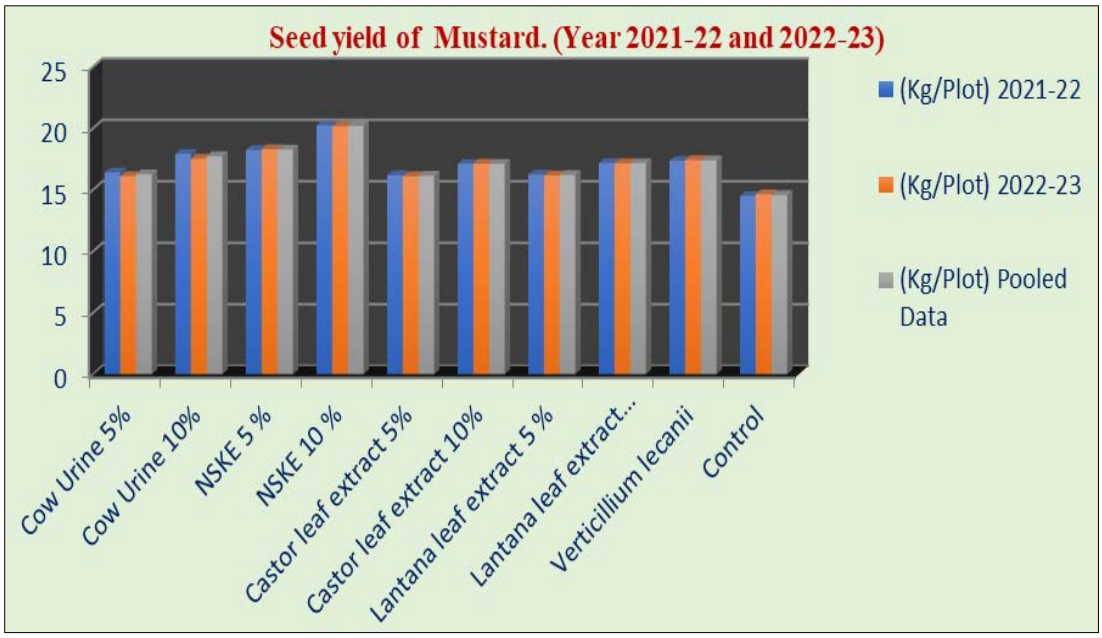

Fig 1: Effect of different Bio-rational treatments on Seed yield of Mustard. (Year 2021-22 and 2022-23)

Table 1: Effect of different Bio-rational treatments on Seed yield of Mustard. (Year 2021-22 and 2022-23)

	Treatments	(Kg/Plot)		
		2021-22	2022-23	Pooled Data
1	Cow Urine 5%	16.4	16.1	16.25
2	Cow Urine 10%	17.92	17.52	17.72
3	NSKE 5%	18.24	18.3	18.27
4	NSKE 10%	20.23	20.17	20.2
5	Castor leaf extract 5%	16.18	16.09	16.135
6	Castor leaf extract 10%	17.1	17.12	17.11
7	Lantana leaf extract 5%	16.24	16.17	16.205
8	Lantana leaf extract 10%	17.17	17.15	17.16
9	*Verticillium lecanii*	17.35	17.42	17.385
10	Control	14.5	14.63	14.565
	SEM±	0.218	0.225	16.25
	CD%	0.652	0.673	17.72

Total cost of crop protection from insecticide include (cost of insecticides + cost of application)

1. Market price if mustard crop Rs. 5200/q
2. No. of spray 3

Conclusion

The maximum seed yield of both the year i.e. 20.23 q/ha and 20.17 q/ha, respectively, during 2021-2022 and 2022-2023, respectively, and followed by NSKE 10%, > NSKE 5%, > Cow Urine 10%, > *Verticillium lecanii*, 1.5 kg/ha, > Lantana leaf extract 10%, > Castor leaf extract 10%, > Lantana leaf extract 5%, > Castor leaf extract 5%, > Cow Urine 10%, respectively. The highest net profit (₹ 31348.00 and 30309.00/ha) was obtained from the NSKE 10% for both the years i.e. 2021-2022 and 2022-2023, respectively, By working out the BC Ratio and also showed that the NSKE 5% ranked 1st with highest i.e. 1:8:5 and 1:8:4 for both the years, respectively,

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