International Journal of Research in Agronomy 2024; 7(1): 01-05

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(1): 01-05
Received: 02-11-2023
Accepted: 01-12-2023

Gopal Lal Choudhary
Research Scholar, Department of Agronomy, S. K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Dr. AC Shivran
Professor, Department of Agronomy, S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Dr. Basant Kumar Dadarwal
Assistant Professor, S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Corresponding Author:
Gopal Lal Choudhary
Research Scholar, Department of Agronomy, S. K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Effect of integrated nutrient management on yield and qualitative characters of mustard [*Brassica juncea* (L.) czern. & coss]

Gopal Lal Choudhary, Dr. AC Shivran and Dr. Basant Kumar Dadarwal

DOI: https://doi.org/10.33545/2618060X.2024.v7.i1a.183

Abstract
A field experiment was conducted to investigate the impact of integrated nutrient management on the yield and quality characteristics of mustard throughout two successive rabi seasons in the years 2019-20 and 2020-21, respectively. The experiment was conducted using a Split Plot Design with three replications. The main plots consisted of seven different integrated nutrient management treatments, including control, 100% RDF, 50% RDF + FYM @ 6.0 t ha^{-1}, 50% RDF + vermicompost @ 3.0 t ha^{-1}, 100% RDF + *Azotobacter* + PSB, 50% RDF + FYM @ 6.0 t ha^{-1} + *Azotobacter* + PSB, and 50% RDF + vermicompost @ 3.0 t ha^{-1} + *Azotobacter* + PSB. The subplots consisted of three foliar sprays of agrochemicals, including control, salicylic acid @ 100 ppm, and brassinosteroid @ 0.40 ppm. The findings of this study showed that there was a significant increase in seed, straw, biological yield, nitrogen, and protein content with the application of 100% RDF + *Azotobacter* + PSB. This result was statistically similar to applying 100% RDF and 50% RDF + Vermicompost @ 3.0 t ha^{-1} + *Azotobacter* + PSB, and was superior to the other treatments. The application of 50% RDF combined with vermicompost @ 3.0 t ha^{-1}, together with the use of *Azotobacter* and PSB, resulted in a significantly greater oil content. This increase was statistically similar to all other treatments, except for the control, in both years of the experiment and when the data from both years were combined. While, the application of 100% RDF + *Azotobacter* + PSB resulted in a significantly greater oil yield, which was statistically similar to the application of 100% RDF, 50% RDF + Vermicompost @ 3.0 t ha^{-1} + *Azotobacter* + PSB, and 50% RDF + Vermicompost @ 3.0 t ha^{-1}, respectively, during the study. In case of foliar application of agrochemicals, Brassinosteroid resulted in significantly higher yield (seed, straw and biological yield), nitrogen content, protein content and oil yield compare to the other treatments. The above treatments did not show significant influence on the harvest index.

Keywords: Mustard, vermicompost, brassinosteroid, *Azotobacter* and phytohormone

Introduction
Indian mustard {*Brassica juncea* (L.) Czern. & Coss}, is an amphidiploid species that was formed by the crossbreeding of *Brassica rapa* and *Brassica nigra* (Nagaharu, 1935) [35]. Mustard seed oil has an oil content of approximately 38 to 43%, and it is characterised by its yellow colour and pleasant fragrance. This oil is widely regarded as a highly nutritious and healthy cooking medium, as supported by studies conducted by Patel *et al.* (2012) [16] and Kumar *et al.* (2017) [11]. The estimated area, production, and productivity of rapeseed-mustard in India during the 2021-22 period were 8.06 mha, 11.75 m tonnes, and 1458 kg ha^{-1}, respectively (Anonymous, 2022-23) [3]. Indian mustard is mostly grown in the states of Rajasthan, Madhya Pradesh, Haryana, and Uttar Pradesh, which collectively account for 75.21% of the cultivated area and 81.43% of the total production. Rajasthan holds the top position in terms of both area and production of Indian mustard, contributing about 44% of the country's total mustard production. Rajasthan cultivates the most significant oilseed crop during the rabi season, covering an area of 3.37 m ha^{-1}. The yearly production of this crop amounts to 5.48 million tonnes, with an average productivity of 1627 kg ha^{-1}. Rajasthan primarily cultivates this crop in the districts of Alwar, Bharatpur, and Sri Ganganagar (Anonymous, 2022-23) [3].
The fundamental idea behind the principle of integrated nutrient management (INM) is to maintain, adjust, and potentially enhance soil fertility and plant nutrient supply to an optimal

level in order to sustain desired crop productivity. This is achieved by optimizing the benefits derived from all available sources of plant nutrients in an integrated manner. The optimal combination of mineral fertilizers, organic manures, and biofertilizers is contingent upon the specific land use system, ecological factors, social factors, and economic situations. In contrast to low external input (LEI) and organic methods, the integrated nutrient management (INM) strategy incorporates a low to medium level of external inputs. It considers a comprehensive perspective on soil fertility and the specific nutritional needs of plants to achieve a desired yield (Sahoo, 2013) [18].

Rapeseed-mustard necessitates a substantial quantity of nutrients to achieve its maximum output potential. However, insufficient nutrient availability frequently results in diminished productivity. Therefore, it is crucial to enhance crop yield by supplying well-balanced and sufficient nutrition through both organic and inorganic sources. There are few limits when using only organic or inorganic nutrient sources exclusively. Hence, the prudent utilisation of both organic and inorganic fertilizers is necessary to augment the productivity of rapeseed-mustard. The combined utilisation of organic and inorganic fertilizers not only ensures availability of all necessary plant nutrients, but also promotes improved soil health (Thakur *et al*., 2009) [24]. Utilizing farm yard manure (FYM), vermicompost, and bio-fertilizers such as *Azotobacter* in a balanced manner with fertilisers can enhance profitable and sustainable production and have been observed to enhance physical, chemical, and biological soil characteristics (Shroff and Devasthali, 1992) [20].

Nevertheless, there is a dearth of knowledge concerning the implementation of integrated nutrient management in mustard cultivation in Rajasthan. In light of the aforementioned facts regarding the availability of adequate information and limited research in this area, the current study was conducted to determine the impact of integrated nutrient management on the yield and quality characteristics of mustard in Jaipur district of Rajasthan.

Materials and Methods

The experiment was carried out at the Agronomy farm, S.K.N. College of Agriculture, Jobner, which is located at latitude 78o 28' North and longitude 26o 26' East, at an altitude of 427 metres above mean sea level, during two consecutive rabi seasons in the years 2019–20 and 2020–21, respectively. A total of 3.1 mm and 10.2 mm of rainfall were recorded during the agricultural growing seasons of the years 2019-20 and 2020-21, respectively. The soil in the experimental field had a loamy sand texture, a slightly alkaline pH, moderate electrical conductivity, low organic carbon content, and moderate levels of accessible nitrogen, phosphorus, and potassium.

The experiment conducted using Split Plot Design with seven integrated nutrient management treatments in main plots *viz*., control, 100% RDF, 50% RDF + FYM @ 6.0 t ha^{-1}, 50% RDF + vermicompost @ 3.0 t ha^{-1}, 100% RDF + *Azotobacter* + PSB, 50% RDF + FYM @ 6.0 t ha^{-1} + *Azotobacter* + PSB and 50% RDF + vermicompost @ 3.0 t ha^{-1} + *Azotobacter* + PSB and three foliar spray of agrochemicals in sub plots *viz*. control, salicylic acid (100 ppm) and brassinosteroid (0.40 ppm). The main plots were bordered by a 1.5 m wide buffer, while the subplots were bordered by a 0.5 m wide buffer. This was done to prevent unintentional irrigation and the infiltration of water. There were three replications of the treatments. The prescribed dosage of fertilisers (60:40:20 kg N: P: K ha^{-1}) was administered using prilled urea for nitrogen, di-ammonium phosphate for phosphorus, and muriate of potash for potash. A uniform distribution and incorporation of designate quantity of well rotten FYM and vermicompost were made in soil of experimental plots according to the treatment specification before seeding. Half of nitrogenous fertilizer and full quantity of phosphatic and potassium fertilizers were uniformly applied through placement in furrows before seeding strictly adhering to the treatment specification. Remaining dose of nitrogenous fertilizer was applied according to designate treatment in two equal splits manually through top dressing 3-4 days after irrigation applied at 35 and 70 DAS. Bio-fertilizers (*Azotobacter* and PSB each) were used for seed treatment. Fertilizers and bio-fertilizers were weighed on a digital electronic balance having a precision of ± 1 g for each experimental plot to ensure high accuracy in treatment application. The foliar sprays of each agrochemical (water in control, salicylic acid @ 100 ppm, and brassinosteroid @ 0.40 ppm were applied twice during the experiment, first at 30 days after sowing (DAS) and second at 60 DAS, according to the treatment protocol. A spray volume of 500 L ha-1 was utilised during both years of the trial. To enhance the efficacy of sprays, they were conducted in the morning and evening, while avoiding the noon hours. Teepol, a sticking agent, was added to the spray solution @ 0.5 ml per litre. The research utilised the mustard variety "Laxmi". The protein content in the seed was determined by multiplying the nitrogen content in the seed by a factor of 6.25, as specified by AOAC (1960) [1]. The oil content of the seeds was evaluated using the Soxhlet technique. The data pertaining to each character were analysed using the analysis of variance approach, and the significance was assessed using the "F" test (Gomez and Gomez 1984) [10].

Results and Discussions

Effect on yield

The mustard yield significantly influenced by the combined use of nutrient management strategies and foliar spaying of agrochemicals (Table 1). Among the treatments, the application of 100% RDF combined with *Azotobacter* and PSB resulted in significantly higher seed yield (1817, 1947, and 1882 kg ha-1), straw yield (4824, 5011, and 4918 kg ha-1), and biological yield (6641, 11213, and 8927 kg ha-1) during both experimental years. These results were also comparable to the application of 100% RDF and 50% RDF combined with Vermicompost @ 3.0 t ha-1, *Azotobacter*, and PSB, which outperformed the other treatments. Nevertheless, the control exhibited the lowest values for seed, straw, and biological yield. However, the harvest index did not reach a statistically significant level during the research.

The application of chemical fertilisers leads to an increase in seed and straw yields. This is likely because the fertilizers create a better nutritional environment in soil that is low in nitrogen and phosphorus. This is supported by the fact that the plants take up more nitrogen and phosphorus when fertilisers are applied. Additionally, the increased supply and uptake of nitrogen, phosphorus, and potassium by the plants stimulates various physiological processes, resulting in increased growth and yield parameters. As a result, the crop produces more seeds and straw. The enhanced crop productivity resulting from the use of biofertilizers can be attributed to their direct involvement in nitrogen fixation, synthesis of phytohormone-like compounds, and improved absorption of essential nutrients including nitrogen and phosphorus. The results of the current study align closely with the findings of Bijarnia *et al*. (2017) [5], Bisht *et al*. (2018) [19], Murali *et al*. (2018) [14], Reddy and Singh (2018) [17], and Sahoo *et al*. (2018) [19] in the context of mustard crop.

In case of foliar application of agrochemicals, Brassinosteroid resulted in considerably higher seed yield (1810, 1917, and 1863 kg ha^{-1}), straw yield (4669, 4829, and 4749 kg ha^{-1}), and biological yield (6478, 10837, and 8658 kg ha^{-1}) compared to the other treatments in both experimental years. Nevertheless, the control exhibited the lowest reported values for seed, straw, and biological yield. Throughout the testing, the use of agrochemicals did not have a significant impact on the harvest index. This could be attribsuted to the synergistic interaction between brassinosteroids and endogenous auxins, which play a role in enhancing fruit set. As a result, there is an increase in the number of silique plant^{-1} and the number of seeds silique^{-1}. The increase in crop output is thought to be a result of delayed ageing of plant organs, specifically leaves and flowers, in response to the application of agrochemicals. This helps the plant to prolong the period of active photosynthesis, leading to higher productivity. As a result, there was a noticeable rise in crop productivity. The present experiment has demonstrated a substantial increase in crop output with the administration of brassinosteroid via foliar spray. This conclusion aligns well with the research conducted by Singh *et al*. (2010) [23], Bera and Paramanik (2013) [4], and Chouhan *et al*. (2015) [8].

Table 1: Effect of integrated nutrient management and agrochemicals on yield and harvest index of mustard

Treatments	Yield (kg ha^{-1})									Harvest index (%)		
	Seed yield			Straw yield			Biological yield					
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Integrated nutrient management												
Control	1378	1428	1403	3629	3799	3714	5007	8313	6660	27.47	27.25	27.36
100% RDF	1786	1903	1845	4731	4935	4833	6516	10828	8672	27.32	27.76	27.54
50% RDF + FYM @ 6.0 t ha^{-1}	1560	1660	1610	4060	4282	4171	5620	9335	7478	27.66	27.85	27.75
50% RDF + vermicompost @ 3.0 t ha^{-1}	1636	1729	1682	4284	4481	4382	5920	9985	7952	27.64	27.73	27.68
100% RDF + *Azotobacter* + PSB	1817	1947	1882	4824	5011	4918	6641	11213	8927	27.45	28.05	27.75
50% RDF + FYM @ 6.0 t ha^{-1} + *Azoto.* + PSB	1598	1704	1651	4271	4436	4354	5869	9739	7804	27.28	27.74	27.51
50% RDF + Vermi. @ 3.0 t ha^{-1} + *Azoto.* + PSB	1714	1838	1776	4533	4731	4632	6246	10472	8359	27.44	28.06	27.75
SEm±	48	56	37	139	144	100	145	362	195	0.80	0.66	0.52
CD (P=0.05)	147	171	107	427	442	291	446	1117	569	NS	NS	NS
CV (%)	8.73	9.57		9.59	9.52		7.27	10.89		8.74	7.10	
Agrochemicals												
Control	1432	1543	1488	3982	4185	4083	5413	9052	7233	26.48	26.97	26.73
Salicylic acid	1682	1772	1727	4349	4561	4455	6031	10061	8046	27.95	27.94	27.95
Brassinosteroid	1810	1917	1863	4669	4829	4749	6478	10837	8658	27.96	28.42	28.19
SEm±	35	41	27	70	81	54	76	141	80	0.53	0.55	0.39
CD (P=0.05)	102	119	76	203	235	152	220	409	227	NS	NS	NS
CV (%)	9.81	10.76		7.41	8.21		7.82	7.49		8.91	9.06	

*NS = Non-significant

Effect on quality

Qualitative characters *viz.* nitrogen content in seed, protein content (Table 2), oil content and oil yield (Table 3) were significantly affect by integrated nutrient management and foliar application of agrochemicals.

Among the treatments listed in Table 2, the application of 100% RDF combined with *Azotobacter* and PSB resulted in significantly higher nitrogen content (3.04%, 3.01%, and 3.02%) and protein content (19.01%, 18.79%, and 18.90%) in mustard seeds. These results were consistent across both experimental years and the pooled analysis. The performance of this treatment was statistically similar to all other treatments, except for the control. Nevertheless, the control exhibited the lowest levels of nitrogen and protein content in the seed. The nitrogen content has significantly increased as a result of the enhanced availability of nutrients in the soil, which has been achieved by adding fertilisers. The rise in protein content could be attributed to the heightened nitrogen concentration in mustard seeds resulting from the application of a combination of inorganic fertilisers, organic manure, and biofertilizers, which stimulate protein synthesis. The results closely align with the research conducted by Shukla *et al*. (2002) [21] and Tripathi *et al*. (2010) [25].

In case of foliar spaying of agrochemicals, Brassinosteroid resulted in considerably greater nitrogen content (3.00, 3.04 and 3.02%) and protein content (18.78, 18.95 and 18.86%) in mustard seeds. These results were statistically similar to those obtained with Salicyclic acid in both experimental years, when compared to the control. Nevertheless, the control exhibited the lowest value of nitrogen and protein content in the seed. The rise in protein content could be attributed to the elevated nitrogen concentration in the seed resulting from the application of agrochemicals through foliar spray, which enhances protein synthesis. The findings of the current investigation align closely with the results reported by Ameta (2009) [2], Singh *et al*. (2010) [23], and Bera and Pramanik (2013) [4].

The data in Table 3 showed that using 50% RDF along with 3.0 t ha^{-1} of vermicompost, *Azotobacter*, and PSB resulted in significantly higher oil content (35.13%, 36.11%, and 35.62%). These values were statistically similar to all other treatments, except for the control, in both years of the experiment and when the data was combined. Nevertheless, the application of 100% RDF + *Azotobacter* + PSB resulted in significantly higher oil yield (624.62, 682.31, and 653.46 kg ha-1). This yield was statistically similar to the application of 100% RDF, 50% RDF + Vermicompost @ 3.0 t ha^{-1} + *Azotobacter* + PSB, and 50% RDF + Vermicompost @ 3.0 t ha^{-1}, respectively, throughout the study. The control treatment resulted in the lowest oil content and oil yield. The notable rise in oil content and oil yield can be attributed to the process of fatty acid synthesis in plants, which involves the conversion of acetyl Co-A to malonyl Co-A in the presence of ATP and phosphate (Bonner and Varner, 1998) [7]. The increase in oil yield can be attributed to the relationship between seed yield and oil content, as oil yield is a direct result of these two factors. Similar results were reported by Bijarnia *et al*. (2017) [5], Singh *et al*. (2017) [5], Kumar *et al*. (2018) [12], and Sahoo *et al*. (2018) [19] in the context of mustard crop.

In case of foliar application of agrochemicals, Brassinosteroid resulted in significantly greater oil yield (625.80, 673.18, and 649.49 kg ha^{-1}) compared to the other treatments in both years of the trial. Agrochemicals application did not have a significant impact on oil control. The increase in oil yield can be attributed to the relationship between seed yield and oil content, as oil yield is a direct result of these two factors. Muhal *et al*. (2014) [13] and Dadhich *et al*. (2015) [9] have also reported similar findings.

Table 2: Effect of integrated nutrient management and agrochemicals on nitrogen and protein content (%) in mustard seed

Treatments	Nitrogen content (%)			Protein content (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Integrated Nutrient Management						
Control	2.73	2.72	2.72	17.09	16.97	17.03
100% RDF	2.97	2.95	2.96	18.57	18.44	18.50
50% RDF + FYM @ 6.0 t ha^{-1}	2.93	2.94	2.94	18.33	18.40	18.36
50% RDF + vermicompost @ 3.0 t ha^{-1}	2.95	2.95	2.95	18.41	18.41	18.41
100% RDF + *Azotobacter* + PSB	3.04	3.01	3.02	19.01	18.79	18.90
50% RDF + FYM @ 6.0 t ha^{-1} + *Azoto.* + PSB	2.99	2.97	2.98	18.69	18.47	18.58
50% RDF + Vermi. @ 3.0 t ha^{-1} + *Azoto.* + PSB	3.03	2.99	3.01	18.97	18.68	18.82
SEm±	0.04	0.05	0.03	0.25	0.28	0.19
CD (P=0.05)	0.12	0.15	0.09	0.77	0.88	0.55
CV (%)	4.09	4.67		4.09	4.67	
Agrochemicals						
Control	2.88	2.78	2.83	18.00	17.39	17.70
Salicylic acid	2.97	2.97	2.97	18.54	18.57	18.55
Brassinosteroid	3.00	3.04	3.02	18.78	18.95	18.86
SEm±	0.02	0.03	0.02	0.12	0.19	0.12
CD (P=0.05)	0.06	0.09	0.05	0.36	0.56	0.33
CV (%)	3.10	4.78		3.10	4.86	

*NS = Non-significant

Table 3: Effect of integrated nutrient management and agrochemicals on oil content (%) and oil yield (kg ha^{-1}) of mustard

Treatments	Oil content (%)			Oil yield (kg ha^{-1})		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Integrated nutrient management						
Control	32.48	32.46	32.47	447.86	464.37	456.11
100% RDF	34.21	34.91	34.56	612.45	665.38	638.91
50% RDF + FYM @ 6.0 t ha^{-1}	34.59	35.34	34.96	539.36	587.54	563.45
50% RDF + vermicompost @ 3.0 t ha^{-1}	35.02	35.66	35.34	573.12	618.98	596.05
100% RDF + *Azotobacter* + PSB	34.36	35.10	34.73	624.62	682.31	653.46
50% RDF + FYM @ 6.0 t ha^{-1} + *Azoto.* + PSB	34.87	35.52	35.20	557.57	604.23	580.90
50% RDF + Vermi. @ 3.0 t ha^{-1} + *Azoto.* + PSB	35.13	36.11	35.62	602.62	662.97	632.80
SEm±	0.47	0.57	0.37	17.38	22.83	14.34
CD (P=0.05)	1.45	1.76	1.08	53.55	70.33	41.87
CV (%)	4.10	4.88		9.22	11.18	
Agrochemicals						
Control	34.21	34.92	34.56	490.58	541.50	516.04
Salicylic acid	34.41	35.03	34.72	579.73	622.08	600.90
Brassinosteroid	34.53	35.10	34.81	625.80	673.18	649.49
SEm±	0.23	0.37	0.22	14.18	16.83	11.00
CD (P=0.05)	NS	NS	NS	41.07	48.76	31.17
CV (%)	3.11	4.87		11.49	12.60	

*NS = Non-significant

Conclusion

Based on the comprehensive study mentioned above, it is advised to cultivate mustard in the Jaipur region of Rajasthan under certain agro-climatic conditions using 100% recommended dose of fertiliser (RDF) along with the addition of *Azotobacter* and PSB. Additionally, applying Brassinosteroid through foliar application is recommended to get higher yield and better quality.

References

1. AOAC. Official method of analysis, 18th edition. Association of Official Agricultural Chemists, Washington; c1960.
2. Ameta V. Response of mustard [*Brassica juncea* (L.) Czern. & Cross.] Varieties to balanced fertilization and agrochemicals. Ph.D. Thesis, MPUAT, Udaipur (Rajasthan); c2009.
3. Anonymous. Data of rapeseed and mustard; c2022-23. Available from: www.srmr.org.in/nbc
4. Bera AK, Pramanik K. Effect of biofertilizers and homobrassinolide on growth, chlorophyll content, yield, nutrient content, and uptake of lentil (*Lens culinaris* Medik). Int. J Agric. Environ. Biotechnol. 2013;6(3):427-436.
5. Bijarnia AL, Yadav RS, Rathore PS, Singh SP, Jat RS. Study of integrated nutrient management and weed control measures on mustard (*Brassica juncea* L.) and its residual effect on fodder Pearlmillet (*Pennisetum glaucum* L.) in North Western Rajasthan. Int. J Chem. Stud. 2017;5(3):314-318.
6. Bisht S, Saxena AK, Singh S. Effect of integrated nutrient management on growth and yield of mustard (*Brassica*

juncea L.) cultivar T-9 under Dehradun region (Uttarakhand). Int. J Chem. Stud. 2018;6(4):1856-1859.
7. Bonner A, Varner G. Sequences, datalog, and transducers. J Comput. Syst. Sci. 1998;57(3):234-259.
8. Chouhan GS, Joshi A, Padiwal NK. Studies on irrigation management and brassinosteroid application on productivity and quality of chandrasur (*Lepidium sativum* L.). Annual Report (2014-15), All India Coordinated Research Project on Medicinal and Aromatic Plants, Directorate of Research, MPUAT, Udaipur (Rajasthan); c2015. p. 45-49.
9. Dadhich RK, Dadhich RS, Reager ML, Kansotia BC. Response of bio-regulators to yield and quality of Indian mustard (*Brassica juncea* L. Czernj. and Cosson) under different irrigation environments. J Appl. Nat Sci. 2015;7(1):52-57.
10. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd ed. John Wiley and Sons, New York; c1984.
11. Kumar A, Bharati AK, Yadav S, Pandey HC, Kumar V. Influence of biofertilizer and farmyard manure on growth, yield, and seed quality of Mustard (*Brassica juncea* L.) in rainfed condition. Int. J Agric. Sci. Res. 2017;7(2):197-202.
12. Kumar D, Singh RP, Awasthi UD, Uttam SK, Kumar R, Kumar M, *et al*. Effect of bio-fertilizer and moisture conservation practices on growth and yield behavior of mustard under rainfed conditions. J Pharmacogn. Phytochem. 2018;7(1):2038-2041.
13. Muhal S, Solanki NS, Singh P, Shukla KB. Effect of salicylic acid on productivity and nutrient uptake of *Brassica* species under different planting durations. Afr. J Agric. Res. 2014;9:1101-1106.
14. Murali M, Umrao R, Kumar H. Effect of different levels of organic manure on the growth and yield of mustard (*Brassica juncea* L.) under Jatropha (*Jatropha curcas* L.) based agroforestry system. J Pharmacogn. Phytochem. 2018;7(4):955-958.
15. Nagaharu. *Brassica* U triangle. In: Plant breeding principles and methods; c1935. p. 664.
16. Patel AM, Prajapati DB, Patel DG. Heterosis and combining ability studies in Indian mustard [*Brassica juncea* (L.) Czern. & Coss]. Indian J Sci. Technol. 2012;1:38-40.
17. Reddy GK, Singh R. Effect of integrated nitrogen management on the growth and yield of mustard [*Brassica juncea* (L.) Czern. & Coss]. J Pharmacogn Phytochem. 2018;7(3):617-619.
18. Sahoo RC. Integrated nutrient management in mustard [*Brassica juncea* (L.) Czern. & Coss]. M.Sc. (Ag.) Thesis, MPUAT, Udaipur; c2013.
19. Sahoo RC, Purohit HS, Prajapat OP. Integrated nutrient management in mustard (*Brassica juncea* L.). Int. J Curr. Microbiol. Appl. Sci. 2018;7:3545-3549.
20. Shroff RS, Devsthali S. Earthworm farming: Scope and limitation. In: Somani LL, Tatawal KL, Basu BL, editors. Proceedings of National Seminar on Natural Farming; c1992. p. 126-142.
21. Shukla RK, Kumar A, Mahapatra BS, Basanth K. Integrated nutrient management practices in relation to morphological and physiological determination of seed yield in Indian mustard [*Brassica juncea* (L.)]. Indian J Agric. Sci. 2002;72:670-672.
22. Singh H, Singh RP, Meena BP, Lal B, Dotaniya ML, Shirale AO, *et al*. Effect of integrated nutrient management (INM) modules on late-sown Indian mustard [*Brassica juncea* (L.) Czern. & Coss] and soil properties. J Cereals Oilseeds. 2017;9(4):37-44.
23. Singh Y, Rathore HS, Tiwari RC, Sharma SK. Nutrient uptake, consumptive use, and economics of fenugreek (*Trigonella foenum-graecum* L.) as affected by irrigation schedules and growth regulators. Ann. Agric. Res. New Ser. 2010;31(3 &4):129-132.
24. Thakur NP, Kachroo D, Kour M, Kumar P, Sharma R, Khajuria V, *et al*. Long-term effect of integrated nutrient management on crop productivity and fertility of clay loam (Inseptisol) soil in continuous rotation of rice-wheat cropping system under sub-tropical ecosystem of Jammu region. Paper presented in 75th Annual convention of ISSS held at IISS, Bhopal during Nov; c2009. p. 14-17.
25. Tripathi MK, Chaturvedi S, Shukla DK, Mahapatra BS. Yield performance and quality in Indian mustard (*Brassica juncea*) as affected by integrated nutrient management. Indian J Agron. 2010;55(2):138-142.