A-6056
[1-6]

RESEARCH ARTICLE Indian Journal of Agricultural Research

A Sustainable Approach to Improve the Mustard (*Brassica juncea*) Yield and Quality Parameters by Bees Visitation in the Regions of Punjab-India

Shimpy Sarkar[1], Arshdeep Singh[2], Anita Jaswal[2], Pritha Ghosh[1]

10.18805/IJARe.A-6056

ABSTRACT

Background: Mustard is an oil seed crop and most oilseed crops are cross pollinated. A substantial increase in seed production requires adequate pollination. Rapeseed and mustard are both self-pollinated and cross-pollinated plants. Brown sarson is a cross pollinated crop whose seed production is reliant on honeybees and wild insect pollinators.

Methods: All parameters were carefully monitored during 2019-2021 crop growing year. Mustard blooming crop was visited by 12 insect species from 4 orders and 7 families. Hymenopterans were the most common visitors followed by others. Temperature and sunshine increased honeybee foraging, while relative humidity, wind speed and rainfall declined the same.

Result: In this present investigation, amongst the various attractant used for attracting pollinators jaggery solution 10 per cent and sugar solution 10 per cent were found superior to attract the maximum number of bees on crop and recorded highest yield and more oil and protein content in the seeds as compared to other treatments.

Key words: Attractants, Biotic pollination, Ecosystem, Production and sustainable approach, Quality and quantitative, Responsible consumption.

INTRODUCTION

Oilseed crops have long been the backbone of India's agricultural industry. Edible vegetable oil is derived from oilseed products such as groundnut, rapeseed and mustard, sesamum, safflower, soya bean, sunflower and Niger and non-edible vegetable oil is derived from linseed and castor. The major crops are groundnut and canola mustard, which produce 78% of the oil (Altinoz *et al*., 2020). These products occupy approximately 20 million hectares. The Indian government's oilseed technology initiative in 1986 increased productivity. Multi-prompt technology boosted mission generation from 12.7 million tonnes to 12.7 million tonnes. However, this substantial rise in production has not been enough to meet population growth. India consumes 4.1 kg of oil/head compared to 11 kg globally. However, rising population has accelerated food oil demand. The government imports edible oil to meet demand due to a shortage. Oilseed crop yield is low because (1) 90-95% of oilseed land is rainfed, 80% of which is dry land without irrigation. Lack of rain at key growth stages of oilseed crops before maturity often reduces yield and oil content. (2) Most oilseed crops are grown in marginal soils, making output unstable. (3) Limited high-quality seeds. (4) Variety of insect pests and control challenges. India produces highest amount of canola and mustard. Rape seed and mustard oil, North India's most essential edible oil, is hard to replace (30-48% oil). Insects fertilise 90% and 85% bees. Pollination boosts crop production. Pollinators, especially honeybees, increase cross-pollinated food yields cheaply and sustainably (Chauhan *et al*., 2020). They pollinate and consume nectar from mustard and rapeseed buds, boosting yield 5-19-fold. Bees increase crop yield and quality. It ensures early crop growth and uniformity. Crop flowering requires simple beehives. Despite oilseed crop land use, a national bee pollination plan solves the edible oil shortage (Thakur *et al*., 2020). Mustard crops supply oil to a growing populace. 2022 will see 8.0 billion people and 138 lakh Asians. Every family needs 3 pints of mustard oil to meet their demand. Bees and wild bees increase mustard yield on the same land. Bee pollination shows 4.07 mustard seeds/siliqua. These attractants were used to boost Indian mustard output. This study studied how bee attractants impact mustard pollinator visitation and output (Gupta *et al*., 2020).

[1]Department of Entomology, School of Agriculture, Lovely Professional University, Phagwara-144 411, Punjab, India.
[2]Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144 411, Punjab, India.

Corresponding Author: Shimpy Sarkar, Department of Entomology, School of Agriculture, Lovely Professional University, Phagwara-144 411, Punjab, India. Email: shimpy.23645@lpu.co.in

How to cite this article: Sarkar, S., Singh, A., Jaswal, A. and Ghosh, P. (2023). A Sustainable Approach to Improve the Mustard (*Brassica juncea*) Yield and Quality Parameters by Bees Visitation in the Regions of Punjab-India. Indian Journal of Agricultural Research. doi:10.18805/IJARe.A-6056.

Submitted: 30-09-2022 **Accepted:** 30-03-2023 **Online:** 05-06-2023

MATERIALS AND METHODS

Influence of attractants on bee visitation on mustard

Between the two years 2019-2021, Lovely Professional University's experimental Entomology farm in Phagwara, India, hosted field study (Punjab). The land is at latitude 31.25°N and longitude 75°E, above mean sea level (249 m). In *rabi* season, the crop was grown in 3×3 m^2 plots using PAU's suggested package and practises. All treatments used the recommended dose of fertilisers to maintain crop growth and yield. The trial used GSC 6 as planting material. The crop was sown in October, protected from diseases and pests, but no insecticide was sprayed during flowering. Table shows the randomised block design with three replications and treatments. The trial used locally available bee lures. May, June and July are the warmest months, with temperatures reaching 49°. Rains begin in the last week of July, lowering the temperature. Due to Earth's distance from the sun, winter starts in October. The coldest months are December and January. Local molasses, sugar, honey and jaggery were tried as attractants. Molasses and sugars were 100% concentrated and directly dissolved in water to prepare the needed concentrations. Dissolving 50 grammes of a specific attractant in 1000 cc water yielded a 5% spray solution. For 10%, add 100 g of attractant to 1000 cc of water (10/100×1000). At 10% and 50% blooming, attractants were sprayed. From blooming to seed set, nylon nets controlled the crop (closed pollination). SPSS analysed both years' data (Statistical Package for Social Sciences).

S. no.	Treatments
T1	Crop sprayed with sugar 5% + RDF
T2	Crop sprayed with sugar 10% + RDF
T3	Crop sprayed with honey 5% + RDF
T4	Crop sprayed with honey 10% + RDF
T5	Crop sprayed with jaggery 10% + RDF
T6	Crop sprayed with molasses 5% + RDF
T7	Crop sprayed with molasses 10% +
T8	RDF closed pollination + RDF

The recommended dose of fertilizers was used in all the treatments as per the package and practices of Punjab Agriculture University Ludhiana, India. For phosphorous Single super phosphate fertilizer used as it is having sulphur quantity. Sulphur is required in the oil crops to maintain the pungency and quality of oil.

Influence of attractants in enhancing productivity and quality of mustard

To study the role of bee attractants in enhancing the productivity and quality of mustard following quantitative and qualitative parameters were recorded.

Quantitative and qualitative parameters

Number of pods/plant and seeds/pod

In each plot, 10 plants were selected randomly and the number of pods in these plants were counted and mean number of pods per plant was calculated. The observations were made by selecting 25 pods at random from each replication of the treatment during harvesting. The number of seeds per pod was recorded in each treatment.

1000 seed weight and seed yield (kg/ha)

The observations were made by weighing 1000 seeds sampled randomly from each replication of the treatment by using a single pan electronic balance. Seeds harvested from each treatment were obtained and weighed. The yield/ plot was later converted for 1 ha area.

Root and shoot length (cm)

The shoot length, root lengths were recorded by using a measuring scale in centimetre and average were used in analysis of data. The root to shoot length ratio of seedling was calculated by dividing root length to the shoot length.

Oil content and protein content (%)

Seed samples were kept in hot air oven at 70°C for removal of moisture. Thereafter, the seeds were grinded with the help of pistil and mortar. The oil content in the seed samples was analysed with the help of the Soxhlet apparatus. The oil per cent was calculated by using following formula:

$$\text{Oil content (\%)} = \frac{\text{Weight of oil flask + Ether extract - Weight of flask oil}}{\text{Substances taken}} \times 100$$

Pearson's association coefficient, Sokal and Rholf were used. Pearson's correlation coefficients were computed for maximum and lowest temperature, relative humidity morning and evening, rainfall, sunshine hours and wind speed with mustard crop insect pollinators *Apis mellifera*, *Apis cerana*, *Apis dorsata* and *Apis florea*. Kjeldahl's method was used to calculate the protein amount of dried seed powder by multiplying the nitrogen percent by 6.25.

RESULTS AND DISCUSSION

Diversity of insect pollinators on mustard bloom

Table 1 showed that mustard blooms attracted many insects. These insects were 4 orders, 7 families, 9 names and 15 species. Honeybees-A. *mellifera*, *A. cerana*, *A. dorsata* and *A. florea*-were the most frequent floral pollinators. 85.27% of floral pollinators were honeybees. They were abundant in this order: Melifera > cerana > dorsata > florae. Honeybees, due to their anatomy, visited mustard flowers in large numbers throughout the day, making them ideal for in-depth study. They were great mustard pollen collectors. Mustard bloom pollinator profusion. Table 2 showed the seasonal abundance pattern of honeybees *Apis mellifera*, *Apis cerana*, *Apis dorsata*, *Apis florea* and other insect pollinators in relation to abiotic factors like maximum temperature, minimum temperature, morning and evening relative humidity, rainfall, sunshine hours and wind speed. The measurements were done on alternate days from 0800 to 1800 hours. Pooling data from various hours yielded alternative day observations. Honeybee activity generally rose with temperature and sunshine and decreased with relative humidity, wind speed and rainfall.

Correlation coefficient (r) between bee activity and weather parameters

Apis mellifera foraging population was strongly correlated with maximum, lowest and sunshine hours. This population was not correlated with rainfall, wind speed, or early and evening relative humidity (Table 2). However, *Apis cerana* foragers showed a significant positive association with maximum and minimum temperatures and a negative correlation with morning relative humidity. This population did not correlate with evening relative humidity, rainfall, sunlight hours, or wind speed. With *Apis florae*, the pattern was stronger and favorably correlated with sunshine. Chandranath *et al*., (2020). *Apis dorsata* populations had a significant and positive correlation with maximum and lowest temperature, sunshine hours, wind speed and morning relative humidity. This populace did not correlate with evening relative humidity or rainfall. Another insect behaved similarly. Thus, all four honeybee species and other pollinators responded differently to the climate at a given time.

Table 1: Insect visitors and their percentage proportion on mustard bloom.

Order	Family	Species	Percentage composition	Total
Hymenoptera	Apidae	*Apis mellifera*	28.09	85.27
		A. cerana	25.10	
		A. dorsata	18.00	
		A.florea	13.52	
	Andrenidae	*Andrena leaena*	1.66	2.21
		A.ilerda	0.55	
Lepidoptera	Pieridae	*Pieris rapae*	1.36	1.36
	Danaidae	*Danaus plexippus*	1.87	1.87
Diptera	Muscidae	*Musca* spp.	3.02	3.02
	Syrphidae	*Eristalis* spp.	0.99	3.76
		Episyrphus balteatus	1.30	
		Metasyrphus corollae	1.47	
Coleoptera	Coccinellidae	*Coccinella septumpunctata*	0.87	2.51
		C. sexmaculata	1.64	

Table 2: Correlation coefficient matrix between bee pollinators and weather parameters.

Name of the parameters	*A. mellifera*	*A. cerana*	*A. dorsata*	*A. florea*
Maximum temperature	0.535**	0.438**	0.347*	0.388**
Minimum temperature	0.461**	0.427**	0.461**	0.411**
Relative humidity morning	-0.434**	-0.354*	-0.376*	-0.389**
Relative humidity evening	-0.307*	-0.228	-0.083	-0.154
Rainfall	0.057	0.062	0.165	0.147
Sunshine hours	0.210**	0.196	0.089*	0.190**
Wind speed	0.258	0.237	0.302*	0.253

*.Correlation is significant at the 0.05 level (2-tailed). **.Correlation is significant at the 0.01 level (2-tailed).

Table 3: Impact of different indigenous attractants on the visitation rate of *Apis cerana and Apis dorsata* after spraying attractants.

Treatment	1st day visit average of *A. cerana*	3rd day visit average of *A. cerana*	5th day visit average of *A. cerana*	7th day visit average of *A. cerana*	1st day visit average of *A. dorsta*	3rd day visit average of *A. dorsta*	5th day visit average of *A. dorsta*	7th day visit average of *A. dorsta*
T1-Sugar solution 5%	0.33	0.00	0.33	0.67	2.00	0.00	1.00	2.00
T2- Sugar solution 10%	0.67	1.00	1.00	2.00	0.33	0.33	0.00	0.67
T3 Honey solution 5%	0.33	0.00	1.00	0.67	1.67	0.00	0.00	1.33
T4 Honey solution 10%	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.33
T5 Jaggery solution 10%	0.67	0.00	0.00	2.67	2.00	1.00	0.33	0.67
T6 Molasses solution 5%	0.00	1.33	0.00	1.00	0.33	0.00	0.00	0.33
T7 Molasses solution 10%	0.67	0.00	0.33	2.33	0.00	0.00	2.67	0.67
T8 Control	0.33	0.33	1.00	0.33	0.00	0.00	1.33	0.00

Visitation rate of *Apis mellifera* before and after spraying of attractants

Before sprinkling, the experimental area had 0.00-1.33 bees/plot per minute. On the first day after spraying, molasses 5% solution drew 6.33 bees/plot/minute, followed by sugar solution at 4.67. S. Chakraborty *et al*., (2018). Untreated areas had the fewest bees, averaging one per minute. On the third day after spraying a 10% sugar solution, 10 bees were observed per plot per minute, compared to 1.67 in the untreated region (Fig 1). On the fifth day after misting, honey solution 10% produced the most bees/plot/minute, while jaggery solution 10% produced 5.33. 10% liquids were used. After seven days of spraying, the attractants began to lose their efficacy and visitation data began to decline. The spraying was discovered seven days later. However, reduced molasses solutions retained their attractants. Kim *et al*. (2021) found that *Apis mellifera* spent 1.64 blooms, followed by *Apis dorsata*.

Apis cerana and dorsata visitation after spraying

For *Apis cerana*

The first day after misting, the untreated area had 0.33 bees/plot/minute, while the 5% molasses solution had 0.67. On the third day after spraying the sugar solution, 5% and 10% of areas had no bees per minute. Honey solutions of 5% had 1.00 bees/plot/minute. The area treated with sugar had 0.33 bees/plot/minute, while the untreated area had 1.33. Five days of spraying showed the same behaviour. On the seventh day after applying the 10% jaggery solution, 2.67 bees/plot/minute were recorded, with the untreated group having the lowest at 0.33. (Table 2).

For *Apis dorsata*

The first day after spraying, 5% molasses solution and untreated plots had the same number of bees as 0.00 bees/plot/minute. On the third day after spraying, 5% and 10% molasses solutions had 1.00 bees/plot/minute. On the fifth day after applying sugar solution 5%, one bee per plot per minute was found compared to sugar solution 10%, honey solution 5% and honey solution 10%. The jaggery solution only had a 10% concentration and no bees per area or minute. 0.33 bees/area/minute in the treatment group, 2.67/plot/minute. Seven days after spreading 5% sugar solution. 2,000 pollinators per area per minute, recorder with 10% sugar solution. The clean plot had the lowest bees/plot/minute. 5% molasses drew 0.67 bees/plot/minute (Table 3). Shorna *et al.* (2020) studied pollinator insects and their effects on mustard (*Brassica rapa*) seed set in rural West Java.

Bot and syrphid fly visitation after misting

The first day after spraying the sugar solution showed a 5% rise, or 0.67 bot flies/plot/minute. 10% honey formula

Table 4: Impact of different indigenous attractants on the visitation rate of Bot fly and Syrphid fly after spraying.

Treatment	1st day visit average of Bot fly	3rd day visit average of Bot fly	5th day visit average of Bot fly	1st day visit average of Syrphid fly	3rd day visit average of Syrphid fly	5th day visit average of Syrphid fly
T1-Sugar solution 5%	0.667	1.333	0.667	0.000	1.000	0.000
T2- Sugar solution 10%	0.333	1.333	0.333	1.667	0.000	1.000
T3 Honey solution 5%	0.000	2.000	0.333	0.000	0.000	1.000
T4 Honey solution 10%	0.667	0.667	0.667	0.667	1.000	0.333
T5 Jaggery solution 10%	0.000	0.333	0.000	1.000	0.333	0.000
T6 Molasses solution 5%	0.333	1.667	0.000	0.333	0.000	1.333
T7 Molasses solution 10%	0.000	0.000	1.000	0.000	1.333	0.000
T-8 Control	0.000	0.000	0.000	0.000	0.000	0.000

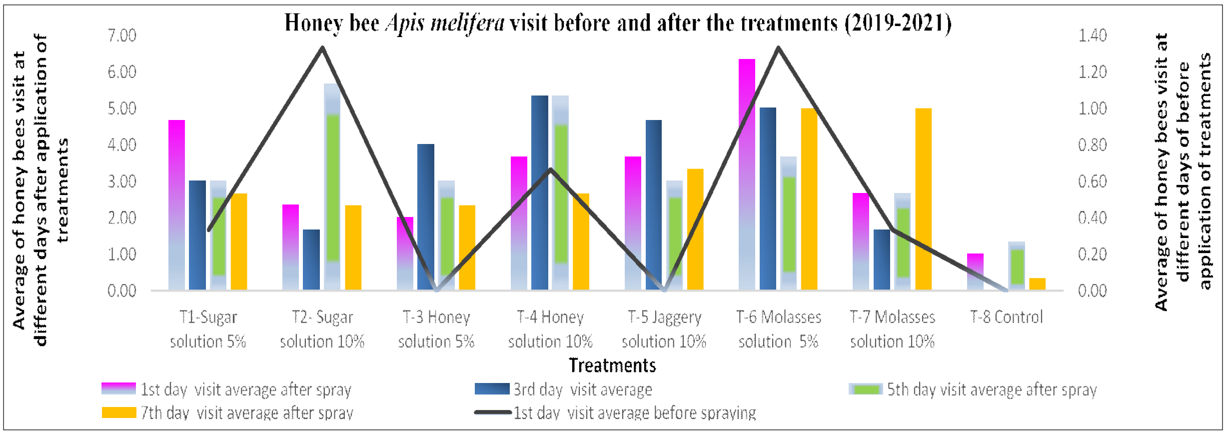

Fig 1: Impact of different indigenous attractants on the visitation rate of *Apis mellifera* before and after spraying attractants.

Table 5: Influence of bee attractants on the quantitative parameters of mustard crop and effect on crop yield parameters.

Treatments	Root length (cm)	Shoot length (cm)	No. of pods	Pod length	1000 seed weight	Seed yield (q/ha)	Oil content (%)	Protein content (%)
Sugar solution 5%	3.49d	4.76 b	73.73 (8.62)[c]	4.80 (2.30)[c]	5.91 (2.53)[ab]	7.72d	26.16	6.16
Sugar solution 10%	3.95 c	4.88b	74.60 (8.67)[c]	4.85 (2.31)[c]	6.67 (2.68)[a]	8.27c	32.1	6.87
Honey solution 5%	3.88cd	4.83b	69.27 (8.35)[d]	5.08 (2.36)[c]	6.03 (2.56)[ab]	7.75d	27.16	6.2
Honey solution 10%	3.84c	4.69c	68.20 (8.29)[d]	5.01 (2.35)[c]	4.76 (2.29)[ab]	7.98d	29.66	6.6
Jaggery solution 10%	5.09a	5.27a	86.53 (9.33)[a]	6.49 (2.64)[a]	6.82 (2.71)[a]	11.04a	33.16	7.43
Molasses solution 5%	4.03 b	5.03ab	81.47 (9.05)[b]	5.55 (2.46)[b]	6.17 (2.58)[ab]	9.91b	32.5	6.9
Molasses solution 10%	3.90c	4.79c	69.47 (8.36)[d]	4.89 (2.32)[c]	4.64 (2.27)[ab]	7.78d	28.69	6.05
Untreated (closed pollination)	2.69e	4.10d	63.73 (8.01)[e]	3.87 (2.09)[d]	4.26 (2.18)[b]	6.08e	22.31	5.23

Figures in the $\sqrt{(X + 0.5)}$ are transformed values.

eliminated bot flies every minute. On the third day after spraying the 5% and 10% sugar solutions, 1.33 and 2.00 bot flies/plot/minute were noted. Molasses solution 10% measured 1.67 bot fly/plot/min, while the untreated condition measured 0.00. Kour *et al*., (2016). On the fifth day after spraying the 10% sugar solution, 0.67 bot flies/ plot/minute were detected, while the untreated plots had 0.00. Treated areas had one bot fly per minute. On the first day after sugar sprinkled, 1.67 syrphid flies/area/ minute were seen using a 5% honey solution. A 5% sugar solution produced 1.00 syrphid flies/patch/minute. 0.00 syrphid fly was recorded/plot/minute, untreated. Three days after sugar solution spray. A 10% sugar solution produced 1.00 syrphid flies/patch/minute. 5% molasses drew 0.33 syrphid flies/plot/minute. The untreated area had 1.33 syrphid flies/plot/minute, but the treated area had none (Table 4).

Influence of attractants in enhancing productivity and quality of mustard

Table 5 shows mustard yield properties. Seeds treated with 10% jaggery solution had roots and stems that were 5.09 and 5.27 centimetres long, compared to 2.69 and 4.10 centimetres for closed pollination. Spraying with a 10% sugar solution increased pod production by 35.7% (86.53 pods/five plants). The control group had the fewest peas per five plants (63.73). The 10% jaggery solution treatments had a considerably longer maximum pod length per five plants than the control, which measured 6.49 centimetres. Treatments sprayed with a 10% jaggery solution yielded the highest weight of 1000 seeds, 6.82 grammes. The unheated control yielded the fewest seeds (6.08 q/ha), while the jaggery solution 10% yielded 11.09 q/ha. The 10% jaggery solution treatment had the largest oil and protein content, 33.16% and 7.43%, respectively. Records showed the control had the least fat and protein (22.31% and 5.23%). Sharma, B., *et al*., 2020 found that insect pollination in sarson improved seed yield and produced well-shaped, larger grain and more viable seed.

CONCLUSION

The current study showed that jaggery and sugar solutions at 10% attracted the most bees on crop and yielded the most. Sugar cane jaggery is raw. Molasses gives jaggery more nutrition than refined sugar. Ca, zinc, phosphorus and copper are also found in jaggery. Fermented sugars, vitamin B6 and minerals like calcium, potassium, copper, iron, etc. However, treated crops retained more molasses and jaggery, which may draw other pollinators. Three pollinators were Hymenoptera and two Diptera. Honeybees dominated Hymenoptera. In North-West Punjab, *B. juncea* had five pollinators: *Apis mellifera*, *Apis dorsata*, *Apis cerana*, *Syrphus ribesii* (syrphid fly) and *Chrysomya megacephala* (bot fly).

Conflict of interest: None.

REFERENCES

Altinoz, M.A., Ozpinar, A., Ozpinar, A. and Hacker, E. (2020). Erucic acid, a nutritional PPARδ-ligand may influence Huntington's disease pathogenesis. Metabolic Brain Disease. 35(1): 1-9.

Chakraborty, S., Gupta, S.S., Sengupta, A. and Ghosh, M. (2018). Quality ascertain of different mustard oil samples obtained from the local market of West Bengal, India. Asian J. Dairy and Food Res. 37(2): 138-143.

Chandranath, H.T., Babalad, H.B. and Hegde, Y. (2020). Growth, yield and oil quality of mustard in chickpea (*Cicer arietinum*) and mustard (*Brassica juncea* L.) intercropping system under different row ratio in northern transition zone of Karnataka. Indian Journal of Agricultural Research. 54(3): 322-328.

Chauhan, J.S., Choudhury, P. R., Pal, S. and Singh, K.H. (2020). Analysis of seed chain and its implication in rapeseed-mustard (*Brassica* spp.) production in India. Journal of Oilseeds Research. 37(2): 71-84.

Gupta, M., Bharat, R., Kour, S. and Kachroo, D. (2020). Effect of mixed farming on farm productivity and income in Kandi areas of North-Western plains. Indian Journal of Agronomy. 65(2): 144-150.

Kim, D.S., Kim, S. and Fennimore, S.A. (2021). Evaluation of broadcast steam application with mustard seed meal in fruiting strawberry. Hort Science. 56(4): 500-505.

Kour, R., Sharma, B.C., Kumar, A., Kour, P. and Nandan, B. (2016). Study of physiological growth indices of chickpea in chickpea (*Cicer arietinum*) + mustard (*Brassica juncea*) intercropping system under different weed management practices. Legume Research. 39(3): 453-458.

Sharma, B., Kumari, P., Kumari, R., Tripathi, S.K., Kumar, A. and Dhara, P.K. (2020). Impact of multistorey system on yield and soil quality of mustard in Alfisols of Eastern India. ADRRI Journal of Agriculture and Food Sciences. 4(64): 27-46.

Shorna, S.I., Polash, M.A.S., Sakil, M.A., Mou, M.A., Hakim, M.A., Biswas, A. and Hossain, M.A. (2020). Effects of nitrogenous fertilizer on growth and yield of Mustard Green. Tropical Plant Research. 7(1): 30-36.

Thakur, A.K., Parmar, N., Singh, K.H. and Nanjundan, J. (2020). Current achievements and future prospects of genetic engineering in Indian mustard (*Brassica juncea* L. Czern and Coss.). Planta. 252(4): 1-20.