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Oil Yield and Quality Different Varieties of Indian Mustard (*Brassica juncea* L.) as Influenced by Organic Manures and Biofertilisers

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Authors' contributions

This work was carried out in collaboration between both authors. Author OB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author EPL managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The study was conducted at the Central Research Field of Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during 2016-17 and 2017-18. The experiments consisting of two factors viz., 5 varieties and 10 fertiliser treatments was laid out in a factorial randomized block design with replicated thrice. The results of the study revealed that the oil yield was significantly highest with Rani variety while the oil content did not vary significantly amongst different varieties. The fatty acid composition such as palmitic acid, stearic acid, oleic acid, linoleic & linolenic acid, and arachidic acid contents showed non-significant variations amongst varieties. The biochemical characters viz., total chlorophyll, total soluble sugars and proline content was recorded at 45, and 60 DAS were significantly higher in Rani variety. Both protein content and protein yields were also significantly highest in Rani variety. Application of 75% N through vermicompost produced significantly highest oil content and oil yield, protein content and protein yield, biochemical

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characters total chlorophyll, total soluble sugars and proline content recorded at 45 and 60 DAS, while palmitic acid, stearic acid and oleic acid were significantly highest with application of recommended dose of chemical fertilisers. Linoleic acid was significantly maximum with fertiliser treatment of 50% N through vermicompost + Azotobacter + Both linolenic and arachidic acid contents remained unaffected by the fertiliser treatments.

Keywords: Oil yield; oil quality; biochemical; Indian mustard; protein.

1. INTRODUCTION

It is the major *rabi* oilseed crop of India. Mustard is the second most important edible oilseed crop and it constitutes one fourth of oilseeds grown in India. Among the seven annual edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6 percent in the total production of oilseeds. The main purpose of growing mustard is to fulfill the need of oil consumption. It is a rich source of oil and protein. The oil content varies from 37 to 49% [1]. The imbalanced and continuous use of chemical fertilisers in the cropping system is leading to an imbalance of nutrients in soil which have an adverse effect on soil health, growth, yield and quality of crops, besides causing environmental pollution. In additions the high cost of chemical fertilisers is unaffordable for the farmers to purchase them.

Organic agricultural practices aims to enhance biodiversity, biological cycles and soil biological activity so as to achieve optimal natural systems that are socially, ecologically and economically sustainable. Manure management is a process aiming to combine profitable agricultural production with minimum nutrient losses from manure, for the present and in the future. The manures apart from increasing yield and quality of crops improve soil health, make nutrients available to the plant and facilitate better uptake of nutrients by the crop. During recent years biofertilisers have emerged as a promising component of integrating nutrient supply system in agriculture. Certain strains of soil microbes referred to as plant growth promoting rhizobacteria that include species of Azotobacter and Azospirillum both of which provide direct and indirect effects on the plant growth and pest resistance.

The aim of present study was to test the effects of chemical fertilisers, organic manures and biofertilisers on the protein and oil content and yield, fatty acid composition and biochemical characters like total chlorophyll, total soluble sugars and proline content in the fresh leaves of Indian mustard (*Brassica juncea* L.) varieties.

2. MATERIALS AND METHODS

A field experiment was conducted at the Central Research Field of Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad [25.41°N,81.51°E] during 2016-17 and 2017-18 to study the "Oil yield and quality of different varieties of Indian mustard (*Brassica juncea* L.) as influenced by organic manures and biofertilisers. (*Brassica juncea* L.) The experiment consisting of two factors viz., 5 varieties (V_1 = Rudra 99-D, V_2 = Shikhar, V_3 = Rani, V_4 =Varuna and V_5 = Yellow Goldey) and 10 fertiliser levels (T_1 = control, T_2 = Recommended dose of fertiliser (RDF), T_3 = 75% N through Farm Yard Manure, T_4 = 75% N through Vermicompost, T_5 = 50% N through Farm Yard Manure+ Azotobacter, T_6 = 50% N through Farm Yard Manure+ Phosphate Solubilising Bacteria, T_7 = 50% N through vermicompost + Azotobacter, T_8 = 50% N through Vermicompost + Phosphate Solubilising Bacteria, T_9 = 25% N through Farm Yard Manure + Azotobacter + Phosphate Solubilising Bacteria and T_{10} = 25% N through vermicompost + Azotobacter + Phosphate Solubilising Bacteria was laid out in a factorial randomized block design with replicated thrice, the seed was sown in lines at 30 cm row spacing at the rate of 7.5 kg ha⁻¹ as per treatment. The crop was thinned twice to maintain plant to plant spacing of 15 cm. The crop was harvested on 2-02-17 and 4-05-2018 during 2016-17 and 2017-18, respectively. Oil content in seed sample was determined using Soxhlet apparatus. Fatty acid analysis was done by following procedure described by AOAC [2]. Protein content was determined by the method described by Jackson [3]. The biochemical characters viz; total chlorophyll content, total soluble sugars and proline contents in seed were determined by the methods given by several authors [4,5,6], respectively. The data was analysed by the method described by Cochran and Cox [7].

3. RESULTS AND DISCUSSION

The data (Table 1) revealed that Rani variety recorded significantly higher yield, while the oil

content did not show any significantly variation amongst varieties. The results are in line with the findings of AOAC [8] who did not observe any significant variation in the oil content of SEJ2 and Pusa Bold mustard varieties. The significant variation in the oil yield amongst varieties attributed to the higher seed yield recorded by Rani variety as oil yield is the product of seed yield and respective oil content. The study also indicated that amongst fertiliser treatments, application of 75% N through vermicompost + Azotobacter recorded significantly highest oil content and oil yield. These results corroborate the findings of Singh and Singh [9] who reported that application of 5t FYM ha⁻¹ along with inorganic fertilisers and biofertilisers recorded significantly highest oil content and yield in mustard. Non significant variation was noticed amongst varieties with regard to saturated and unsaturated fatty acids (Tables 2 and 3). The investigation also revealed that the palmitic acid, stearic acid and oleic acid were significantly maximum with fertiliser treatment of recommended fertiliser dose, while linoleic acid was significantly highest with the treatment 50%

N through vermicompost + Azotobacter + PSB. Both linolenic and arachidic acid content remained unaffected by fertiliser treatments. There was a strong negative relationship between linoleic and oleic acid concentrations which is similar to the results obtained earlier by several authors [10,11] also reported that the biofertilisers singly or combination of two along with organic manures decreased saturated fatty acids (Palmitic and stearic acids) while significantly increased unsaturated fatty acids. Further, they also reported that oil and oleic acid content was negative due to adverse effect of nitrogen. Both protein content and yield were significantly highest in Rani variety (Table 1) this may be attributed to genetic potential of the varieties with regard to the accumulation of nitrogen [12] also found higher protein content and yield in RLC1 variety than other mustard varieties tested. It was also noticed that application of 75% N through vermicompost + Azotobacter recorded significantly highest protein content and yield. The high nitrate supply from the treatment might have increased amino acid synthesis in leaves which stimulated

Table 1. Protein content/protein yield and oil content/oil yield as affected by Indian mustard varieties and organic manures /biofertilisers

Treatment	N content in seed (%)		Protein content in seed (%)		Protein yield (Kg ha ⁻¹)		Oil content (%)		Oil yield (Kg ha ⁻¹)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Varieties										
V ₁	2.98	2.97	18.62	18.56	216.18	221.23	37.88	37.75	440.16	431.26
V ₂	2.88	2.89	18.00	18.06	182.34	188.00	37.47	37.45	379.57	387.67
V ₃	3.01	3.02	18.81	18.87	222.15	228.33	38.07	37.96	452.27	459.32
V ₄	2.92	2.94	18.25	18.37	208.96	215.30	37.67	37.54	431.32	439.97
V ₅	2.95	2.96	18.44	18.50	212.61	218.30	37.73	37.63	434.65	444.03
SE (m) ±	0.039	0.042	0.207	0.224	2.956	2.996	0.429	0.389	13.238	14.375
CD (P=0.05)	0.11	0.12	0.58	0.63	8.30	8.41	NS	NS	37.16	40.35
Fertilisers/ Biofertilisers										
T ₁	2.40	2.41	15.00	15.06	135.75	140.81	36.28	36.18	328.33	338.28
T ₂	3.14	3.15	19.62	19.69	232.50	239.23	37.34	37.24	442.48	452.47
T ₃	2.71	2.70	16.93	16.87	179.12	183.21	37.72	37.57	399.08	409.64
T ₄	2.72	2.71	17.00	16.94	186.83	190.91	37.90	37.69	416.52	424.77
T ₅	3.21	3.22	20.06	20.12	241.72	248.08	38.52	38.40	465.17	473.47
T ₆	2.82	3.82	17.62	17.62	198.40	203.69	37.50	37.40	422.25	432.34
T ₇	3.24	3.23	20.25	20.19	246.24	251.36	38.66	38.60	470.10	480.57
T ₈	2.83	2.84	17.69	17.75	203.43	209.45	37.62	37.56	4732.63	443.21
T ₉	3.20	3.21	20.00	20.06	235.60	211.92	38.04	38.00	448.11	458.28
T ₁₀	3.21	3.22	20.06	20.12	237.51	244.05	38.06	38.02	450.63	461.18
SE (m) ±	0.053	0.060	0.292	0.317	4.68	4.225	0.605	0.549	18.668	20.271
CD (P=0.05)	0.15	0.17	0.82	0.89	11.70	11.86	1.70	1.54	52.4	56.9

V₁ = Rudra 99-D T₁ = control T₂ = RDF
V₂ = Shikhar T₃ = 100%N Through FYM T₄ = 100%N Through Vermicompost
V₃ = Rani T₅ = 75%N Through FYM+ Azotobacter T₆ = 75%N Through FYM+ PSB
V₄ = Varuna T₇ = 75%N Through vermicompost + Azotobacter T₈ = 75%N Through Vermicompost + PSB
V₅ = Yellow Goldy T₉ = 50% N through FYM + Azotobacter+ PSB T₁₀ = 50% N through vermicompost + Azotobacter + PSB
RDF: Recommended dose of fertilisers; FYM: Farm yard manure; PSB: Phosphorus solubilising bacteria; SE: Standard error; CD: Critical difference

Table 2. Saturated and unsaturated fatty acids as affected by varieties and organic manurers /biofertilisers

Treatment	Palmitic (%)		Stearic acid (%)		Oleic acid (%)		Linoleic acid (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
V ₁	5.64	5.67	3.59	3.65	36.79	36.80	45.90	45.94
V ₂	5.34	5.38	3.49	3.56	36.38	36.45	45.30	45.36
V ₃	5.70	5.70	3.69	3.71	36.99	37.01	46.10	46.15
V ₄	5.42	5.45	3.49	3.54	36.48	36.54	45.60	45.64
V ₅	5.60	5.64	3.59	3.62	36.58	36.62	45.81	45.81
SE (m) ±	0.139	0.135	0.096	0.085	0.328	0.339	0.399	0.409
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
T ₁	4.34	4.36	3.05	3.08	34.20	34.22	42.60	42.63
T ₂	6.83	6.87	4.46	4.52	37.10	37.16	45.87	45.92
T ₃	5.28	5.32	3.27	3.29	38.60	38.62	44.74	44.77
T ₄	5.32	5.36	3.26	3.19	38.62	38.68	44.64	44.69
T ₅	5.70	5.71	3.61	3.72	36.85	36.89	45.25	45.30
T ₆	5.66	5.69	3.59	3.61	36.70	36.74	45.10	45.15
T ₇	5.72	5.73	3.73	3.74	36.90	36.92	45.32	45.36
T ₈	5.65	5.69	3.68	3.70	36.75	36.81	45.15	45.19
T ₉	5.40	5.43	3.50	3.54	35.80	35.35	49.33	49.36
T ₁₀	5.51	5.54	3.58	3.59	35.40	35.43	49.42	49.44
SE (m) ±	0.196	0.189	0.135	0.121	0.463	0.748	0.563	0.577
CD (P=0.05)	0.55	0.53	0.38	0.34	1.30	1.33	1.58	1.62

V₁ = Rudra 99-D T₁ = control T₂ = RDF
V₂ = Shikhar T₃ = 100%N Through FYM T₄ = 100%N Through Vermicompost
V₃ = Rani T₅ = 75%N Through FYM+ Azotobacter T₆ = 75%N Through FYM+ PSB
V₄ = Varuna T₇ = 75%N Through vermicompost + Azotobacter T₈ = 75%N Through Vermicompost + PSB
V₅ = Yellow Goldy T₉ = 50% N through FYM + Azotobacter+ PSB T₁₀ = 50% N through vermicompost + Azotobacter + PSB

RDF: Recommended dose of fertilisers; FYM: Farm yard manure; PSB: Phosphorus solubilising bacteria

Table 3. Linonic acid and oleic acid concentrations in mustard oil (fatty acid) as affected by varieties, inorganic and organic fertilisers and biofertilisers

Treatment	Oleic acid (%)		Linoleic acid (%)	
	2016-17	2017-18	2016-17	2017-18
Varieties				
V ₁	0.32	0.33	0.92	0.94
V ₂	0.31	0.31	0.91	0.92
V ₃	0.32	0.33	0.92	0.94
V ₄	0.31	0.32	0.91	0.92
V ₅	0.31	0.32	0.91	0.93
SE (m) ±	0.007	0.007	0.012	0.012
CD (P=0.05)	NS	NS	NS	NS
Fertilisers/ Biofertilisers				
T ₁	0.30	0.31	0.89	0.92
T ₂	0.32	0.32	0.90	0.93
T ₃	0.31	0.31	0.92	0.92
T ₄	0.31	0.31	0.92	0.92
T ₅	0.32	0.32	0.91	0.93
T ₆	0.30	0.32	0.90	0.92
T ₇	0.33	0.34	0.93	0.94
T ₈	0.31	0.32	0.90	0.92
T ₉	0.31	0.32	0.90	0.93
T ₁₀	0.31	0.32	0.90	0.93
SE (m) ±	0.011	0.011	0.017	0.017
CD (P=0.05)	NS	NS	NS	NS

V₁ = Rudra 99-D T₁ = control T₂ = RDF
V₂ = Shikhar T₃ = 100%N Through FYM T₄ = 100%N Through Vermicompost
V₃ = Rani T₅ = 75%N Through FYM+ Azotobacter T₆ = 75%N Through FYM+ PSB
V₄ = Varuna T₇ = 75%N Through vermicompost + Azotobacter T₈ = 75%N Through Vermicompost + PSB
V₅ = Yellow Goldy T₉ = 50% N through FYM + Azotobacter+ PSB T₁₀ = 50% N through vermicompost + Azotobacter + PSB

RDF: Recommended dose of fertilisers; FYM: Farm yard manure; PSB: Phosphorus solubilising bacteria

accumulation of protein in seed. Akbari et al. [13] also reported similar findings. Moreover, vermicompost also balance nutrition under favourable environment might have helped in increased chlorophyll content at flowering stage.

The data (Table 4) showed that the biochemical characters viz., total chlorophyll content total soluble sugars and proline content recorded at 45 and 60 DAS were significantly higher in Rani variety. These results may be attributed to significant variation in the level of biosynthesis of chlorophyll and photosynthesis depending on genetic potential of mustard varieties. Further, the differential response of varieties to environmental stress and different levels of osmotic adjustment might have produced significant variation in proline content. Banerjee et al. [14] have also found significant variation in total chlorophyll content amongst different

mustard varieties. Ali [15] recorded variation in total soluble sugar content in leaves of Iris. Ozturk and Demir [16] reported significant variation in the proline content of different mustard varieties. The study also revealed that significantly highest biochemical characters were recorded by the treatment 75% N through vermicompost + Azotobacter. The results are in agreement with those of several authors [17,18]. The increase in total chlorophyll content may be attributed to increased uptake of magnesium from soil in the form of Mg^{+2} under the influence of bio-fertiliser. Further, higher biosynthesis of chlorophyll and photosynthesis of mustard crop under Azotobacter treated plots might have resulted towards higher level of sugar in leaves. The higher accumulation of proline in leaves of mustard might be attributed towards the response of biofertiliser treated crop to mitigate and stimulating of draught tolerance.

Table 4. Biochemical characters as affected by varieties and organic manures/biofertilisers

Treatment	Total chlorophyll (mg g ⁻¹ fresh weight of leaves)				Total soluble sugars (mg g ⁻¹ leaf fresh weight)				Proline content (mg g ⁻¹ fresh leaf weight)			
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
Varieties												
V ₁	2.10	1.39	2.13	1.41	8.92	9.80	8.98	9.84	10.22	10.23	10.28	10.31
V ₂	1.59	1.18	1.62	1.23	8.46	9.53	8.55	9.54	9.27	9.24	9.14	9.15
V ₃	2.22	1.45	2.23	1.46	9.27	10.29	9.30	10.33	10.46	10.47	10.46	10.46
V ₄	1.83	1.24	1.85	1.28	8.60	9.64	8.63	9.66	9.75	9.75	9.56	9.59
V ₅	1.96	1.33	1.97	1.35	8.65	9.74	8.68	9.75	9.94	9.94	9.76	9.76
SE (m) ±	1.62	1.04	1.82	1.01	1.22	1.25	1.24	1.58	1.24	1.23	1.25	1.22
CD (P=0.05)	0.44	0.26	0.45	0.25	0.33	0.37	0.36	0.40	0.36	0.35	0.37	0.34
Fertilisers/ Biofertilisers												
T ₁	1.04	0.85	1.06	0.88	6.71	7.80	6.74	7.84	8.01	8.015	8.00	8.12
T ₂	2.49	1.64	2.53	1.67	7.43	8.44	7.47	8.46	8.60	8.73	8.43	8.54
T ₃	1.43	1.03	1.44	1.08	7.52	8.53	7.56	8.54	9.49	9.59	9.40	9.28
T ₄	1.49	1.06	1.53	1.10	7.56	8.58	7.59	8.59	9.60	9.50	9.62	9.73
T ₅	2.89	1.85	2.93	1.86	11.74	12.75	11.77	12.77	10.70	10.60	10.45	10.25
T ₆	1.64	1.13	1.65	1.15	9.35	10.36	9.37	10.38	10.25	10.50	10.20	10.05
T ₇	3.09	1.91	3.10	1.94	11.92	12.93	11.95	12.94	11.40	11.21	11.25	11.40
T ₈	1.72	1.14	1.74	1.17	9.41	10.41	9.42	10.44	10.55	10.38	10.46	10.58
T ₉	1.75	1.22	1.76	1.24	7.83	8.86	7.87	8.86	10.20	10.32	10.22	10.16
T ₁₀	1.84	1.35	1.85	1.38	8.34	9.34	8.37	9.37	10.40	10.28	10.40	10.49
SE (m) ±	1.98	1.24	2.21	1.22	1.56	2.10	2.05	2.24	2.05	1.62	2.00	1.58
CD (P=0.05)	0.52	0.37	0.64	0.36	0.47	0.53	0.51	0.57	0.51	0.49	0.52	0.48

V₁ = Rudra 99-D

V₂ = Shikhar

V₃ = Rani

V₄ = Varuna

V₅ = Yellow Goldy

T₁ = control

T₃ = 100%N Through FYM

T₅ = 75%N Through FYM+ Azotobacter

T₇ = 75%N Through vermicompost + Azotobacter

T₉ = 50% N through FYM + Azotobacter+ PSB

T₂ = RDF

T₄ = 100%N Through Vermicompost

T₆ = 75%N Through FYM+ PSB

T₈ = 75%N Through Vermicompost + PSB

T₁₀ = 50% N through vermicompost + Azotobacter + PSB

RDF: Recommended dose of fertilisers; FYM: Farm yard manure; PSB: Phosphorus solubilising bacteria

4. CONCLUSION

From the above results it is concluded that Indian mustard variety 'Rani' supplied with of 75% N through vermicompost and Azotobacter produced significantly highest protein and oil yields and biochemical characters viz., chlorophyll, total soluble sugars and proline content in fresh leaves whereas, recommended fertiliser dose of N P and K recorded significantly the highest concentration of saturated fatty acids. The oleic acid being significantly highest under 100% N dose through vermicompost.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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